FISKERIDIREKTORATETS SKRIFTER
Serie Fiskeri
Vol. II. No. 1.
Published by the Director of Fisheries

THE TECHNOLOGY OF HERRING UTILIZATION

REPORT OF THE FAO MEETING ON HERRING TECHNOLOGY

Bergen, Norway, 24—29 Sept. 1950

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FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS
Viale delle Terme di Caracalla, Rome, Italy.

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A.s John Griegs Boktrykkeri, Bergen

MEETING OFFICERS

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Vice-Chairman:

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General Secretary:

Mr. *Mogens Jul,* FAO

Assistant Secretary:

Mr. *Michel Girard,* FAO

PREFACE

The FAO Meeting on Herring Technology, of which this book is a report, arrived at several definite conclusions which can furnish a useful guide for future technological research. Some of these are quoted at the end of the relevant chapters.

In addition, the meeting led to the initiation of a committee which would ensure continued cooperation in research related to fish handling and processing. It is gratifying that the work of such a committee is well under way while this report is being printed; it is likely that, as an outcome of the meeting, a permanent committee for this purpose will be set up.

The papers and discussions at the meeting contained a wealth of technical information which the participants found highly useful. This material could be brought into even greater use if it were made available in printed form. The Norwegian Government, through its Director of Fisheries, Mr. *Klaus Sunnanå,* therefore generously offered to print the full report of the meeting in the publication series of the Directorate of Fisheries. For this, FAO is greatly indebted to the Norwegian Government, which had already born the expenses of the meeting itself.

The material has been arranged according to subject so that the book can be used as a handbook. Thereby, each author's contribution is sometimes split into several sections, and may have lost some of its continuity. It was felt, however, that the advantage of a strict subject arrangement of the material would outweigh this disadvantage. Authors have very kindly agreed to this arrangement.

As a point of interest, it might be mentioned that the proceedings of the meeting were recorded acousticaly on plastic belts. The summaries of the discussions from the meeting were prepared from those records. Thereby, the summaries could be quite complete. The method proved, however, to be quite time-consuming as far as the final preparation of the report is concerned.

It is regretted that considerable delay has been experienced in the issuance of this report. This is due to several factors: the international crisis in the fall of 1950 created in Washington, D. C., U. S. A., a serious shortage of playback equipment for the recordings, making it impossible to complete editing of the discussion summaries before February 1951, when FAO's work was disrupted by the move of the Organization from its temporary headquarters in Washington, D. C., U. S. A., to Rome, Italy. Later, the work was again delayed by prolonged illness of one of the editors.

A great many acknowledgements are in order. Thanks go, first of all, to the Former Norwegian Minister of Fisheries, the Hon. *Reidar Carlsen,* and his staff in the Norwegian Department of Fisheries. Sincere thanks also go to everyone who assisted in the arrangement of the meeting itself, most of all to the Norwegian Director of Fisheries, Mr. *Klaus Sunnanå* and to everyone he, as Chairman of the meeting, thanked in his speech at the closing session of the meeting, re-printed on p. 24. These were in particular Dr. *G. A. Reay,* Vice-chairman of the meeting, and Mr. *A. J. Aglen* and Dr. *C. J. H. van den Broek,* who prepared the final summary report. Also Mr. *R. P. Elliott* and Miss *Sparre,* who operated the recording system, and to the persons from the staff of the Norwegian Directorate of Fisheries itself, Mr. *J. W. Blich,* Miss *Hansen,* and Mrs. *Haugsøen,* who were carrying out a very great part of the work involved in preparing and servicing the meeting.

Thanks go next to the Director of the Norwegian Directorate of Fisheries' Chemical-Technical Research Institute, Mr. *Eirik Heen* and his staff; to the director of the Norwegian Herring Oil and Herring Meal Industry's Research Institute, Mr. *Trygve Sparre* and his staff, for assisting in the arrangement of visits to these institutes; also to Mr. *P. Haraldsvik,* head of the Norwegian Herring-grading Service, who arranged a spesial exhibit of various Norwegian salted-herring products. Assistance was given in arranging exhibits of herring products by Mr. *Frode Bramsnæs,* Director of the Danish Ministry of Fisheries Technological Laboratory; Mr. *Ewald Luckey,* Lysekil, Sweden; and Mr. *Erling Mathiessen,* head of the Norwegian Canning Industry's Laboratory.

Special acknowledgement is given to Dr. *Georg Borgström.* Director of the Swedish Institute for Food Preservation Research, who prepared an address on: "Fisheries and the World's Food Problem", and to all authors of papers for the meeting and participants in the discussions, quoted elsewhere in this book. During the preparation of this report these persons have most patiently gone over manuscripts of papers and discussions to ensure technical and sometimes even orthographic accuracy. Every author has been most helpful in this respect; there are reasons to mention in particular the staff of the *Torry Research Station,* Aberdeen, Scotland, who did a very large share of this work.

Acknowledgement is also given to the representative of the Dictaphone Corporation of the United States in Oslo, Norway: Firma Claussen og Manus, who made the recording equipment available.

Lastly, it should be stated that the greatest part of the thanks must go to the Norwegian Director of Fisheries, Mr. *Klaus Sunnanå,* and his staff who, both by their personal assistance at the meeting, and by the funds the Norwegian Government made available, did most to make the meeting and this report a reality.

Rome, August 1951.

Mogens Jul

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INTRODUCTION

The FAO MEETING ON HERRING TECHNOLOGY, from which this book is a report, was held in Bergen, Norway, 24 to 29 September 1950. It was called by FAO on the recommendation of the Herring Meeting, held 29 August to 2 September 1949 in the Hague, the Netherlands, under the auspices of FAO. That meeting was concerned mainly with the economic problems of the herring industry with particular reference to the critical situation of the industry in many producing countries. The Hague meeting made several suggestions for practical steps that might be taken by FAO. Among these were the suggestions that FAO should:

1. Explore the possibilities of introducing into the diet of Asiatic and African people a product acceptable to their tastes derived from herring.
2. Bring together technologists to examine the possibilities of developing new or existing processes that would lead to an increase in the marketing of herring.

As a first step towards a solution of the problem mentioned in conclusion no. 1 it was found expedient to make this question the subject of further exploration at the meeting of fisheries technologists recommended in conclusion no. 2. FAO, therefore, proceeded with the preparation of such a meeting.

On the invitation of the Norwegian Government this meeting was arranged in Bergen, Norway, in September 1950. It was attended by representatives and observers from the following countries: Belgium, Canada, Denmark, Finland, France, Iceland, the Netherlands, Norway, Sweden, United Kingdom, United States of America, and Western Germany. A representative of the International Council for the Exploration of the Sea was also in attendance.

Mr. *Klaus Sunnanå,* Director of Fisheries, Norway, was unanimously elected chairman of the meeting, and Dr. *G. A. Reay,* Director of the Torry Research Station, Aberdeen, Scotland, vice-chairman.

The meeting also elected a representative from each participating country as member of a steering committee, the composition of which is given on page 2.

This book contains the proceedings of the meeting including the technical papers presented at it, summaries of the discussions, and the recommendations made by the meeting.

As the publication of this report has been considerably delayed, the various constributors have been asked to bring the information contained in their papers or remarks during the discussion up-to-date. In some cases, therefore, the book contains information which was not available at the time of the meeting.

PROGRAM OF THE MEETING

Registration, meetings and film showings took place in Bergens Haandverks- og Industriforening, except where otherwise indicated.

Each technical session was introduced by one or more papers which were available in mimeographed form. The papers were summarized at the beginning of each session, the greater part of these being taken up by discussions.

Sunday 24 September

10:00 A.M.
to 8:00 P.M. *Registration.*

8:00 P.M. *Informal Session:* Speech by Dr. *Georg Borgström*, Sweden: "Fisheries and the World's Food Problems".

9:00 P.M. *Showing of the film:* "The World is Rich" (FAO).

9:30 P.M. *Reception* by the Norwegian Government and FAO.

Monday 25 September

9:00 A.M. *Registration.*

10:00 A.M. *Formal Opening and General Session:* Speech by the Representative of the Norwegian Government, Dr. *Karl Evang,* Director-General of Public Health, Norway, and by a representative of the Director-General of FAO. Thereafter, election of Chairman and appointment of Steering Committee.

11:00 A.M. *Presentation of the following papers: G. A. Reay,* United Kingdom: "The Utilization of Herring"; *Olav Notevarp,* Norway: "Herring, the Raw Material"; *Finn Devold,* Norway: "The Influence of Natural Factors on the Landing of Herring".

2:00 P.M. *Technical Session:* Discussion regarding the possibilities for finding new markets for herring products, based on the papers: *G. M. Gerhardsen,* FAO: "Factors Influencing Supply and Demand for Herring"; *H. H. Goodwin,* United Kingdom: "Efforts to Increase Sales and Exports of Herring Products"; *G. L. Kesteven,* FAO: "Possibilities for Exporting Herring Products to Asia and the Far East"; *C. F. Hickling,* United Kingdom: "Herring Products in the British Dependencies"; *Neal M. Carter and Basil E. Bailey,* Canada: "A Review of the Technology of British Columbia Herring Products Investigated at the Pacific Fisheries Experimental Station of the Fisheries Research Board of Canada"; *P. A. Sunderland,* Canada: "Dry Salting and Canning of Herring in British Columbia".

4:30 P.M. *Showing of the Film:* "Fish for Asian People" (FAO).

5:30 P.M. *Film Showings:* (Open to the public). Shown were: "Science Goes Fishing" (Canada); "Sardines for Supper" (U. S. A.); "Silver Harvest" (Norway).

8:00 P.M. *Informal Dinner.*

Tuesday 26 September

9:30 A.M. *Technical Session:* Discussion based on the papers: *D. J. van Dijk,* the Netherlands: "Salted and Spiced Herring"; *Georg Borgström,* Sweden: "Hering Delicatessen and Marinated Products".

2:00 P.M. *Technical Session:* Discussion based on the papers: *C. A. Cutting,* United Kingdom: "Preservation of Herring by Smoking and Drying"; *Frode Bramsnæs and Halvor Petersen,* Denmark: "Hot Smoking of Herring".

4:00 P.M. *Showing of the Film::* "Sild — gennem Is og Ild". (Denmark).

7:30 P.M. *Visit* to Fiskeridirektoratets Kjemisk-Tekniske Forskningsinstitutt (Norwegian Directorate of Fisheries Chemical-Technical Research Institute). Demonstration of salted and dried herring delicatessen, and Oriental fishery products.

Wednesday 27 September

9:30 A.M. *Technical Session:* Discussion based on the paper: *J. G. Huntley,* United Kingdom: "Herring Canning".

11:45 A.M. *Film Showings* in Ole Bulls Kino (open to the public). Shown were: "Sildefisket" (Norway); "Frossen fisk" (Norway).

2:00 P.M. *Technical Session:* Discussion based on the papers: *G. A. Reya and J. M. Shewan,* United Kingdom: "The

Preservation of Fresh Herring"; *Eirik Heen and Olaf Karlsen,* Norway: "Freezing of Herring"; *A. Banks,* United Kingdom: "Freezing and Cold Storage of Herring".

5:15 P.M. *Showing the Film:* "It's the Maine Sardine" (.US.A.).

Thursday 28 September

9:30 A.M. *Technical Session:* Continued discussion of the possibilities for developing new herring products.

2:00 P.M. *Technical Session:* Discussion based on the paper: *Gudmund Sand,* Norway: "New Reduction Processes".

5:00 P.M. *Visit* to Sildeolje- og Sildemelindustriens Forskningsinstitutt (The Herring Oil and Herring Meal Industry's Research Institute) Damsgård, Bergen.

8:00 P.M. *Dinner:* Bergens Kommune (The City of Bergen) had invited representatives and official observers to be the guests of the City at a dinner at Restaurant »Fløien«.

Friday 29. September

9:30 A.M. *Technical Session:* Discussion based on the papers: *J. A. Lovern,* United Kingdom: "Production of Herring Oil"; *Trygve Sparre,* Norway: "Fish Solubles"; *J. A. Lovern,* United Kingdom: "Note on Protein Products from Herring".

2:00 P.M. *Technical Session:* Continuation of preceding meeting.

4:00 P.M. *Closing Session:* Speeches by Mr. *Gunnar Rollefsen,* the International Council for the Exploration of the Sea, and Mr. *Klaus Sunnanå,* Director of Fisheries, Norway.

5:30 P.M. *Film Showings:* (Open to the public) Shown were: "Grand Manan" (Canada); "Boneless Cod" (Canada); "Salmon Run" (Canada); "På jakt efter Fladensill" (Sweden).

Chapter 1

SCOPE AND RESULTS OF THE MEETING

OPENING SPEECH

By *Dr. Karl Evang,* Director-General of Public Health (Helsedirektør), Oslo, Norway

Mr. Chairman, Gentlemen. On behalf of the Norwegian Government, the Norwegian Nutrition Council, and the Norwegian FAO Committee, I have the great honor and pleasure to extend a hearty welcome to you to these two meetings which are taking place in Bergen under the auspicies of FAO, first the FAO Meeting on Herring Technology and after that the FAO meeting of Fisheries Technologists. The Norwegian Government has taken an active interest in the establishment of FAO from the very first day of its creation in Hot Springs, and has, as have many other governments of the world, attached a great deal of hope to the work of this Organization. Norway finds herself in an extremely unbalanced situation as far as food production is concerned, as she produces a large surplus of certain types of food, making her largely dependent on exports while the country must rely on imports for other kinds of food. Therefore it was not difficult in Norway to find understanding for the philosophy behind FAO, aiming at the creation of a rational food policy nationally and internationally. It was as a result of a Norwegian proposal that fisheries and forestry were brought into the scope of FAO. There is no reason to deny that Norway has watched with great anxiety and also some regret the difficulties into which FAO, as well as other parts of the United Nations machinery, has run. While I need not go into details on this point, I should say that we have been most favorably impressed by the way FAO has adapted itself to this difficult situation and in a flexible way developed both its central and regional organization. We have also noted its willingness to cooperate with related bodies within the UN machinery, and last but not least, we have been impressed by the way in which FAO has shown ability to get down to brass tacks to tackle the practical problems, large or small, as they exist in real life, and gradually has refrained from dealing with generalities only. The way, for example, in which this meeting, the first meeting in fisheries technology under the FAO auspicies, is organized to my mind means a very great step forward in international work.

This meeting is dedicated to some questions related to herring. It is perhaps natural that the meetings take place in this country, which is, I believe, at present the greatest single contributor to the world's supply of herring, producing close to 1 million tons a year. Theoretically, if this amount were distributed evenly, and under the assumption that one half of the need of animal protein of each individual were covered through herring, it would suffice for about 15 million people. The underfed peoples of the world are in need of animal proteins and fat, including fat-soluble vitamins. For awhile modern research gave us the hope that certain vegetable proteins might have the same value physiologically as animal proteins, but has now come to the conclusion that a certain minimum of animal proteins is indispensable in human nutrition. The fact that the number of amino acids, which are considered essential, has been cut down from about 22 to 8 does not change the basic point.

The problem which you are facing in the utilization of herring, that is, how to deal with this excellent raw material, handling it in such a way that it can be presented to a great number of consumers in a palatable and hygienically acceptable way, therefore, is a problem not only for the herring-producing countries but for great numbers of consumers as well.

You are meeting in the old city of Bergen, an old trading center, and an old center of the Norwegian fishing industry. One finds here all the different stages of the production, processing, and distribution of fish. Here one finds as in the middle ages, the fisherman himself bringing his catch, partly alive, to the market, bartering with the trained housewives of Bergen, discussing the advantages and disadvantages of each individual fish. On the other hand, if you visit the Norwegian Directorate of Fisheries you will find modern, central fisheries planning, administration, and research. If you go to the fish canneries, or the herring-meal factories, I hope you will be struck by their technical developments.

I am very glad that the question of palatability of herring products is included in your agenda. It requires the attention of nutritionists, technologists, and distributors. The question of nutrition is not only and perhaps not first and foremost a question of calories. It is of no use to supply calories if they are not given in a form which can be utilized. Great Britain, as you know, had the experience, during the last war, that the consumption of calories for certain groups of the population went down to precariously low levels in 1941. This was in spite of the fact that enough calories were available to each individual as bread was not rationed. I had an opportunity to eat that bread, and found it excellent.

Nevertheless it was necessary to bring into circulation a certain amount of calories in a more palatable form, to secure for the British people the amount of calories which they needed in their war efforts.

There are many problems relating to herring products which are still unsolved. We feel in the Norwegian Government that this meeting can and should contribute at least partly to the solution of some of them.

Finally, I feel convinced that the representatives of the various countries while looking into one detail of the vast nutritional problem of the world, will not lose sight of the broader and more significant context into which these details regarding herring utilization fit. This, unfortunately, is a world made up of rich countries, middle-class countries and poor countries. Unless we find ways to raise considerably the standard of living of the poor countries, ways of bringing food, as well as other necessary commodities, to the needy and hungry and sometimes even starving populations, especially in the East and South, there will be little possibility of eradicating the economic and political tensions which we now have seen grow with such disastrous effects. Therefore, if carried out in the right spirit, these two meetings, besides their technological value, will be part of the difficult efforts of FAO and other specialized agencies within the United Nations to secure peace. The very fact that meetings of this type take place show that according to the charter of the United Nations established in San Francisco in 1945, experts now have a better chance than they had before the last world war to play their part in securing peace. On very few occasions, it seems to me, have their contributions been more necessary than just now. At this moment the cool, rational voice of the scientist and the technologist will often be drowned by the emotional roar of many voices flinging incredible insults across the continents. Never should the scientist, the technologist, the expert let himself be carried away by hate, suspicion or other destructive forces of human nature which are so easily brought into light. As a private person he may, of course, have any political conviction, but as a scientist he has the privilege, I would say the duty, to carry out his work in a detached manner, with regard only to the truth, endeavoring to increase the amount of knowledge which we possess, and hoping that this knowledge may be applied in a peaceful and beneficial way.

With these words I welcome you to these meetings, express the gratitude of the Norwegian Government that you have come to this country, and the hope that this meeting, even if it only deals with one detailed item on the whole big agenda of the world's food-supply problem, nevertheless, will increase exchange of knowledge and understanding, thereby also making it possible to equalize the standard of living in the world. This is the only way in which we believe the future peace will be secured.

THE PURPOSE OF THE MEETING

By *Mogens Jul,* Chief Technologist, Fisheries Division, FAO

Delegates and participants in this meeting, Gentlemen. On behalf of the Director-General of FAO I thank Dr. Evang, the Chairman of the National Norwegian FAO Committee, Director-General of the Public Health Service of Norway and also, internationally, a very well-known person, last year chairman of the annual Conference of the World Health Organization, for his warm words of welcome. Through Dr. Evang, I thank also the Norwegian Government for its kind invitation to FAO to call this meeting in their country. I thank also the Norwegian FAO Committee for the good assistance given in the arrangement of this meeting and above all the Norwegian fisheries authorities, both the Fisheries Department and the Directorate of Fisheries and especially the Director of Fisheries, Mr. Klaus Sunnanå, who has himself, and through his staff, given the most generous assistance, without which this meeting could not have taken place.

I thank every person present because you have found it worth while to come here, thereby showing an active interest in the work of FAO. A special word of thanks goes to all those who have cooperated with us to such an extent as to prepare papers for the meeting. All this meant a great deal of extra work, often performed under stress, as time was limited.

You all know that FAO, as Dr. Evang pointed out, is the United Nations Organization which governments have created to look after the world's food problem. This is not a small problem in a world where at least one third of the population is undernourished, and hundreds of thousands are starving every year. It is a very real problem, as Dr. Evang also pointed out, especially as today the world seems to be almost aflame.

There are desperate populations in each of these undernourished countries; and desperate people may do desperate things. They need assistance. We hope they will join up behind the United Nations, and follow the United Nations' course of peace. Here, however, words are not enough. They must be given proof that the United Nations are willing to support them by action. You know that FAO itself is doing whatever it can within its means, but we have to admit that it is very little. You may know also that the United Nations are getting underway a program of technical assistance which also has the object of helping these populations. That may mean more. Also because it is something like that which is needed — something big, something which can really show that the United Nations are out to act, to help, not just to talk.

But to give help is a very difficult thing. The world food problem is not one that can be solved along sentimental lines. As Dr. Evang pointed out, it is clear to FAO that it is not enough to think of the consumers' needs for fod alone. True, there are needy populations in many places, but the simple fact remains that we cannot get food to them unless, in some way or other, we can get the food producer a proper return for his efforts. If the fish is going to be fished, if wheat is going to be grown, if cattle is going to be raised, it has to be profitable to the producer. Therefore, a very important part of FAO's job is also to assist food producers in the various countries. We must help them to get their products produced as well as possible and assist them in their distribution and sale.

It is a huge job which the nations have given to FAO. Compared with its magnitude, FAO is but a small organization. Somebody might say that an organisation with a budget of about 5 million U. S. dollars a year is large. It is as large as a middle-sized agricultural college. Such a college generally has to deal with the affairs within one small country, or maybe one province or one state. FAO has been given the task of doing the same job in the whole world. But it has been asked to do several things in addition. It has been asked to look after not just agricultural production, but also forestry and fisheries and nutrition; not just the scientific aspects of these, but the administrative, economic, and organizational ones as well. Therefore, what FAO can do is very limited. The Organization has only one hope. We must catalyze action. We must try to get nations together and to get their respective governments to help us do the things which should be done.

FAO must also try to get industry to help accomplish the immense task. The attendance of this meeting shows that this time we have been somewhat successful in this respect. When we look at the list of participants at this meeting it is a much longer one than we expected. We hope this indicates that you feel that here is an important job to be done. When one looks closer at the list of participants, it appears even more impressive because the group which is gathered here is a very qualified one.

At this point I would like to thank the Norwegian Government, and particularly the Fisheries Authorities because they have also contributed financially to this meeting. We appreciate this on two grounds. Firstly, because it actually is a great help. Secondly, and even more important, because it clearly indicates that the Norwegian Government realizes that FAO is too small to do its job alone and that your country is behind us and willing to help us. The development of that attitude among all nations gives hope for FAO that it may still accomplish the immense task in front of it.

You probably all know that this meeting really started in the Hague about a year ago. Experts among government officials, administrators, fisheries economists, *etc.,* gathered together and discussed the situation of the world's herring industry. They took note of the fact, which you will see stated in Mr. Gerhardsen's paper today, that at least at certain times and in certain places, there is a herring catch for which there seems to be no market. So they recommended that FAO, as one possibility, should investigate whether it would be possible to use some of this so-called surplus herring for food products that might be interesting for countries that at present are undernourished with regard to proteins, especially countries in Africa and Asia. This is one thing that FAO may have some qualifications for doing. Because FAO has a fisheries council in the Far Eastern area, the Indo-Pacific Fisheries Council, it is in a position to get pertinent information from that area. We have called this meeting in Europe to get people together in order to find out what has been done so far. We do not wish to start from scratch; we want to collect all the work which has been done towards this goal; we know, it is not insignificant. Once we have obtained that information, this meeting is designed to discuss what further possibilities there might be, what work should be done, and what action is needed.

Another recommendation from the Hague meeting was that FAO should call fisheries technologists together to discuss whether new or existing processes could be devised or improved which would create new markets for herring products or create new herring products for which there might be a potential market. FAO also took this second recommendation with great interest because it gave us a reason for calling a meeting of fisheries technologists. Such a specialized meeting of fisheries technologists from many countries has never been held before. You know that in the fisheries-biological field in this part of the world international scientific meetings have been held regularly almost every year for close to 50 years through the International Council for the Exploration of the Sea. The technologists have not had such meetings. It seems, however, that fisheries technology has now become of age, and that there are reasons for all of us interested in this field to get together to discuss our problems and possibly try to divide the huge field which lies befores us, try to divide the work, in order that we may perform it more effectively. It may as a result of this meeting be decided that such meetings should be held regularly. If that be the case, this meeting would be a historic occasion.

Some will question what fisheries technologists can do. We ourselves, probably more than anyone, know our own limitations, and realize that we can do only a small part of the total developmental work. However, if one considers herring industries as they were, say 50 years ago, what was there? Some distribution of fresh herring took place, but not very much because technical facilities, artificial ice, *etc.,* did not exist. Freezing and canning were practically nonexistent, herring meal and oil were produced only on a small scale. Some products, like fish solubles, have only been known for the last 5 or 10 years but yet have today attained very considerable importance. All those developments were technological developments. Therefore, technologists have been able to do a great deal. There are more of us today, and better means of cooperation. Therefore, we should be able to do more in the future. The development will take place step by step. There will be many failures, disappointments and setbacks. Nevertheless, if we can just keep the same pace as technology has done in the last 50 years, we will be doing very well indeed.

Development has not always been brought about by the most advanced fisheries experts, engineers, or chemists. We just as often owe important improvements to business men, plant foremen, and superintendents. We technologists must cooperate with all these people, and are, therefore, very happy to see the active interest which the fisheries industry is taking in this meeting. FAO does not can, freeze or smoke herring, nor do most of the governments. It is industry that does it. Therefore, if government technologists are to accomplish something, we have to be in as close contact as possible with industry itself.

There is another group we appreciate seeing here; that is a group of fisheries economists and fisheries administrators. It is quite obvious that no matter what technical product or process is discussed, it cannot be discussed intellingently unless one keeps an eye on the economic and administrative possibilities. There are a great number of things that are technically possible; but some of them may be too expensive or too difficult to organize. Here, the economists and administrators advice is invaluable.

We are also glad to see Dr. Evang, and other nutrition experts here. There are, as Dr. Evang pointed out, products that are technically and nutritionally good; but for some reason or other people do not like them and do not buy them. Therefore, we must cooperate with the persons who are in close touch with the consumers of food products.

There is then nothing left but for me to suggest that we, so to speak, roll op our sleeves and get to work with the technical part of this meeting. I hope that we at this meeting may concentrate on points where additional research investigations should be done, and that we will also be able to try to look into the future to see what products have special possibilities of development. If we concentrate on those two aspects, it ought to be possible for every one present at this meeting to go back with the knowledge that he had got something out of it, which made it worth while his attending. Research workers might feel that they leave with a better idea of the research they should carry out. If that could be accomplished, I think that this meeting will have done what it should, and I now call on the cooperation of all of you so that we may accomplish that aim. Thank you.

COOPERATION BETWEEN FISHERIES BIOLOGISTS AND FISHERIES TECHNOLOGISTS

By *Gunnar Rollefsen,* Director of the Norwegian Institute of Marine Research (Havforskningsinstituttet), Bergen, Norway, representing the International Councli for the Exploration of the Sea.

Mr. President, Gentlemen. On behalf of the International Council for the Exploration of the Sea, I will express the Council's gratitude for having been invited to this meeting, in which I have been greatly interested.

As a biologist I would recommend that all scientists dealing with the problems relating to the products from the sea should keep in contact with the marine biologists. We know that the animal life of the ocean, forming the raw material on which you work, is influenced by different factors causing variations both in quality and quantity. Besides this, fish is international in character, which in contrast to the forests and grain crops cannot be exploited within the boundaries of each country. Therefore, our work is international in scope.

Although the oceans are great, the men investigating the problems connected with the stocks of fish are few, I think it would be wise to cooperate with them, tell them about your problemes, and tell them how much you want to take from the sea. They can perhaps give you some advice. Thank you.

CLOSING SPEECH

By *Klaus Sunnanå,* Director of Fisheries, Bergen, Norway.

Ladies and Gentlemen. I wish at the close of this meeting to offer many thanks to the persons who have assisted us in making this meeting so successful. I must first apologize that, owing to pressure of work, I have not been able to attend the meetings as often as I wished to do. The loss is, I regret, mine. I thank especially Dr. *G. A. Reay,* the meeting's Vice-Chairman, because he has frequently taken my place and has conducted the meetings in my absence better than I could have done. I thank *Mr. Aglen* and Dr. *van den Broek* who have prepared the final report for this meeting. I also thank the Chief Technologist of FAO's Fisheries Division, Mr. *Mogens Jul.* We all know that he is the heart and the backbone of this meeting and of the international cooperation of the fisheries technologists. I also thank Mr. *Gerhardsen* and Mr. *Girard* who have attended the meeting and been of invaluable help here; Mr. *Imbert,* the interpreter; Mr. *Elliott,* who has conducted the recording system and Miss *Sparre,* who has carried the heavy microphone from speaker to speaker. I thank the persons who have prepared the papers, those who have read them, all who have participated in the discussion and all who have been interested listeners. I thank also my own people in the Directorate of Fisheries for the assistance they have rendered me, Mr. *Blich,* Miss *Hansen* and Mrs. *Haugsøen.*

Allow me then at the closing of this meeting to express some general remarks as to its value. I must admit that when I saw that the herring meeting in the Hague last year recommended FAO to convene a meeting of technologists to discuss the herring problems, and Mr. Jul later told me that FAO would very much like to have this meeting in Bergen, I was very doubtful as regard to its usefulness. You will here realize that, as Director of Fisheries, to be doubtful is my business. So many persons, experts and organizers present their proposals and plans to me. I have to be critical, and they must be able to convince me that their proposals and their plans are good. When Mr. Jul originally expressed his view to me I thought: Would it be worth while and right to assemble so many busy research workers, business people and experts? Would it justify the expense in staff, money and currency? I give in, Mr. Jul, I am convinced that the value of this meeting is evident. I think that you have reached that stage where the herring industries and the fisheries authorities in many countries are convinced that you can do very much to help industry and authorities in the future. If I am right, you will no longer be met with doubts such as I expressed to you, Mr. Jul. You may expect in the future that the industry and authorities will say to you "Hurry up, Gentlemen, do your best to help us." Of course, we are up against troubles and difficulties and crises in the herring industries. In that case, we will ask you to make available proposals as to how we can solve the problems for our country, for our people, for our fishermen, for our industry. That is an essential outcome from this meeting that I will have the right to return to you for effective advice in a more earnest way later.

I agree with Mr. Rollefsen that you scientists should keep together, have close contacts with each other and try to solve the problems in cooperation. We know hat recent years have taught all of us that the peoples of the world have to keep together, to cooperate, to solve the very difficult problems we are facing. This meeting, I am sure, has been of historical value by bringing the research workers together on a special problem, which may be of the greatest importance for the interested countries and for the whole world. With these words I wish to thank all of you for the time we have been together here. I hope that you have had a good time in Bergen, that you have also enjoyed this town, and I wish you a good journey home to your countries, to your laboratories, and to your work there. Thank you.

FINAL RECOMMENDATIONS

At the closing session of the meeting, the following conclusions were introduced by Mr. *A. J. Aglen,* Fisheries Division, Scottish Home Department, Edinburgh, Scotland, and adopted unanimously:

The meeting considered the recommendations made by the FAO meeting on Herring Problems at the Hague in 1949 in regard to developing new and improved herring products, which might be introduced into the diet of Asian and African peoples. It was felt that definite possibilities exist in these fields, and the meeting recommended that a cooperative study thereof be undertaken.

The meeting was also of the opinion that in the field of fisheries technology research workers were, in many cases, working on the same or very similar problems and recommended that FAO should study the possibilities of establishing further international cooperation between such research workers.

As most readers of this report will know, a special meeting was arranged for representatives from the governments participating in the meeting. These representatives fully endorsed the above conclusion and outlined how a committee for the cooperation between fisheries technologists might be set up. It elected an interim committee, consisting of Mr. Eirik Heen, Norway; Mr. Le Gall, France; Dr. Reay, United Kingdom; and Dr. van den Broek, the Netherlands. This committee would, in cooperation with FAO, proceed with the preparations for the etablishment of such a permanent committee. These preparations were in progress when this report was being printed.

Chapter 2

THE HERRING INDUSTRIES

THE UTILIZATION OF HERRING[1]

A paper presented by *G. A. Reay,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland.

The present world catch of herrings and allied species appears to be of the order of three and a half million metric tons, of which herrings account for at least two million tons, and thus, quantitatively, herrings are the most important species of commercial fishes. In addition to some 16 per cent of first-quality protein — which it has in common with the "white" fishes — it usually contains a considerable proportion of fat at the times when major catches are made. British-caught herrings, for instance, range in fat content from, say, 8 to over 20 per cent during the main fishing periods. At worst, there is always more fat present than in cod and allied species, which represent another major source of fish food. In addition, the vitamin-D content of the herring fat is not negligible.

By far the bulk of the world herring catch is taken in the northermost half of the Northern Hemisphere, all three continents being represented, Europe greatly predominating over the others.

From the FAO Report of the Herring Meeting held last year at the Hague, it appears that there is no clear evidence that there is overfishing of herrings; that the catching capacity of the fleets will soon have reached or exceeded the pre-war level; and that compared with pre-war, the catching capacity in some countries is already much greater and that the increases planned for the next few years, in some cases, are quite substantial.

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Department of Scientific and Industrial Research. Paper for Publication No. T. 50/24. Also published in "The Fishing News" (Reay 1951).

How best is this enormously important catch to be utilised? Two principles, it appears, should be kept steadily in mind. The first, which concerns production, is that the herring stocks should be fished to the maximum extent that marine biology determines to be permissible, having due regard to economic and social profitability. The previous Herring Meeting drew attention to the incompatibility with the aims of FAO of restricted production; and to the hardship such a policy would impose on fishermen and the resulting threat to capital invested in the fishing industry. The solution was to seek extended markets, to develop new techniques or processing, and to seek for means of lowering costs of production, transport and distribution. In consequence, it is the purpose of this conference to consider how the utilisation of herrings may be improved to meet current or likely future needs. It was pointed out, however, how urgently required for economic planning and optimum exploitations of the huge herring harvest is the further biological knowledge of the herring stocks and their fluctuations in magnitude and occurence as well as the discovery of better means of detection and more flexible methods of catching.

The second principle is that in the utilisation of the herring catch, wastage, in its broadest sense, whether in quantity or quality should be reduced to a minimum. The catch should be put to the highest possible grade of nutritional or social use. Thus, wherever possible, herrings or herring products, including by-products, should be used for direct human consumption rather than for feeding animals, or used for the latter rather than for fertilizing the land.

The broad picture of the present situation in the herring industry, although well known to you, may be briefly reviewed. For centuries in Europe, herrings were consumed "fresh", or at any rate unprocessed, only within areas near the ports of landing, whilst the rest — usually the major part of the catch — was processed almost entirely by heavy salting, combined sometimes with heavy smoking, and transported — mostly exported — over large areas reaching down to the Mediterranean. To a relatively small extent, sudden surpluses that could not be otherwise handled were no doubt used as animal food or as fertilizer, or simply "dumped" back in the sea.

During the present century, however, and apparently with accelerated speed since the World War I, the taste for heavily-salted and smoked fish has diminished in Europe, the chief market, in the face of an increase in the amount and variety of other foods. There has been a growing tendency to prefer more lightly-salt- or smoke-cured herrings, marinades, and chilled, frozen or canned herrings — in all cases products with less crude flavours and odours than the mediaeval ones. Such outlets, however, have not been rapidly enough compensating for the decline in the usual markets for the older types of cure, for which new markets have not to any sufficient extent been developed in other parts of the world. With the development of plant for cooking and pressing, oil separation and press-cake drying, much improved means became available for dealing with surpluses of herrings; which have consequently been converted into oil for nutrional or industrial use and into animal feeding meal. During the past thirty years a change has come over the industry, taken as a whole, at least as striking in magnitude as the collapse of the older curing practice. Although, as the Report of the Hague Herring Meeting avers, it would not be profitable to maintain or expand the herring industry wholly on the basis of reducing the fish to meal and oil, it is true that a very large, if not the major, portion of the world herring catch is today so treated. Particularly in countries where abundant supplies of relatively cheap raw material have been available, this new industry has grown apace, so that a very large proportion of the catch indeed is absorbed for this purpose.

A parallel development has occured in the case of other pelagic fisheries, *e.g.*, those for pilchard, menhaden, and in many instances the fishery is primarily conducted for the reduction industry. Of the annual pre-war production of fish meal (about 1 200 000 metric tons, equivalent to some 6 to 7 million metric tons landed weight), a small proportion was made from "white" fish or its offal; but the most of the meal and about 150 000 metric tons of oil was made from pelagic fatty fish (herring and allied species). Japan, together with Korea, Formosa and Sakhalin produced about 750 000 metric tons of meal, about two thirds of the world output, and accounted for the major portion of a huge catch. This enormous quantity, the product of some 6 000 small plants, was apparently used mainly as a fertilizer. While recent FAO statistics suggest that the Japanese industry is now practically at a standstill, the production of other major countries has recovered from the war and is still going up. Thus, in 1948, about 120 000 metric tons of pilchard and menhaden meal and 50 000 metric tons of oil were produced in U. S. A.; 30 000 metric tons of meal and 12 000 metric tons of oil in Canada; 110 000 metric tons of herring meal and 40 000 metric tons of oil in Norway; and about 20 000 metric tons each of herring meal and oil in Iceland. The total of 400 000 metric tons of meal would correspond to about two million metric tons of fresh herring and related species. Probably only a small proportion of this oil is used for the production of edible fat by hydrogenation, most being fed to animals or used in industry. Although most of the meal is used as animal feeding stuff, a substantial amount is used as fertilizer, *e.g.*, menhaden.

Although it seems to be true that, as compared with the other pelagic fishes, the products of herring reduction are put to relatively higher grade use — manufacture of edible fats and of animal foods — the very high proportion of the catch reduced, probably over half, points to the need to consider seriously the possibilities of developing on a large scale improved or new techniques for treating herrings, so as to obtain directly edible products that will meet the needs and tastes of consumers not only in the more sophisticated countries, but also the more backward regions of the world, *e.g.*, in parts of Asia and Africa, in most of which the populations are in great need of proteins of high biological value.

Consideration of the possibilities of selling herring products in countries undersupplied with proteins has rightly been chosen as a main item on the programme of this conference. Later speakers will develop this theme in greater detail, but a few points may be made here. There is no doubt that, as the FAO contend, the adoption of a nutritional policy in the backward countries as they become more enlightened is certain to be accompanied by a growing readiness to experiment with new food products, that could make good recognised deficiencies in the current national diet.

Possibly too much, however, can be made of the difficulty of creating new food habits. It can be held that the acceptability of new products is rather unpredictable, if only because individuals vary so much in readiness to try new products. Although it is a very readily understood and undoubtedly useful approach to study existing local products, as reflecting native tastes, and their modes of production and preservation, as indicating primitive methods of overcoming natural environmental obstacles such as high temperatures and humidities and pest infestation, it seems quite likely that some new product, of a kind quite different from any of the native cures, might prove more or less immediately acceptable to many of a population and would find rapidly increasing markets provided the price were suitable. It would be equally unwise to assume that a product simply because it conflicted with accepted taste in Europe or North America would be unacceptable in the more backward countries.

Native fatty fish, like herrings, are apparently acceptable in tropical countries after hard drying with or without some salting, often combined with hot smoking. The possibility of exporting similar dried cures in suitable packages to these countries, therefore, merits serious consideration and some experiments are already being made in this direction.

Before the World War II, quite a considerable amount of canned fish of a cheaper sort went to Asiatic, African and other tropical markets, and met with ready acceptance. Canning provides with a minimum of waste, a convenient ready-to-eat product. More important still in this context the container is durable and protective under most natural conditions encountered and the contents have a very long storage life, there being no obligatory need for special refrigeration in storage and distribution. Technically at least, canning would seem to offer perhaps the best solution of the problem of distributing fish in primitive warm countries, and its further possibilities in this direction should be thoroughly explored. With the need to provide a cheap product, making the most economical use of tinplate or aluminum, which are expensive items, packs of minced whole herrings from which some liquor has been expressed might well prove acceptable to some races, for example those accustomed to incorporating what animal protein they can acquire in hashes or stews. It is understood that experiments were carried out in U. S. A. with canned pilchard press-cake for relief feeding after World War II.

During World War II dehydrated minced, cooked fillets of herrings were produced on a small scale in United Kingdom for the Forces. At the same time, small samples were sent to various tropical countries and were favourably received, being in most cases eaten without prior reconstitution. Even dehydrated whole herrings were acceptable, if not preferred to the fillets. The cost of production including packaging of these products was rather high, although less than that of canning; but their good reception not only shows that new foods may win quick approbation, but suggests that a considerable part of the herring catch might successfully be upgraded from reduction to an animal-feeding meal to conversion into a dried, human food. Experiment might show that even the herring meal at present produced would, if suitably packaged at once for transport and preservation, be acceptable to backward races, as a protein supplement in their dishes. If this were not so, it might well prove possible without prohibitive rise in cost to make a more "refined" product for human food that retained the full nutriment of the herring, including the accessory factors now beginning to be recovered from the customary reduction process by concentrating the "stickwater".

Returning now to the provision of herrings and herring products for markets in the more sophisticated, well developed countries in Europe and elsewhere, it is clear that herring commodities must now face keener competition in delivered quality and price, because of the general amelioration of food supplies. It is not to be doubted, however, that herrings of the fine quality of much that is caught off North Western Europe, or products made from them, would compete more successfully with other foods, if the quality of the commodity reaching the consumer were to be improved, although with some increase in price.

In a later chapter ("Fresh Herring", pp. 164—185). Dr. Shewan and I have drawn attention to the fact that herring loses its freshness very rapidly, even in ice, and that this in our view accounts in considerable measure for a lack of popularity. Most of the consuming public do not know what a really fresh herring tastes like; and, consequently, they do not know what they are missing. To bring really fresh herring, however, to populations outside a very limitid area near the fishing ports demands the use of proper freezing and cold storage, when the possibilities of wide distribution become, technically at least, unlimited. Although, as the Report of the Hague Herring Meeting remarks, small consumer packs are finding favour in some places and might do so in many more, it would seem that more frozen herrings would ultimately be sold, if a cheaper, more mechanised, process were discovered that would yield compact blocks of, say, 10 kg (22 lb.), or even more, which could be thawed out by the retailer and the herrings immediately sold ready for cooking. As Dr. Banks indicates in the chapter "Freezing of Herring", pp. 190—216, experiments to this end are in progress in the United Kingdom. Such large blocks of fish would also be very suitable for storage awaiting further processing, such as canning and kippering, and might prove advantaeous in extending the working season and the use of plant.

Despite the appeal, actual and potential, of a really fresh herring of good fatty quality, it is true that a large proportion of the population prefer a processed product. Thus, in the United Kingdom, about three kippers are eaten for every two unprocessed herrings. Treatment in some degree with salt, acid, smoke, spices, sugar, *etc.*, apparently renders a rich fatty fish like the herring more palatable to many consumers. The Report of the Hague Herring Meeting rightly stresses the importance for this conference of closely examining the possibilities of improving such products, in which there is a growing interest, and of extending their consumption. Subsequent speakers will deal with this subject from greater experience; but it might be remarked here that these products are relatively perishable, as compared with canned or frozen herrings. In certain countries, preservatives are used which would not be admissible everywhere, because of legal restrictions of their use, which vary from country to country. Wide distribution of many such lightly-cured products would demand the use of chilling in storage and transport. For lightly smoked cures of the kipper or buckling type, even chilling permits only a very restricted area of distribution; but freezing or canning (with full processing) provide a solution. For export to countries long distances overseas, where modern tastes have developed, freezing and canning clearly would afford the most stable and suitable products.

Canning has already been mentioned in connection with its possible use in extending the export of herring products to protein-deficient areas. Its inherent advantages as a mode of preservation should, it cannot be doubted, ensure for it a permanent place in the processing and distribution of herrings destined for any market. Being a development of the modern scientific era, canning requires and receives management by well-equipped and skilled technologists. The canning branch of the fish industry, therefore, is probably more advanced in this sense than any other. For that reason, more may be expected from it in the way of successful experimentation to improve and diversify its herring products and extend their consumption.

Canning will be discussed in a later chapter, but the opinion may be ventured here that, apart from the possibility of making more attractive packs by using new recipes, improvement in palatability would almost certainly result from lighter heat processing, could this be safely achieved. In this connection, the pretreatment of the fish with suitable antibiotics seems to offer a useful field for investigation.

An attempt has been made as a preamble to this conference to indicate broad considerations that, it seems, should be kept in mind in deliberation, and also to draw attention to certain possible lines of development that, given the necessary technological, economic and social research, may lead the herring industry out of the present *impasse* and at the same time bring about a more satisfactory utilisation of the herring catch in supplying the world's needs.

REFERENCE

REAY, G. A.: The Utilization of Herring. *The Fishing News*, (London, England), 1951 No. 1980, pp. 8—9. 31 March 1951.

HERRING, THE RAW MATERIAL[1]

A paper presented by *Olav Notevarp*, The Royal Norwegian Technical College, (Norges Tekniske Højskole), Trondheim, Norway.

Introduction

At a meeting on the possibilities for better utilization and increased use of herring, it may be fitting to consider the available supplies of herring and similar species, and also the value of herring as food and as raw material for the manufacture of feedstuffs, oils, fats and other products.

The question of supplies of herrings and similar species is partly a

[1] Also published in "The Fishing News" (Notevarp 1950).

biological one, and I do not feel competent to estimate the future possibilities. I will, however, give some indications of the effect of fisheries and of restrictions in existing fisheries, to illustrate what quantities may be available.

The value of herrings as food is known by most fisheries technologists. However, a brief survey of the constituents of some of the more important species of the herring family is difficult to find, and may be of interest here.

The value of the herring species as raw material for feedstuffs, oils and other products depends mainly upon their content of protein, fat and other nutrients. However, the nature of the oil and constituents such as cholesterol will be mentioned, as they are important in connection with other uses.

The supplies of herring and similar species

Table 1. *Total landings of herring shown as annual averages*

	All countries	Europe	North America	Japan
	metric tons			
1930—34	3 776 000	1 409 000	666 000	1 701 000
1935—39	4 127 000	1 598 000	1 120 000	1 409 000
1940—44	3 206 000	1 054 000	1 133 000	1 019 000
1945—49	3 250 000	1 576 000	1 112 000	562 000

Note: Landings in U.S.S.R. are not included in these figures.
Source: FAO.

In *Table 2* the annual average landings of all fish and of herrings and similar species are given for principal countries for 1946—1950, and for 1938.

It will be seen that the catch of herring and similar species in such countries as Norway, Portugal, the Netherlands, Iceland and Sweden amounts to a very substantial part of the total catch. After World War II the United States and Norway had the largest landings of *Clupeidae;* from 1947 to 1949, landings by Norwegian fishermen were about 1 million tons. In 1950 a much larger Norwegian catch would have been possible if the processing plants had been able to take off the fish as fast as the fishermen could land them.

Spain is not mentioned above, but has important sardine and anchovy fisheries. The landings 1947—48 averaged 120 000 tons (Anon. 1949 A).

Table 2. *Total landings of fish, and landings of herring and similar species in 15 countries, 1938 and 1946—50.*

Country	1938			Average 1946—50		
	Total landings all species	Herring and similar species	Per cent [1]	Total landings all species	Herring and similar species	Per cent [1]
	metric tons 000 omitted		%	metric tons 000 omitted		%
Japan	3521	1128	32.0	3092	593	19.2
United States	2345	840	35.8	2394	835	34.9
Norway	1139	662	58.1	1212	741	61.1
United Kingdom[2]	1194	283	23.7	1100	222	20.2
Germany[3]	787	227	28.8	412	176	42.7
Canada	499	181	36.3	629	254	40.4
Newfoundland	375*	13*	3.5	309	43	13.9
Iceland	274	156	56.9	414	126	30.4
Netherlands	236	124	52.5	234	127	54.3
Portugal[4]	241	120	50.0	289	90	31.1
France[5]	479	116	24.2	389	84	21.6
Sweden[6]	144	77	53.5	195*	96*	49.2
Italy	195	60	30.8	176	51	29.0
Denmark[7]	106	15	14.2	229	31	13.5
Belgium[8]	43	7	16.3	71	25	35.2
Ireland	13	3	23.1	21	4	19.0
Total	11591	4012	34.6	11166	3498	31.3
Total minus Japan	8070	2884	35.7	8074	2905	36.0

Source: FAO, *Yearbook of Fisheries Statistics 1948—49* (Washington—Rome, 1950) and FAO files.

* FAO Estimates.

[1] Herring and similar species as per cent of total landings.

[2] Excludes Northern Ireland and (in 1949 and 1950) Isle of Man.

[3] Western Germany.

[4] Continental Portugal and adjacent islands.

[5] Continental France only, excluding Algeria and other overseas departments, 1946—50.

[6] Includes landings in foreign ports.

[7] Excludes Faeroe Islands and Greenland.

[8] May include landings by foreign fishing craft, 1938, and includes landings in foreign ports, 1946—50.

The landings of herring species in South America, Africa and Asia (besides Japan) are also considerable, and fishing has recently been developed very fast in some countries, *e.g.*, the Union of South Africa, where the annual catch of sardines now exceeds 100 000 tons. FAO has estimated the world's annual landings of herrings and similar species at more than 5 millions tons. This quantity might be substantially increased if modern fishing were introduced in certain areas where species of the herring family seem to be abundant, *e.g.,* along the coasts of Africa and India. More herrings might also be caught in the Northern Hemisphere, if the fishing possibilities were fully utilized and the processing plants were able to take care of the herrings at reasonable cost. Countries such as the United Kingdom and Norway have recently been forced to restrict their fishing because the markets or the processing plants were unable to absorb more. Thus, as herrings and similar species offer an abundant source of raw material, improvements in the utilization of the catch are likely to be much more important than efforts directed solely towards increased landings.

This situation is illustrated by some figures given in FAO Fisheries Bulletin (FAO 1948). From reported landings of more than 3 million tons in 20 countries in 1946 only 1.1 million tons were used for human consumption. In the last years the situation has been even worse because the demand for food has been decreasing. The Norwegian winter-herring fisheries in this year's season give an illustrating example. The amount used for food was only half the amount used for this purpose the year before; 82 per cent had to be used for oil and meal production. This high figure is to some extent explained by the fact that the expansion of the Norwegian herring fisheries has been based upon the oil and meal industry, which normally has taken care of 60—70 per cent of the catch.

The meal and oil rendered from herring and similar species have in recent years given a fair return for the fish. These have proved to be products of high value; a substantial part of the oil is refined and transformed into edible oils and fats.

However, the high nutritive value of the fish is far better utilized when the herring is used directly for human consumption; the first goal for better utilization of herrings and allied species, therefore, should be to have more of them used for food products. This may be clearly illustrated by facts about the nutritive value, which I shall try to survey in the following chapter.

Nutritive Value of Herring and Similar Species

The species of fish belonging to the herring family have some characteristical properties in common, *e.g.,* their protein, fat and vitamin-D content in the body oil. Analytical data in the literature regarding the sardines (pilchards), menhaden and herrings caught along the coast of North America are, however, very scarce, and it has been difficult to find reliable information about their composition. My details about the food value are therefore mainly restricted to European herrings, especially to herrings caught off the Norwegian coast.

As various types of herrings differ in their characteristics, it is advisable to describe some of the most important ones:

Norwegian winter herring: "Storsild", early-caught, mature herrings, weight 200—350 g. (7.1—12.3 oz.), containing roe and milt. "Vårsild", later caught, mature and spent herrings of the same type.

Norwegian fat and small herring: Immature herrings. Fat herrings, weight 50—200 g. (1.8—7.1 oz.), and small herrings, weight less than 50 g. (1.8 oz.).

North Sea herring: Mature and immature herrings, weight 100—250 g. (3.5—8.8 oz.), mostly caught as immature herrings.

Scottish herring: North Sea herring and herrings caught off the coast of West Scotland and Shetland. Mature and immature herrings of different sizes, mostly immature, weight 100—200 g. (3.5—7.1 oz.).

Icelandic herring: Mostly large adult herrings without roe and milt, weight 250—300 g. (8.8—12.3 oz.), caught off the coast of North Iceland in July—October.

The most important herring species in North America are probably the Newfoundland and Canadian Atlantic herring, the British Columbia herring and the Alaska herring.

The important part for food uses of all these herring species is the fillet or the edible flesh. Roe and milt from mature herrings, *e.g.,* from the Norwegian "storsild", are also to some extent utilized as food, and as food products.

The edible-flesh portion of the different species may vary from 55 to 70 per cent the yield of fillets from 40 to 55 per cent. The highest fillet yield is obtained from the large Icelandic herrings and from large, fat, immature herrings, the lowest from mature herrings containing much roe and milt, and from small and lean herrings.

The approximate content of the most important nutrients in some of these species and in flesh of sardines and menhaden is shown in *Table 3.*

It should be emphasized that individual variations in the composition, especially in fat content, may be greater than shown in the table, which

Table 3. *Approximative composition of herring flesh.*

	Protein	Fat	Phosphatides	Ca.	P	J	Vitamins A	Vitamins D	Vitamins B_1	Vitamins B_2
				(in ash)						
	g/100 g		%	mg/100 g			I.U./100 g		mg/100 g	
Norwegian winter herring:										
Storsild	17-18	12-15	1.1	100	270	0.06	400	1500	0.04	0.24
Vårsild	17-18	8-12	1.1	100	250	0.06	400	1500	0.05	
Norwegian fat herring	17-18	8-20	0.8	40	250	0.07	400	1500	0.05	0.23
Norwegian small herring	16-17.5	3-15	0.8	40	200	0.07	400	1000	0.05	
North Sea and Scottish herring	16-18	5-18								
Icelandic herring	16-18	12-20					(500)	(2500)		
British Columbia herring	14.5	10.5					100	350	0.05	0.11
California sardines	(17-20)	10-20						(1500)	0.023	0.22
Menhaden	(18-19)	5-15						(1000)		
Herring roe, Norwegian	22-27	1.5-2	4-4.5	10	200	0.015				0.22
Herring milt, Norwegian	17-22	2.5	2-3.5	10	200	0.01				0.23

Sources: Norwegian herring: Notevarp (1949); North Sea and Scottish herring: Lovern and Wood (1937); British Colombia herring: Bailey (1942); Menhaden and California sardines: Stansby (1947), Bradley (1942), Manning, Nelson and Tolle (1931).

gives the approximate mean values for fish caught in different seasons. Fillets from individuals in the same catch have been shown to have a fat content varying from about 3 to 19 per cent (Notevarp, Baalsrud 1942). Similar variations in the individual compostion may be common for most fishes and wild animals, but the majority of the individuals are normally close to the approximate mean values.

Table 3 shows that herring flesh contains about as much protein as other common fishes. It is also a good source of fat and fat-soluble vitamins, especially vitamin D. The mineral content is high, and the riboflavin (B_2) content fair. The content of other vitamins of the B-group is appreciable, as indicated by recent determinations carried out on stickwater (Lassen, Bacon 1946). The animal protein growth factor, B_{12}, should be mentioned as important in this connection. I have no figures for herring flesh, but the values reported for stickwaters may indicate that the flesh contains this factor (Ney, Tarr 1949). The high content of phosphatides should also be mentioned. Analysis of the amino-acid composition of herring protein has shown that it contains all the essential amino acids in favorable amounts, and that it a first-class protein (Deas, Ney, Tarr 1948).

Altogether, herring flesh is of outstanding food value. It compares favorably with the best flesh of other fat fishes such as mackerel, flounders, halibut and salmon, and no other ordinary food contains as much vitamin D as herrings and fat fish. As compared with most fish and meat, herrings are by far the most inexpensive and the low price of herrings and similar species may only be explained by their abundance. The herring species, therefore, may be used for furnishing protein and fat for man at very reasonable prices.

Consequently it may be emphasized that an increased utilization of herrings as food is of at least as great interest to consumers as to the fisheries industry.

The Value of Herring and Similar Species as Industrial Raw Material

The value of herrings and similar species as industrial raw material has hitherto been based mainly upon their content of protein and oil. These components are likely to be the most important in the future too, but research has shown that these fish contain other valuable components which may increase their value as industrial raw material. Such components are, as mentioned above, vitamin D, cholesterol, choline and vitamins of the B-group such as the animal protein growth factor. The oil has been shown to have a composition which may make possible more profitable utilization than before, *e.g.*, by means of fractionation and proper chemical conversion to edible oils and drying oils.

As for the fillets of fish of the herring family, the fish show relatively small variations in their average protein content, which normally lies between 15 and 18 per cent. The fat content, as mentioned above, shows greater variations. The average fat contents of the stocks are different, and the content depends for each stock upon the size of the fish and varies with the seasons. Because the oil may represent half or more of the value of the fish for industrial purposes, the variations in fat content will be considered more closely.

The seasonal variation of fat in North Sea and Shetland herring was determined by Lovern and Wood (1937) and in North Sea herring by Mygind (1949). Data on variations in Norwegian fat and small herrings were published by Bull (1910, 1915), Lexow (1925) and Notevarp (1949). All of these investigations show that *immature* herrings from the North Sea region and along the coast of Norway have their highest content of fat in July—August, ordinarily 12—20 per cent according to size. There is then a steady decrease during the months September to February, the lowest fat content being normally observed in March—April, when it frequently is down to 5 per cent for large herrings and 1 per cent for the smallest ones. In May and June the fat deposit is quickly restored, reaching its maximum in July. In Norway, this cycle has been followed during the last 9 years by determinations of fat in samples from most of the fat and small herrings delivered to the Norwegian meal and oil factories.

For mature herrings the picture does not seem to be the same. For many years, the Norwegian winter herring has, from the middle of January to the middle of February, ("storsild") averaged 14 to 11 per cent fat, and the decrease in fat content during a month has been about 1 per cent. The later-caught winter herring ("vårsild") has averaged about 8.5 to 9.5 per cent in the last part of February and about 8 to 9 per cent in the last part of March, when they are spent. The fat content of these types at other times of the year has not been determined, as their living places are unknown.

Scottish autumn spawners have been found to have their highest fat content in July, Scottish spring spawners in October—December (Lovern, Wood 1937).

The fat content of the large Icelandic herrings in the fishing season July—October, is fairly constant, between 16 and 20 per cent, although there is some decline towards the end of the season. Data for the fat content of this stock outside the season are not known to the writer.

Analytical data for California sardines have been difficult to find. However, yields of oil in the meal and oil factories indicate the average fat content, and calculations for 1940—46 show 17 to 20 per cent in the Monterey—San Francisco area, 10 to 14 per cent in the San Pedro area and 8 to 12 per cent in the San Diego area. In the poor seasons 1946—47 and 1947—48 the fat content was extraordinarily low in the districts first mentioned (Anon. 1949 B).

The yields of oil from menhaden also indicate a decrease in fat content from 10—12 per cent in the northern districts, New Jersey and New York, to 5—8 per cent in the southern ones, North Carolina and Florida. In Mississippi and Texas the values quoted for the oil yield correspond to fat contents of about 10—13 per cent (Tressler 1940, Anon. 1949 C).

From the variations mentioned here, it is easy to see that the fattest stocks of herrings and similar species, as raw material for oil and meal production, demand prices at least twice as high as those for the leanest ones. When stocks are likely to be limited, it should accordingly be sound economy to try to land as much of the fish as possible when they have their highest fat content, and to restrict fishing in periods when the fat content is at a low level.

The slight differences in the content of protein or solids may also influence the value of the fish, because the yield of meal by the ordinary wet rendering process, may be 20 per cent from fish containing most solids, such as early Norwegian winter herrings, and down to 17 per cent or less from small herrings.

It is generally realized that the value of herrings as raw material for oil and meal production depends upon their freshness. When the fish spoil, the proteins are partly broken down to water-soluble substances, the expression of oil is more difficult and yield of meal decreases. The solubles may be recovered as concentrated stickwater or by dry rendering processes, but the value of the product may be diminished. The worst effect of the spoilage may, however, be the decrease in oil quality, by the rise of free-fatty-acid content and darkening of the oil. Other constituents such as essential amino acids and phosphatides may also be partly destroyed.

The importance of the freshness of fish which are used for food or food processing is obvious to all technologists working in this field, and I have not found it necessary to give prominence to that fact here. When it comes to fish as raw material for oil and meal production, the requirements have been far less strict. It should be emphasized, however, that even slightly spoiled fish are liable to give products of lower commercial value. In addition, the nutritive value of the meal may also be diminished to a higher degree than has been realized up to now. For instance, determinations of choline by Jebsen (unpubl.) at The Norwegian Directorate of Fisheries, Chemical-Technical Research Institute indicate higher contents of choline in meal from fresh herrings than from partly spoiled ones, and investigations by Lassen, Bacon and Dunn (1949) have shown destruction of essential amino acids in spoiling stickwater.

The decrease in the choline content of the meal may be explained by the fact that the phosphatides are broken down when fish spoil, which has been shown by Baalsrud (unpublished). The fate of the choline during spoilage and processing is not clarified, but considerable amounts are likely to disappear during the drying process.

The importance of the choline content of the meal may be demonstrated by the fact that ordinary meal, rendered from winter herrings by the wet process, may contain 3—5 g. choline/kg. meal, dry-rendered about

5 g./kg. According to the prices paid for choline chloride for poultry feeding, the value of this should correspond to about 2 to 3 cents per kg.meal. Mature herrings contain more choline because the roe and milt contain 3—4 times as much as the flesh. The values are about 0.14 per cent for Norwegian winter herrings and a little more than 0.1 per cent for Norwegian immature herrings. The greater part of the choline content of the herring is found in the meal and only about 5 per cent in the oil. The stickwater from fresh herrings contains about 20 per cent, as determined in concentrated fish solubles. Reliable corresponding figures for stickwater from spoiled herrings are not known to the author.

The effects of the spoilage of the fish upon the proccessing, upon the yields and the value of the products, and upon the nutritive value of the meal, show the importance of improved preservation of herrings which have to be stored before they are processed. Efforts are now being made in Norway to improve the preservation of the large seasonal landings, of which very much has to be stored for weeks before the plants are able to finish processing. New preservation methods are being developed; large-scale experiments have been carried out and larger ones are planned for the next winter season.

Besides protein, fat and choline, fish contents of vitamin D, riboflavin and the animal protein factor are of significance for the herring meal, and for condensed fish solubles. The vitamin D is contained in the oil, and the oil contained in the meal withholds a corresponding amount, about 50—100 I.U./g. oil, which may be conserved in the meal for months if the meal has been properly dried. About half of the riboflavin content of the herrings is retained in the meal by wet rendering, the other half is retained in the stickwater. By dry rendering, the riboflavin and the vitamin B_{12} are retained in the meal, and considerably enhance its food value.

The contents in herring and similar species of vitamin B_{12} (animal protein factor) are not known to the author. Nor is the fate of this factor by wet processing known, but the following values are given for concentrated stickwater by Ney and Tarr (1949):

Alaska herring	0.31 mg. B_{12}/lb. solids	(0.68 mg/kg)
Norwegian whale.	0.14 —»—	(0.31 —)
Menhaden.	0,13 —»—	(0.29 —)
California sardine	0.20 —»—	(0.44 —)
British Columbia herring, local. . . .	0,081 —»—	(0.18 —)

For concentrated stickwaters from Norwegian winter herring values of 1—1.3 mg/kg solids have been reported (Sildolje- og Sildemelind. Forsk.inst. 1950). This high content may be due to the roe and milt.

Unfortunately, information on values of meal from herring and similar species are lacking. Taking into account the high price for vitamin B_{12}, the content of this vitamin in the fish and in the products made from them should add substantially to their value.

The Oils of Herring and Similar Species

The oils of the whole fish consist of about 99 per cent glycerides and 1 per cent unsaponifiable matter which contains 60 to 80 per cent cholesterol, and vitamins A and D corresponding to about 100—250 and 50—100 I.U./g.oil, respectively.

Several figures for the vitamin-D content of oils from various species may be found in the literature; the content depends for each variety upon the size of the fish and their fat content, because oils from lean fish are likely to contain more vitamin D than oils from more fatty fish of the same kind. Systematic investigations on this point are, however, incomplete or lacking, and I shall here refrain from detailed discussion and references.

Until now these oils have been valued mainly as glycerides although they have been used to some extent as sources of vitamin D_3 in the same way as cod-liver oil. The last-mentioned use may however decrease, because the price of vitamin D_3 has dropped to a low level owing to its production from cholesterol. The possibilities of extracting vitamins D_3 and A from the oil before its use as glycerides for industrial purposes or before refining to edible oils or fats have, therefore, lost much of their economic feasibility.

The situation might be difficult if the cholesterol of the oils was extracted and taken care of together with the vitamins. Ordinarily the oils contain 0.6 to 0.8 per cent cholesterol; in oil from Norwegian winter herrings about 15 per cent of the rest of the unsaponifiable matter are hydrocarbons and 5 per cent higher alcohols (according to unpublished investigations at the Directorate of Fisheries' Chemical-Technical Research Institute, Bergen, Norway, and the Institute of Technical Organic Chemistry, The Royal Norwegian Technical College, Trondheim, Norway). For oils extracted from fish meals, Beatty (1948) has found 7—24 per cent unsaponifiable matter containing 65—90 per cent cholesterol. Because the price of cholesterol is said to be about 2 cents per g., the extraction of the cholesterol together with the vitamins should have considerable commercial possibilities; according to Lassen (private communication) cholesterol is now commercially produced from sardine oil.

The values of the oils for edible purposes, and as industrial oils, are based upon their glycerides, the nature of which is important for the use of the oils for these purposes. For hydrogenation to edible fats, less unsaturated oils lend themselves better than highly unsaturated ones; for use for drying oils the latter are much more preferable. The iodine values of the oils give some indication of their suitability for these purposes, and the different species show characteristic differences in this respect:

	Iodine values		
Menhaden oil	150—190 (a)	—	150—170 (b)
California sardine oil	160—190 (c)	—	160—183 (b)
European sardine oil	160—190 (a)		
Japanese » »	170—190 (a)	—	173—189 (b)
Herring oil			105—128 (b)
Norwegian winter-herring oil	115—135 (d)		
Norwegian small and fat herring oil	125—160 (d)		

Sources: (a) Tressler 1940
(b) Williams 1950
(c) Brocklesby 19. .
(d) Notevarp 1949

It has been shown by Lexow (1925) that there is a relation between the oil content and the iodine value in Norwegian small and fat herrings, the fattest fish showing the highest unsaturation of the oil.

The amounts of the different fatty acids in the oils and their chemical nature are also important for the evaluation of these raw materials. The oils are characterized by their high content of highly unsaturated fatty acids; 30—50 per cent may average 300 in iodine value. At the same time, they show a relatively high content of saturated fatty acids; 20—25 per cent according to the survey given by Hilditch (1947). From Norwegian winter herring oil, with iodine value 120, a fraction of 25 per cent having an iodine value of 308 has been isolated, while 30 per cent of the acids from this oil averaged 33 in iodine value. (Unpublished investigations at the Institute of Technical Organic Chemistry, the Royal Norwegian Technical College, Trondheim, Norway).

These mixtures of highly unsaturated and saturated fatty acids may be utilized by fractionation according to saturation. The glycerides, however, contain fatty acids of different degrees of saturation in the same molecule. Splitting of the glycerides or de-esterification must therefore be accomplished before any good fractionation is possible. The glycerides or acids of high unsaturation may furnish raw material for drying oils of high value, while the less unsaturated may be used for edible oils and fats.

Summary

The landings of herrings and similar species represent an abundant source of raw material of high value; possibilities of increased landings should be very good. However, in spite of their very high food value, less than ⅓ of the worlds catch of these fish is at present utilized directly for food. Besides first-class protein and fat, the flesh contains appreciable amounts of choline, vitamin D, riboflavin, animal protein factor, iodine and other important minerals, and fair amounts of the other vitamins of the B group and vitamin A. The nutritive value of these inexpensive fish is in fact outstanding. No other animal raw material furnishes protein, fat, and the other nutrients mentioned, at prices as low as those paid for herrings to the original producer, the fisherman.

In addition, herring and similar species are very valuable raw materials for protein-rich feed meals, which also contain appreciable amounts of other important nutrients, *e.g.*, choline, riboflavin, animal protein factor and vitamin D, and for edible fats and oils, and may be a very good source for cholesterol, vitamin D, and for drying oils for paints and varnishes.

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CONTRIBUTIONS TO THE STUDY OF FLUCTUATIONS IN A FISH STOCK

A paper[1] presented by *Finn Devold*, The Norwegian Institute of Marine Research (Havforskningsinstituttet), Bergen, Norway.

At the end of the last century ichtyologists became more and more interested in age determinations of fish. In 1903 the Norwegian zoologist Dr. *Broch* (1908) discovered that the scale of the herring could be very conveniently used for age determination. The late Professor *Johan Hjort* and Professor *Knut Dahl* were very interested in this matter, and regular collecting of herring samples for this purpose started in Norway in 1907. In 1909 Mr. *Einar Lea* took charge of the

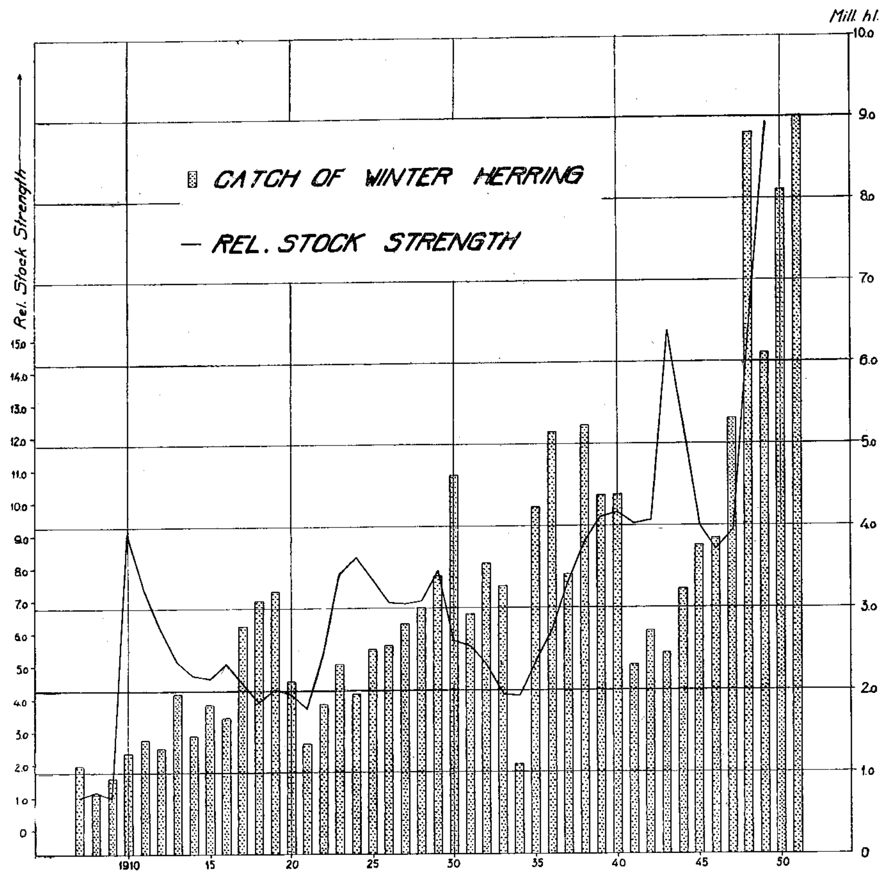

Fig. 1. *The calculated fluctuations in "The Tribe of the Norwegian Herring", and the total landings of winter herring in Norway the respectiwe years.*

[1] This paper has also been published in "Rapports et Procès-Verbaux des Réunions", February 1951 (Devold 1951).

herring investigations, and he continued and extended the collection of samples, so that we now have uninterrupted records of the age composition in the tribe of Norwegian herring for the last 42 years.

Professor *Hjort* and Mr. *Lea* were very interested in calculating the fluctuations of the stock; and when samples had been collected over a series of years, Mr. *Lea* worked out a method for calculating the mortality and fluctuations, a method which is described in his paper "Mortality in the Tribe of Norwegian Herring" (Lea 1930).

Figure 1 demonstrates the calculated fluctuations in the stock from 1907 until 1949. It also shows the output of the winter-herring fisheries over the same period. Broadly speaking, the calculated stock has steadily increased during this period, and at the same time the output of the fisheries has also been steadily increasing.

As far as I know, no objections to *Lea's* formula have been published, and we have felt very safe every year when presenting prognosis of the herring stock for the coming year's fishery, based on such calculations.

In the last years the present author has been responsible for these forecasts and has, therefore, felt it necessary to examine the reliability of our calculations. According to *Lea,* it is possible to calculate not the real number of herring, but the proportion of the increase or decrease, taking the stock in one of the years as unity.

Mr. *Lea* has chosen the year 1907 as unity, and from Figure 1 we see that the calculated stock has grown to about 17 in 1948, and if we calculate the year 1949, we find that the stock is 21.5 times the size of the 1907 stock. The tribe of the Norwegian herring contains, without doubt, milliards of herrings. At the same time, a very simple calculation gives us the result that 100 herring fishermen, operating with purse seines, are killing during a season as many herrings as 20 000 fishermen in the Lofoten area are killing cod.

During the last few years the herring fisheries have been expanded to such a degree that the annual landings have increased to about 3 times the average catch 1907—1942, and it is very important to determine if this expanded fishery has diminished the stock.

The application of *Lea's* formula demonstrates definitely that it has not.

Table 4. *Age distribution in the Norwegian spring herring.*

	Age							
Year	3	4	5	6	7	8	9	10
1946	0.5	3.7	4.4	7.4	5.6	17.2	25.8	3.2
1947	3.7	20.5	4.3	3.1	5.3	3.9	15.3	17.6
1948	0.2	20.1	46.5	2.9	1.6	1.5	2.2	8.2
1949	0.2	3.9	35.6	39.0	1.7	0.9	1.1	2.1

Year	Age 11	12	13	14	15	16	17	18
1946	5.9	15.9	5.4	2.1	2.1	0.7	—	0.2
1947	2.6	6.2	10.3	3.4	2.4	2.4	0.6	—
1948	7.9	1.0	2.4	3.1	1.4	0.8	0.2	—
1949	4.6	5.0	0.9	1.2	2 6	0.7	0.5	0.2

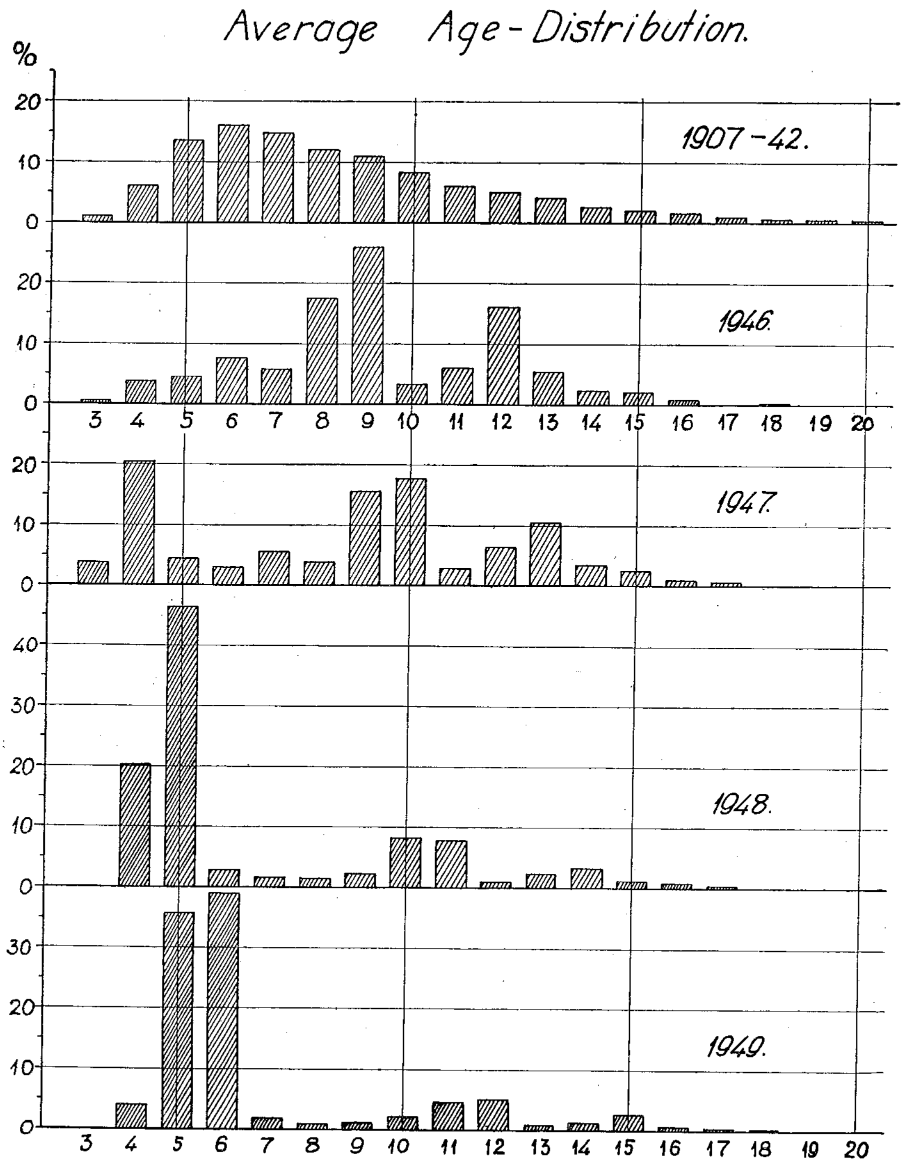

Fig. 2. *The average age distribution in "The Tribe of the Norwegian Herring" in the years 1907—1942, and in the last five years.*

Table 4 and *Figure 2* show the age distribution of the Norwegian spring-herring stock in recent years. In *Figure 2* the first columns demonstrate the average age distribution from the year 1907 to 1942. The following columns give the age distribution for the respective years. It seems as if 2 very strong year-classes, born in 1943 and 1944, have entered the Norwegian tribe of herring. These 2 year-classes in 1948 constituted about 67 per cent of the entire spawning stock, and in 1949 they constitute about 75 per cent.

It is easy to calculate that each of these 2 year-classes is about the same size as the famous 1904 year-class, which according to *Lea's* calculations, was able alone to make the total tribe of the mature Norwegian herring more than 9 times as numerous as it had been before this year-class entered the spawning stock. But we will examine his formula and see if such calculations are reliable.

Instead of using the unknown number of the enormous herring stock, we will build up a theoretical stock where all factors are known and kept close to all suppositions on which *Lea* has based his formula. *Table 5* gives examples of such stocks. We are presuming that the stocks are kept under such conditions that all factors can be controlled, as in an aquarium.

In *example 1* the real number of individuals comprising the year-classes from 3 up to 6 years old is 1000, of 7-year-old fish there are also 1000, and the following age-groups are reduced by 20 per cent. We will, in the same manner as *Lea,* exclude the year-classes older than 16 years. The total number of individuals in the aquarium will consequently be 5464.

The corresponding age distribution in numbers per thousand is given in the column to the right. *Lea's* formula for calculating the fluctuations is

$$\frac{(a_7 + a_8 + a_9 + \dots\dots + a_{15})}{b_8 + b_9 + b_{10} + \dots\dots \quad b_{16}} \varsigma = \frac{A}{B}.$$

ς indicates the proportion of fish which survives from one season to the next, as a mean of the years taken into consideration. A and B is the real number of the stock in two consecutive years. If within a year we remove from our aquarium 20 per cent of all year-classes, and at the end of the year also put into the aquarium so many recruit fish that we get the same number as the year before, it is easy to see that the nominator and the denominator in the formula will be equal—in other words no fluctuation has occurred. *Lea's formula in this case gives the correct picture of what has happened.*

Table 5. *Theoretical stocks.*

Stock $\varsigma = 0.80$		Age Distribution (per thousand)	
Example 1.			
$A_3 + A_4 + A_5 + A_6$	= 1000	$a_3 + a_4 + a_5 + a_6$	= 183
A_7	= 1000	a_7	= 183
A_8	+ 800	a_8	= 146
A_9	= 640	a_9	= 118
A_{10}	= 512	a_{10}	= 94
A_{11}	= 410	a_{11}	= 76
A_{12}	= 328	a_{12}	= 60
A_{13}	= 262	a_{13}	= 47
A_{14}	= 210	a_{14}	= 39
A_{15}	= 168	a_{15}	= 31
A_{16}	= 134	a_{16}	= 25
ΣA	= 5464		1002

Example 2.			
$B_3 + B_4 + B_5 + B_6$	= 1000	$b_3 + b_4 + b_5 + b_6$	= 693
B_7	= 100	b_7	= 69
B_8	= 80	b_8	= 55
B_9	= 64	b_9	= 44
B_{10}	= 51	b_{10}	= 35
B_{11}	= 41	b_{11}	= 28
B_{12}	= 33	b_{12}	= 23
B_{13}	= 26	b_{13}	= 18
B_{14}	= 21	b_{14}	= 14
B_{15}	= 17	b_{15}	= 12
B_{16}	= 13	b_{16}	= 9
ΣB	= 1446		1000

Example 3.			
$B'_3 + B'_4 + B'_5 + B'_6$	= 10000	$b'_3 + b'_4 + b'_5 + b'_6$	= 693
B'_7	= 1000	b'_7	= 69
B'_8	= 800	b'_8	= 55
B'_9	= 640	b'_9	= 44
B'_{10}	= 512	b'_{10}	= 35
B'_{11}	= 410	b'_{11}	= 28
B'_{12}	= 328	b'_{12}	= 23
B'_{13}	= 262	b'_{13}	= 18
B'_{14}	= 210	b'_{14}	= 14
B'_{15}	= 168	b'_{15}	= 12
B'_{16}	= 134	b'_{16}	9
$\Sigma B'$	= 15464		1000

In *example 2* we have removed 90 per cent of the fish 7 years of age and older. The resultant age distribution is presented, and by calculating the fluctuation by means of *Lea's* formula we find that the stock has been augmented 2.67 times. *In reality it is reduced from 5464 to 1466.*

In *example 3* we have the same age distribution as in our first example as far as fish of 7 years of age and older are concerned, but the recruiting stock comprising the year-classes 3 to 6 years old now number 10 000 instead of 1000.

The age distribution in numbers per thousand is just the same as in example 2, and by using *Lea's* formula we find that the increase of the stock from example 1 in this case is also 2.67. *Actually the stock has increased from 5 464 to 15 464.* — The explanation is that *whether a fish stock receives an unusually great number of recruit spawners, or whether the taxation has greatly increased, the age distribution may be the same.* — Every time we discover a fluctuation in a fish stock by use of *Lea's* formula, we are therefore confronted with the problem: is the fluctuation due to a higher mortality, or are the recruiting year-classes stronger than normal?

The strange age composition we now have in the mature stock of the Norwegian tribe of herring, may, in other words, indicate that the stock has received a very strong recruitment during the last two years. On the other hand we may make ourselves advocates for the opposite view and postulate that the recruit spawners are only medium-strength year-classes. The fishermen's efficiency in catching the herring has in fact greatly improved in recent years, and the enormous quantities of herring killed during the years after World War II may have resulted in such a great proportion of the older herrings being removed that we may regard the strange age distribution as a result of the greatly intensified fishing.

Mr. *Lea* has used the great fat-herring fisheries in 1907—1909, which were based chiefly on the 1904 year-class, as a proof that this year-class was really very strong.

We shall now try to see whether the 1943 and 1944 year-classes have given great yields when the small-herring and fat-herring fisheries were founded on them.

Figure 3 shows the total landings in Norway of the small-herring and fat-herring fisheries over the last 50 years.

The small herring consist of the age-groups 0 and I. We should therefore have had a very good small herring fishery in the years from 1943 to 1945. As seen from Figure 3 this was not the case. The fat herring consist of the age-groups II to V, mainly 3- and 4-year-old herring. We might, therefore, have expected a very good fat-herring fishery in the years from 1945 to 1948. But during these years our fishermen have taken an unusually small quantity of fat herring. — I am

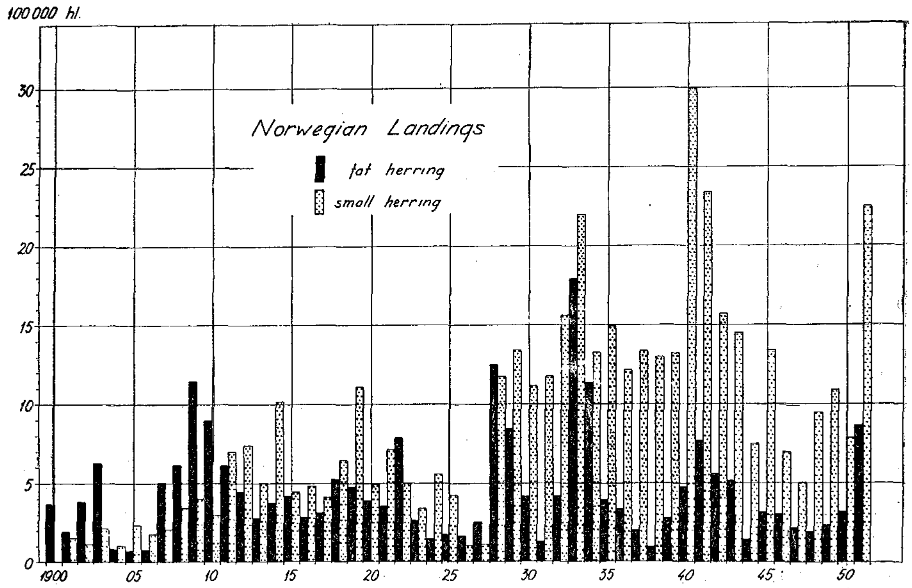

Fig. 3. *The total Norwegian landings of small and fat herring in this century.*

quite aware that the output of the fat herring fisheries is very irregular, and it is impossible in my opinion to draw any safe conclusion about the stock from the output, but at any rate the output of the fat-herring fisheries does not support the theory that the stock has received a strong recruitment.

Another result of a decrease in the stock should be that the older herrings especially would become more scarce. Mr. *Fridriksson* (1944) has suggested that it is the same tribe of herring as that on which the major part of the Icelandic herring fisheries off North Iceland is based. The Norwegian investigations support this view (Rasmussen 1949); and it is mainly the older herrings which are found in Icelandic waters. During the last three years the Icelandic herring fishery has declined very much, and the opinion of the fishermen operating in Icelandic waters is that the shoals are smaller and much more scarce than before the war.

The conclusion to be drawn is that, especially in the coming years, we have to be careful when calculating the prognosis of the stock. If these 2 year-classes born in 1943 and 1944 continue to predominate in our age determinations, we can safely regard them as strong year-classes.

However, if the coming year-classes also seem to be strong, then we may take it as a danger signal that the stock of herring is decreasing. If we in such case continue to calculate our stock by use of Mr. *Lea's* formula, we may find a calculated stock which is 100 times as great as the stock was in 1907. At the same time our fishermen will perhaps have difficulties in realizing profits from their efforts.

We have seen it is possible by the use of *Lea's* formula to conclude that there are fluctuations in a stock of fish, but so far we have no means of determining whether these fluctuations are due to an increase or decrease of the stock. If a rich year-class enters the stock, this fact can only be verified after a period of several years, and it is, therefore, not possible to calculate a true prognosis of the stock by using *Lea's* formula. To do this we must first find means of determining whether a fluctuation found by *Lea's* formula indicates an increase or decrease of the stock. — Here we may get valuable information from marking experiments. I shall try to elucidate this point.

We mark, say, 10 000 specimens every year. (1) If we assume that no fluctuations take place in the stock, then we ought to have a certain number of recoveries per unit of catch. (2) If the stock has diminished the chances of getting a marked herring have increased, and our recoveries per unit of catch should increase at a corresponding rate. (3) If, on the other hand, the stock increases through great influx of recruit spawners, *e.g.*, to twice its previous size, the chance of revovering a marked herring is only half of what it was the year before, and we should, therefore, get a corresponding drop in our returns per unit of catch.

The conclusions are that by the use of *Lea's* formula we can discover a fluctuation, and combined with standardized marking experiments it may be possible to determine whether this fluctuation means an increase or decrease of the stock.

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Chapter 3

THE HERRING-MARKETING SITUATION

FACTORS INFLUENCING SUPPLY OF AND DEMAND FOR HERRING

A paper presented by *G. M. Gerhardsen,* Chief Economist, FAO Fisheries Division

This short survey is based mainly on material presented to the first herring meeting held at The Hague, Netherlands, 29 August to 2 September 1949. Most of the statistics have been brought up-to-date through 1949, and other material has also been added.

Landings

Available statistics show world landings of herring and similar species to have averaged about 4 million metric tons annually in the five-year period 1935—39, which includes the peak year 1936 with 4.8 million tons.[1] This amount is about 20 per cent of the estimated world landings of all species of fish, crustaceans, and mollusks.

Landings of these species were on a relatively high level throughout the interwar period. Expressed as annual averages for five-year periods, the trend in the Northern Hemisphere was as follows:

Period	Total Annual Average	Europe	North America	Japan
	Metric tons, round fresh weight			
1920—24	2 490 000	1 023 000	592 000	875 000
1925—29	3 114 000	1 309 000	695 000	1 110 000
1930—34	3 776 000	1 409 000	666 000	1 701 000
1935—39	4 127 000	1 598 000	1 120 000	1 409 000
1940—44	3 206 000	1 054 000	1 133 000	1 019 000
1945—49	3 250 000	1 576 000	1 112 000	562 000

[1] These statistics do not take into account Southern Hemisphere countries, where landings of Clupeidae species increased greatly during the 1940's, especially after 1945.

There were, of course, lean years in some countries, as a result of fluctuations in weather and in the availability of fish; but reduced landings in these countries were usually outweighed by large landings in other countries, so that the world total shows an almost continuous increase from year to year during the interwar period. Landings in Norway rose from an average of 280 000 tons annually in 1920—24 to over 600 000 tons in 1935—39, and U. S. landings increased from an average of about 500 000 tons during the first three five-year periods to over 920 000 tons annually in 1935—39. Landings in Iceland increased from about 20 000 tons in 1920—24 to over 130 000 tons in 1935—39. Germany quadrupled its herring landings from 1920 to 1933, and intensified expansion during the thirties in an attempt to become self-supplied. In the United Kingdom the trend was in the opposite direction, influenced, no doubt, by expansion in other countries and the drastic reduction in imports by some countries. (In the interwar period the British herring catch was only about half the pre-World War I volume.)

By and large, the gradual increase from year to year in total world landings was a reflection of the increased catching capacity of the various fishing fleets. This increase, which took place in many countries, was partly a result of a larger number of craft in operation, but to a great extent it was attributable to the gradual adoption of mechanical facilities in the herring industry. Steam vessels were introduced in the latter half of the nineteenth century. The internal combustion motor was introduced about 1910. Mechanical means for hauling gear have made larger gear possible; the purse seine has been used for catching herring since the turn of the twentieth century; the trawl was introduced in the herring fisheries during the interwar period, about twenty years ago. During the 1930's depth sounders, the radio-telephone, and other modern facilities greatly increased catching capacity. Increased use of such devices since World War II, coupled with favorable market conditions, have given impetus to sizable investment in the herring-fishing industry.

The most important single technological influence, however, upon the growth of the herring industry has no doubt been the development of an oil and meal industry. If one factor can be singled out and considered in this field, this is it, as far as the last thirty years are concerned; and it may well prove to be the foundation for an even greater expansion in the years to come.

For some years during World War II, the aggregate landings of the countries under consideration amounted to less than 3 million metric tons. But they recovered rapidly after the war and, if it had not been for smaller landings in Japan, the 1947 landings would have been in line with the prewar average. Some few countries indicate further increase. In 1948 Norway had almost one million metric tons of herring and similar species, and the herring fisheries of the United Kingdom also gave maximum returns. Production targets indicated by some important countries and evidence of serious effort to reach them point to a continued increase in landings.

The species known as *Clupea harengus* is dominant in the catches of all the North Atlantic waters off Europe. There are qualitative differences explainable by environment, season, maturity, and age, but the catches are all principally of the same species.

Herring fisheries off the *Norwegian west coast,* which amounted to some 650 000 tons in 1938, are largely confined to territorial waters and are, therefore, conducted solely by Norwegians. Three types of herring are fished for in different seasons; small herring along the entire coast from late spring through December—January; the fat herring of northern Norway from late July through October; and the winter herring (large and spring herring) from late January to the beginning of April.

Iceland's herring-fishing operations exploit the herring species which appear regularly off the northern and, to some extent, the southern shores of the island from July to September. As much of the herring is found outside the territorial waters, Icelandic fishermen have to share this wealth of the sea with fishermen of other nationalities. The total herring catch off Iceland in 1938 amounted to some 155 000 metric tons. Of these, 125 000 tons were taken by Icelanders. In 1949 Icelanders themselves caught 148 000 tons off their shores, Norwegians caught 20 700 tons, Swedes 4 700 tons, Finns possibly some 2 000 tons, and Russians an unknown quantity, possibly some 5 000 tons.

In the *North Sea* and adjacent waters, herring fishing is concentrated on the western half of the area, commencing in the north and moving south as the season proceeds, to concentrate on Dogger Bank down to the Straits of Dover in the autumn. Excluding herring catches in Norwegian territorial waters, the North Sea herring catches in 1938 amounted to some 575 000 metric tons. Of this volume, the United Kingdom accounted for some 228 000 tons, the Netherlands 91 000 tons, Germany 216 000 tons, France 24 000 tons, Belgium 6 000 tons, Poland 5 000 tons, Denmark 1 000 tons, and Norway 3 000 tons.

Herring schools which appear *around the coast of Scotland, England, Wales, and northern Ireland* during the greater part of the year are also exploited. The total herring catch in *all waters west and south of the*

British Isles amounted to 101 000 metric tons in 1938. Of this, British landings amounted to 49 000 tons, French (mainly in the British Channel and along the French coast) 48 000 tons.

In the eastern waters, the total catch recorded for *Skagerrak* and *Kattegat* in 1938 was 40 000 tons (33 000 tons on Sweden, 5 000 on Denmark and 2 000 on Norway). The total catch in the *Belt Seas* and in the *Baltic* (not including catches by the U. S. S. R.) was 74 000 tons (Sweden 33 000 tons, Finland 15 000 tons, Germany 10 000 tons, Denmark 8 000 tons, Latvia 7 000 tons, and Poland (estimated) 1 000 tons).

In *Portugal* and *Spain* the sardine *(Clupea pilchardus)* is by far the most important species caught. As the problems connected with the sardine fisheries of these countries are of a special character and only remotely resemble the herring problem of Northern Europe, less emphasis is being placed on them in this particular study.

Other European countries — in particular, Italy and Yugoslavia — as well as the North African territories fall within the same category.

The species found in the waters along the *North American continent* differ from the European herring to some extent, but they are competing commercially with them. Menhaden *(Brevoortia tyrannus)*, which is exclusively used for conversion, is by far the most important of these species. Stimulated by a high demand for oils and meals and favored by abundant concentrations of menhaden, postwar landings have been very large (485 000 metric tons in 1949).

The "herring" is caught on both coasts; on the west coast the species is known as *Clupea pallassii*, on the east coast as *Clupea harengus*. Most of the west-coast herring is caught in Alaska (the landings in the United States of America and Alaska amounted to 79 000 tons in 1948). On the Atlantic coast of the United States the catch of larger herrings is of relatively little importance; the smaller-sized fish canned as sardines make up about three quarters of the entire Atlantic herring catch of the United States (amounting to 85 900 tons in 1948). Canada landed on the Atlantic coast 58 000 tons of herring and on the Pacific coast, 175 000 tons.

The California sardine *(Sardinops caerulea)*, also known as pilchard, occurs on the Pacific coast of North America from southern Alaska to the Gulf of California (290 000 tons were landed in the United States in 1949 as compared with 504 000 tons in 1938; Canada's Pacific landings declined from 47 000 tons in 1938 to nil in 1948 and 1949).

Anchovies are a relatively undeveloped resource in the United States.

Up to World War II *Japan* was the most important producer of herring and similar species, which constituted a very large proportion (in 1938 about one third) of the annual world totalt. Most of the Japanese herrings and sardines are obtained in coastal waters. About 75 per cent, of the total prewar catch of sardines *(Sardinella melanosticta)* was taken in the coastal waters of Japan proper. In the south, the fishing season begins in the latter part of December and lasts until the latter part of April, with the peak during January and February. In northeastern Honshu and southeastern Hokkaido the season extends from early September to late December, with the peak in November and December.

Important sardine fisheries are also located off the eastern coast of Korea (Chosen), with principal fishing seasons in the early summer and in the fall.

Attention should also be drawn to some countries where herring fisheries constitute more recent developments; during and after World War II many countries with relatively undeveloped fisheries began to extend their fishing activities, and species of the family *Clupeidae* came in for a good share of this interest.

The *Union of South Africa,* for example, has developed its pilchard-canning and oil-meal industries very rapidly during the past few years (1945—49); in 1949 the pilchard landings amounted to some 70 000 metric tons, and the pilchard became the most important of the various commercial species landed.

Also of relatively recent date are the herring fisheries of *South America;* several species of the herring group are caught here, but the herring industry, compared with that of other regions, has not yet started to put out very large quantities.

Reference should also be made to the increasing interest which *Australia* has signified in exploiting its resources of pelagic fish, among which the herring-like species rank high.

In the U. S. S. R. herring fisheries were developed in several waters during the interwar period; in the aggregate, possibly some 200 000 tons are landed annually.

Setting of the Industry

Throughout the centuries the herring industry has experienced violent fluctuations in the level of prosperity and wealth accruing to those participating in it. One of the principal causes of this continual flux in the industry is the fluctuation in the abundance of herring. This creates alternate periods of glut and scarcity in landed quantities, which result in unstable prices and widely varying net returns to fishermen. The long-term trend is characterized also by an absolute decline in the demand for herrings as food and an absolute as well as a relative increase in the quantities utilized for reduction to oil and meal.

Because of the chronic nature of the difficulties besetting the herring industry, common action to counteract them has very often required governmental steps and official endorsement and enforcement of policies.

As a result of rapid reconstruction of the war-damaged herring-fishing fleets, relatively favorable runs of herring, and a more plentiful supply of other food, there is now a threat of a herring surplus. The industry is, therefore, posing two important questions: whether the present high level of production can be maintained or perhaps increased even further on a sound basis; and whether this great annual supply of protein, fats, minerals, and vitamins is being properly utilized for human food.

Organization of the Industry. Individual ownership, or at least the existence of very small-sized enterprises, is common to fishing operations in most countries, and it also characterizes the herring-catching fleet to a large extent. In many countries the units are not organized financially to any noticeable extent, horizontally or vertically. This feature carries with it many advantages; but it also leaves the industry vulnerable to the effect of monopolistic group activities in the trade and mechanical industries which are the outlets for the herring fishermen's product. Also, because of its characteristically small operating units, the industry possibly could not, like larger firms, benefit fully from funds created during prosperous years. Its members have not had very much reserve to carry them through the lean years, of which there have been many.

It is natural, therefore, that the outstanding organizational feature of postwar growth has been the strengthening of the ties between the individual units, not only in primary production, but also in processing and trade, and what could almost be called a balancing of power between the various organizational groups.

Diversification Tendencies. The structural differences within the industry are apparent when one considers the various kinds of gear used. In the North Sea and in the Baltic, the drifting gill net predominates, but a specialized herring trawl also plays an important role, particularly in Germany and Sweden and, to a lesser extent, in the other countries exploiting these waters. Since World War II, the trawl has been used to a greater extent. The floating trawl, a Danish postwar innovation, is now being used on a commercial scale. Gill nets are also used on the Norwegian coast, but purse seines — also known as ring nets — play an equally important role. Off Iceland, both gill nets and purse seines are used.

In the prewar period, relatively low oil and meal prices as compared with the cost at which the herring was caught made it unprofitable to use any large quantities of the North Sea herring for reduction purposes. Countries like the Netherlands, the United Kingdom, Germany, Belgium, France, and Denmark, where fishing was conducted only in the North Sea and adjacent waters, were, therefore, mainly confined to the marketing of fresh herring for direct human consumption or the manufacture of high-quality salted, spiced, or smoked products. Because of the short distance between the fishing grounds and the main European consuming centers, the North Sea herring lent itself very well to these purposes. Since the end of the war the North Sea countries have started to develop a meal and oil industry, as well as other means for diversifying the use of herring.

The Present Fleet. All the countries concerned have endeavored to rebuild and modernize their fleets damaged by war. The herring fleet of Norway now surpasses the prewar years in number, and even more in efficiency. The following figures show the number of craft under each kind of gear which landed winter herring in 1947 and 1948:

	1947	1948
Powered gill-net craft	1 925	2 058
Powered purse-seine craft	254	317

The number of fishermen participating in the winter herring fishery in 1948 has been estimated at about 20 000.

In 1948, 150 Norwegian craft participated in herring trawling in the North Sea. Norwegian participation in herring fishing off Iceland has been as follows:

	1938	1946	1947	1948	1949
Number of craft	...	145	...	255	254
Number of trips	176	146	221	276	261

In *Iceland* before the war, almsot all seaworthy craft were devoted to the catching of herring in the summer. Since World War II the big steam trawlers have been carrying on cod fishing throughtout the year. The medium-sized trawlers, longliners, and other smaller craft continue in the summer to switch to herring fishing with purse seine or gill net, for which they are excellently fitted.

In the *United Kingdom* both drifting gill nets and purse seines are used for catching herring. Drift nets have remained the principal gear, although a significant feature of the fishing during the past three years has been the widening of the sphere of activities of the ring-net boats. Boat building for herring fishing has been carried on at high pressure since the end of the war. In 1948 there was a total of 389 steam drifters, 478 motor drifters, and 226 purse-seine vessels. The steam-drifter fleet, according to the 1949 report of the Herring Industry Board, "is old and its ultimate demise cannot now be very long delayed".

The lugger fleet of the *Netherlands* suffered seriously during the German occupation 1940—45. Of the 245 vessels availbable in 1940, only 35 craft remained in 1945. In the following years a sharp increase in the number of craft for the herring fishery took place.

Year	Steam luggers	Motor luggers	Total	No. of fishermen
1939	41	191	232	3 376
1946	27	137	164	...
1947	31	156	187	...
1948	32	175	207	...

In *Germany* the operating lugger fleet developed as follows during the postwar years as compared with 1938:

	1938	1946	1947	1948	1949
Number	168	56	66	76	95

The herring-fishing fleet in Western Europe has increased very fast indeed during recent years, and its future has become a matter of considerable concern. In Norway the chairman of the governing body of the Winter-Herring Fishermen's Sales Association, drew attention in a recent speech to the charges of overinvestment in the fleet, both because of congestion of craft on the grounds hampering efficient operations, and because of lack of adequate outlets. "If the whole fleet is to make a profit," he stated, "a total catch of some 10—12 million hectoliters would be necessary, and for that much we do not have sufficient outlets."

Possibilities for Further Adjustments. It goes without saying that any technological improvement in fishing and processing and any increase in biological knowledge will not only make economic planning easier, but will also increase the efficiency of the industry. It appears, however, that the gains in the form of lower production costs which have been accomplished so far are limited in their extent. Any further decline in market price will necessarily force marginal producers out of business. But the point at which this will happen depends to a large extent on the cost structur: the amount of overhead costs and the number of production factors that are sharing the economic risk — such and similar matters are closely related to the degree of elasticity within the industry.

Concrete information on the structure of prices is almost nonexistent in the literature. At this juncture, however, it is sufficient to point out some of the characteristics of the cost structure in catching and processing.

As most fishermen are paid on a lay basis, their recompense will fluctuate with the gross taking as a certain percentage of what is left after running expenses have been deducted. In 1933, when conditions were extremely unfavorable, the average computed for a large number of typical boats from six Scottish ports showed that the fishermen had a share of only about 8 per cent of gross takings (compared with 16 per cent in 1929). Wage earners obtained 15 per cent. Fuel (coal) absorbed as much as 29 per cent, and other running expenses (except wages) took 32 per cent. Drifter owners experienced financial losses.

Investigations conducted in Norway for 1943, under very different technical and economic conditions, indicate that, of the average herring price of 16.17 Norwegian kroner per hectoliter (93 kg = 205 lb), about 36 per cent constituted recompense to fishermen on a lay basis, about 5 per cent was wages, 15 per cent went for gear maintenance, and 6 or 7 per cent for fuel.

In the processing industry, the structure is entirely different from that in the catching industry. According to rough estimates of manufacturing costs for herring meal in Norway, the manufacture of 100 kg of herring meal requires about 5.6 hectoliters (520 kg) of round, fresh-weight herrings. From the sale of 100 kg of meal, together with a proportionate amount of oil, total returns of N. Kr. 115 will be accounted for as follows: 67 per cent, the cost of the raw materials (at N. Kr. 13.50 per hectoliter); 4 per cent, labor; 5 per cent, fuel and power; 10 per cent, packing and transport; and 15 per cent, amortization and other overhead.

Trends in Prices to Fishermen. In addition to being the most important individual species among those caught commercially, herring is usually also the cheapest. It is apparent from *Table 9* (page 89) that postwar prices for Clupeidae species are many times higher than the

1938 prices. The relative increases are larger for the less expensive species.

In almost all the countries here considered, herring prices were rigidly controlled during World War II, and in many of them the control was extended for some considerable period beyond the war; but whereas wartime controls were mainly designed to safeguard the interest of the consumer during food shortages, prices are now being regulated to prevent too rapid a decline.

In Norway the fixed prices system has been continued during postwar years, with a tendency for prices to increase from year to year. For the 1949 season, prices to fishermen were made dependent upon the total quantity caught. On the average, N. Kr. 162 per metric ton was obtained in 1949. Because of the sliding scale in the guaranteed price, average prices for 1950 were somewhat lower.

In the *United Kingdom,* where an average of 386 shillings per metric ton has previously been obtained by the fishermen, the herring fishermen refused to accept the price differentials suggested for the 1950 season (58s. per cran (= 180 kg) for top quality; 48s. for second quality; and 35s. for meal and oil).

In *Germany,* fish prices were decontrolled on 1 September 1949, but before that date herring prices had fallen below the fixed maximum. Apart from daily fluctuations, the general trend was downward until the end of September, followed by an upward movement through October and a sharp decline during the first two weeks of November.

As far as Western Europe is concerned, postwar control of many phases of the economy and governmental guidance and management make it difficult to discern the real trend in the behaviour of prices. By now, however, it seems clear that the prices to fishermen are coming down or at least not increasing, while prices for equipment, fuel, gear, and other production tools are still on the upsurge. Devaluation alone increased the fuel-oil price in the United Kingdom by some 25 per cent.

Ever since the war ended, it has been feared that, unless precautions are taken through fast writing off of capital equipment, the high costs of operations may severely jeopardize the industry should herring prices decline.

A crisis seems to have developed, accentuated by the smaller run of herrings in the North Sea during 1949, and it may be even more apparent during 1950.

The large investment of capital tied up in the industry and the great numbers of workers dependent upon fishing for a livelihood will make it very difficult to reduce the quantity landed. Because of the uncertainty connected with herring fishing, the fishermen have to work on the basis of "making hay while the sun shines." Any curtailment in fishing operations in order to control the quantity marketed will face serious problems of execution.

Moreover, in the light of the very great need for food which still exists in the world, the improvement of economic conditions of the herring industry should hardly be sought in reduction of output. More and more this is being realized, and a greater degree of emphasis is being placed on technological improvements and on efforts to determine ways and means by which the existing need might be converted into effective demand.

Utilization

Fresh and Frozen Products. Owing to the perishability of fresh fish, especially fresh herring, this product is subject to trade only over relatively short distances. The international trade in it is mainly a trade between neighboring countries.

From 1925 until the outbreak of World War II, exports of fresh and frozen herring from eight European countries and Canada remained at a level of 200 000 metric tons annually. The main European net exporters were Norway, the Netherlands, Sweden, Denmark, and Belgium, and the main European importers the United Kingdom and Germany. When considering the relatively small quantities that go into this trade, it should be borne in mind that the magnitude of landings in some few weeks in principal fishing countries, such as Norway, and the distance from markets, as in the case of Iceland, place serious limitations on the quantities which can be marketed fresh. Postwar possibilities for expansion of the fresh-herring trade seem to be limited. It is the difference in timing of herring fishing which is the main basis for much of the trade in fresh herring; for example, Norway exports to the United Kingdom and to Germany when domestic supplies in these countries are low. The present tendency is, however, toward contraction rather than expansion in inter-European trade in this commodity.

There is a tendency to preserve more herring by means of freezing, not only for bait but also for human consumption. In 1949, eleven herring-producing countries reported a total production of 73 000 metric tons of frozen herring and similar species.

Salted, Seasoned, and Smoked Products. The salting of herring is closely associated with the history of herring fisheries in Northern

Europe. The *relative* importance of herring has declined in the life of the communities bordering the North Sea during the past few centuries; the relative importance of salted herring has also declined during the past few decades of this century. It is evident that salted herring played a much more important role before World War I, and even in the 1920's, than it did during the 1930's. In 1920 Norway exported 257 000 tons of salted herring; but since 1924 its exports have never exceeded 100 000 tons (except in 1930, 112 000 tons), and between 1933 and 1944 they were never more than 50 000 tons (except in 1936, 54 000 tons). Exports from the United Kingdom were kept at a high level throughout the 1920's, the peak years being 1924 with 327 000 tons and 1929 with 304 000 tons. In the 1930's, the export level declined sharply. During and immediately after World War II, food shortages stimulated the production of salted herring, but now that the emergency food need is over, the downward trend is likely to resume.

The decline in quantities salted during the interwar period took place mainly because of the decline of the Eastern European markets, the U. S. S. R. in particular, but also because of a falling off in the consumption of salted herring in Western Europe.

Since the war, total world production of salted herring has amounted to some 500 000 metric tons annually; in 1949 it reached as high as 610 000 tons, mainly as the result of a large increase in Japan's production. World exports have amounted to some 240 000—280 000 tons.

The countries of northwestern Europe are the main competitors in the world market for salted herring; the following notes will concentrate, therefore, on the trend in these countries.

As no very extensive investments in shore facilities are necessary for the manufacture of salted herring, production can be expanded relatively easily upon demand for the product. *Vice versa,* production drops drastically when outlets fail; for example, Norway's production of salted winter herring in 1950 went down to about half of the 1949 volume because of a less-favorable market outlook. The most drastic drops in production are to be found in the less expensive grades.

The matter of adjusting the production of salted herring to a more stable level is at present a matter of great concern. Much attention has also been paid to the possibilities of rationalizing production and developing more attractive product forms within this category. The opinion has been expressed, for instance in the Duncan Report, that the herring-processing industry has apparently not been very susceptible to technical improvements. It is on this challenge that much of the postwar effort seems to be concentrated.

The FAO Herring Meeting held at the Hague in 1949 found that "from evidence submitted, it appears that whereas the demand for salted herring is declining, the consumer is displaying more interest in soft cures, in the field of pickling, marinating, and smoking, *etc.* In some countries also there is evidence of consumer taste for a deep-freeze article packaged in small quantities, and a new process now developing in Germany along this line may prove valuable."

It is probable that too many producers hoped during the interwar period for a return of the "good old days." This has hampered technological progress and has postponed adjustment to conditions which now appear to be of a more permanent nature.

The trend in each of the major herring-salting countries is briefly reviewed in the following paragraphs.

In *Iceland,* the entire herring catch was salted for several decades, and the bulk of it was still salted until about 1930, when the oil and meal industry, stimulated by state aid, began to develop considerably. During the past three years, Iceland's production of salted herring has amounted to some 8—13 000 metric tons, or about one third of the 1938 production. These production figures should be evaluated in light of the relatively small catches in Iceland and the incentives given to oil and meal production owing to the important role which these products play in many of Iceland's trade agreements.

A great part of the British herring catches were salted during the interwar decades. As there was only a very small domestic demand for salted herring during these years, the *United Kingdom* ranked first among the salted-herring exporters of the world. Expansion of the salted-herring industry was limited by the number of market outlets for this product. In 1948, 40 per cent of the total catch was exported: 19 per cent as salted ("cured"), 6 per cent "redded," and 11 per cent fresh ("klondyked"). The substantial quantities which are consumed domestically in the United Kingdom take the form of fresh herring and various brands of smoked herring. Out of a total catch of 1 459 000 crans in 1948, 809 000 crans (55 per cent) were consumed domestically. The distribution among the various forms was as follows: 24 per cent fresh, 25 per cent smoked ("kippered"), 3 per cent canned, 2 per cent quick-frozen, and 1 per cent salted ("cured").

Germany produces large quantities of salted herring almost exclusively for domestic consumption, particularly in the "Hinterland". The larger part of the production, which in 1949 amounted to 40 000 tons is caught on drifting gill nets and salted at sea (in 1949 about 70 per cent) on a specialized fleet of lugger; the rest is shore-salted herring taken from the catches which the big trawlers land fresh in the German ports for marketing fresh and for processing together with supplementary imports of raw material into a great variety of marinated and other light cure products which possibly play a greater part in Germany than in any other country.

Germany's domestic supply of salted herring is supplemented by import; in 1949 such imports amounted to 70 000 tons.

In the *Netherlands* most of the herring is salted at sea. In May or June, when the Dutch season begins with the fisheries near the Shetland Islands, the herring is very palatable and fat; but the salted product, though gutted, cannot be kept for long, and it is mainly absorbed by the Dutch domestic market in the form of matjes herring.

In the Dutch production of salted herring, distinction is made between "matjes haring," "volle haring" (full of roe or milt), and "yle haring" (lean, after having spawned), all of which are gutted before curing, and "steur haring", which is nobbed and regularly salted. The quantities processed under each of these categories is determined by the quality of the herring and by the actual market outlook for the various processed forms. The disposal of salted herring has been very satisfactory during the past few years. The matjes herring is more or less exclusively destined for domestic consumption and only a few countries — for instance, Sweden — are interested in importing it. Herring which is otherwise salted is principally export herring. The nobbed, salted herring is exported principally as bloaters — "bokking" (smoked).

During the immediate postwar year there was a large domestic demand for salted herring which had previously been used for exports purposes. However, a decrease in the internal consumption of salted herring, with the exception of matjes herring, is clearly apparent during the past few years. In 1946 the *per capita* consumption of salted herring, including matjes herring, amounted to between 5 and 6 kg; in 1948 it dropped to less than 4 kg, and in 1949 to 3.1 kg. Fortunately, the exports increased to such an extent that practically the whole production was disposed of without great difficulties.

Of the total exports in 1949, 51 000 metric tons went to the Bizone of Germany, the largest marketing area of the Netherlands, compared with 10 000 tons in 1948, 6 000 tons in 1947, and nothing in 1946. The U. S. S. R. bought 3 000 tons of herring in the Netherlands in 1949, compared with 11 000 tons in 1947.

Norway produces various kinds of salted herring. First there are several kinds of relatively inexpensive salted winter herring, from the fat large herring caught at the beginning of the season to the lean spring herring caught at the end of the season. Out of a total export of 96 000 tons in 1948, 87 000 tons were destined for U. S. S. R., Poland, and Germany. In 1950 production of these commodities was reduced from about one million to half a million barrels because of a less-favorable market outlook. Secondly, there is the much more expensive salted product of the same herring in its premature stage — the small and fat herring. Production of this commodity has been relatively small during recent years because of less-abundant runs. Most of it has been exported to Germany. Thirdly, there is the salted and spiced, rather high-priced herring which are brought home by Norwegians catching off Iceland. The 1949 production amounted to 224 000 barrels, which is about equal to prewar production. Although there is a domestic market for the Icelandic herring, Norway depends largely on exports, primarily to Sweden but also, according to the 1948 statistics, to the U. S. A., the U. S. S. R., Denmark, and Palestine. The exports of Norwegian smoked herring — during recent years amounting to some 2 000 tons annually — also deserve mentioning. In 1948 the most important market countries were Italy, Cuba, British territories in the Caribbean, Egypt, Liberia, and Jamaica.

In *North America* the salting of herring takes place in Alaska and on the east coast of Canada. Exports from Canada (not including Newfoundland) had been reduced to about 12—20 000 tons during the immediate prewar years as compared with some 50—60 000 tons in the late 1920's. Wartime production of salted herring in Canada proper was very low. Newfoundland, however, obtained contracts for substantial sales for relief purposes, mainly through UNRRA. There is nothing to indicate that any other factor contributed materially to the increase in the total landings from 10—15 000 tons annually to many times this quantity in the war years and postwar years.

Canned Products. This commodity group is confined to heat-processed products in hermetically sealed containers. In the statistics available, no clear line can be drawn between the higher-priced and the less-expensive grades of canned herring and similar species. It appears appropriate however, to exclude the canned sardines of Southern Europe and Northern Africa. This exclusion will confine the subject matter to the commodities produced in Northern Europe, North America, Japan, and a few other regions, particurlarly in the Southern Hemisphere where canning industries have been developed relatively lately.

In *Northern Europe,* production has always been on a comparatively modest scale.

In *Canada* the canning of sardines (immature herring) on the Canadian Atlantic Coast and of herring on the Pacific Coast utilized only a small percentage of the landed quantities before World War II. The war and subsequent emergency demands caused an expansion, especially of the canned output on the Pacific Coast. After the war this pack declined again to nearly the prewar level.

In the *United States* of America where sardines are canned in New England (Maine, Massachusetts, and New Hampshire) and on the Pacific Coast (California and Oregon), the packs expanded during World War II. The peak year in both areas was in 1941. The canned-alewives pack was also increased during the war years and reached a peak in 1946.

In *Japan,* canning of sardines began in the early 1920's and exports of low-priced canned products expanded. During the interwar period the industry registered a very great expansion in production and exports. In 1930 there were only three canneries; in 1932 there were twenty-seven plants, and many of them had been enlarged. During the years preceding World War II Japan exported about 80 per cent of its production. Its markets were practically all over the world, but particularly in Asian countries, during 1935—38 the Philippines, the Netherlands, Indonesia, Malaya, and India absorbed about 75 per cent of the total exports. Japanese canned sardines also appeared to be obtaining a strong position on the European markets.

That these markets are apparently still available to the producers with a low-priced canned sardine or pilchard is evidenced by the readiness of the Malayan market to absorb similar commodities from the newly developed pilchard fishery in South Africa. It must be borne in mind, however, that the existing currency situation will favor soft-currency producers in various importing countries.

Oils and Meals. The production of oil and meal from herring and similar species has developed rapidly during the last thirty years. In 1948 and 1949, about 40 per cent of the world landings of these species were used for oil and meal. In those countries where reduction plants were erected, new demands for herring were thereby created and, in consequence, there was an enormous increase in landings. In Japan, the United States and Canada, and to a great extent also in Norway and Iceland, fishing for herring and similar species could not have expanded so substantially without the growth of the oil- and meal-reduction industry.

This expansion was hampered during World War II, although only in a few countries was physical processing capacity reduced through war damage. With the prewar experience and the great postwar demand for oil and meal in mind, all countries which previously produced these commodities have lately paid much attention to oil and meal production, and new countries are entering the field.

The FAO-sponsored Herring Meeting in 1949 drew attention to the fact that "modern oil-refining methods have been applied to herring oil and, in at least one country (Norway), the greater part of the production of herring oil is used for the manufacture of margarine or as canning oil. This usage appears to justify a relatively higher price than that prevailing before the war. Improved reduction techniques (stick-water utilization, etc.) give promise of more profitable operations." Postwar production of herring oil amounted to some 100—120 000 tons.

Postwar production of meal has fluctuated between 250 000 and 300 000 metric tons annually. World production in 1950 is likely to be high because of Norway's very successful winter-herring fishery.

Whether fisheries based on oil and meal production can be carried on at a profit during the next few years will depend largely on the extent to which recent technological improvements can be applied to match the competition from other products, such as the synthetic "Animal Protein Factor" (A.P.F.). This is now being diligently worked on.

Both in the *United States* and in *Canada,* fish-oil prices declined during 1949. Prices for crude sardine oil from the Pacific Coast, which prevailed at the level of 15 cents per pound from August 1948 to the end of the year, started to drop in January 1949. Towards the end of July 1949 the quoted price was 5½—6½ cents. In the European markets, also, the price trend was downward. At the time of writing (July 1950), the U.S. oil market exhibits a slightly stronger tone; although inventories are comparatively low, current production is being disposed of at low prices, and a substantial increase in prices seems unlikely to materialize unless a sharp increase in the general demand for oils and fats occurs. A low linseed crop in Canada might improve the Canadian domestic markets for fish oils, but the large U.S. cottonseed and soybean crop might keep prices on much the 1949 level in that market.

In the United States the outlook for fish-meal prices (July 1950) is uncertain, depending upon possibilities in menhaden landings. Heavy production, together with imports, as well as the expansion of synthetic commodities, might depress prices even with the present low inventories.

According to Canadian authorities, the demand for fish meal in Canada is still strong; and as only small quantities are in stock, the producers should not encounter serious difficulties in selling the 1950 production. Present prices might, however, be depressed should stronger competition materialize from the synthetic A.P.F. and from heavier Norwegian production, together with a decline in the European demand.

In *Norway* the proportion of the winter-herring landings used for oil and meal passed the 10 per cent mark in 1925. From 1925 to 1929, it varied between 25 and 40 per cent; in 1932 it reached 57 per cent; in 1935, 64 per cent; and in 1938 it exceeded 70 per cent. Utilization for oil and meal has been particularly high when landings are large. Thus, in 1950 some 85 per cent of the total landings of winter herring was used for this purpose.

The capacity of the Norwegian reduction industry has been increased rapidly during recent years, partly by private firms and partly by fishermen's sales associations, and with considerable guidance and support — financially and otherwise — from the Government.

In *Iceland,* a conversion plant was erected in 1911, and the industry developed significantly around 1930 as already noted. The proportion of the catch used for oil and meal production increased from 70 per cent in 1930 to 90 per cent in 1937. During the war an even greater proportion — up to 95 per cent — was utilized in this way owing to marketing difficulties for salted products. The expansion of processing facilities carried with it an expansion of fishing effort, landings, and exports.

The Government of Iceland has been instrumental in the development of an oil and meal industry; in fact, many of the plants are stateowned. In 1945, they numbered eighteen, with a total working capacity of 60 000 hectoliters (5 600 metric tons) in 24 hours; the capacity continues to expand.

Before World War II, the *United Kingdom* produced practically no herring oil and meal. In 1944 the Committee on the Herring Industry recommended the utilization of residual herring for such production and in 1948, the Herring Industry Board was authorized to erect the necessary plants. In the meantime, the Board experimented with pilot-scale and full-scale plants, and a temporary scheme was evolved to convey "surplus" herring to existing fish-meal installations. This process was intended primarily to handle gluts, which were the immediate and most pressing problem.

In *Denmark* a small reduction industry was initiated during World War II. The annual production of oils and meals amounts to a few hundred tons. Belgium, France, Germany, and the Netherlands also figure among the group of producers with a comparatively small annual output of meal.

In the *United States of America* the entire catch of menhaden — the most important of the East Coast species — is converted into oil and meal.

Coincidentally with the development of a pilchard-canning industry in California, utilization of the sardine offal and eventually of the whole fish for oil and meal increased. During the interwar period, the importance of the oil and meal reduction surpassed that of the canned product. Ships equipped with reduction machinery operated outside the three-mile limit in order to avoid California State laws requiring that a certain proportion of the catch be canned.

Regulations imposed under a system of wartime allocations restricted the amount of raw material being diverted into oil and meal reduction. Since the war, production of both oil and meal and canned pilchards has dropped sharply because of the failure of pilchard runs.

The bulk of *Japan's* marine-oil production was obtained from sardines; on the basis of value, which unfortunately is the only information available, sardine and herring oils amounted to between 77 and 87 per cent of its total marine animal oil production during the five-year period 1934—38.

In 1937 Japan produced 600 000 metric tons of marine animal meals. Of this amount, sardine and herring meal accounted for 458 000 metric tons, a volume that exceeds the aggregate output of all the other herring-meal producers in the world. These figures exclude the production of fertilizer. In the years preceding World War II, although most of the meal was consumed domestically, exports were increasing steadily to levels between 50 000 and 100 000 metric tons. It is probable that the Japanese fish-meal industry declined during the war years when the export markets were cut off and the need for herring as direct food became more urgent. The industry might be restored very quickly. C. A. Carter, in a 1945 analysis for the U. S. Tariff Commission, states that "the fish-meal industry in Japan is capable of tremendous expansion."

The pilchard fisheries of the west coast of *Canada* developed rapidly during the first ten years following World War I. Annual landings increased from 1 000—2 000 tons in 1921—25 to about 78 000 tons in 1929, and during the thirties they generally amounted to between 40 000 and 60 000 tons.

On the east coast of Canada, oils and meals are manufactured on a small scale. Two herring-reduction plants were established, but failed. Some herring oil and meal has been produced in Newfoundland during the last ten years, but the quantities amount to only some few hundred tons annually.

In the Southern Hemisphere several countries with expanding fisheries have developed an oil and meal industry. *Chile* is now producing a few hundred tons of pilchard meal. The *Union of South Africa* has produced whitefish meal in small quantities since 1936 principally from "offal" landed by trawlers. Since 1945, ten plants have been erected along the Atlantic Coast north of Cape Town for the reduction to meal and oil of pilchards, principally, and maasbankers *(Trachurus trachurus)*; the annual production is some 5 000 tons. The industries have expanded greatly, and new plants are beginning to operate in *Southwest Africa.*

Appendix A: NOMENCLATURE OF THE CLUPEIDAE

Sardines

1. *Sardinops caerulea* .... West coast of North America.
2. *Sardina* (sometimes also called *Clupea*) *pilchardus* .... European North Atlantic and Mediterranean Sea.
3. *Sardinella* (*Clupea*) *aurita* .... Mediterranean Sea, West Africa, Brazil along the coast of the State of Rio
4. *Sardinops* (*Arengus*) *sagax* ...... West coast of South America along the coasts of Peru and Chile; coast of South Africa.
5. *Sardinops neopilchardus* .... Australia and New Zealand.
6. *Sardinella melanosticta*............ Japan and Korea.
7. *Sardinella anchovia* or *Sardinia pseudohispanica* .... Venezuela.
8. *Sardinella longiceps* .... Indian coast; Malabar coast; Bay of Bengal, coast of Java (Oil sardine).
9. *Sardinella fimbriata* .... Malabar coast, India; coast of Java.
10. *Sardinella gibbosa* .... Southeast coast of India; Malayan coast.

Herrings

1. *Clupea harengus* .... European North Atlantic; Atlantic coast of North America.
2. *Clupea pallasii* .... Pacific coast of North America; coast of Japan.
3. *Clupea* (sometimes also called *Ethmidium*) *maculata* .... West coast of South America along the coast of Chile.

Shads

1. *Alosa* (sometimes also called *Clupea*) *alosa* .... European North Atlantic; Mediterranean Sea.

2. *Alosa finta* .... European North Atlantic; Mediterranean Sea.
3. *Alosa nordmanni* .... Black Sea.
4. *Alosa pontica* .... Black Sea.
5. *Alosa sapidissima* .... Atlantic and Pacific (introduced), coasts of North America.

Menhadens

1. *Brevoortia tyrannus* .... Atlantic coast of the United States; Gulf of Mexico.
2. *Brevoortia pectinata* .... Coast of Uruguay.

Sprats

1. *Clupea sprattus* .... European North Atlantic and Mediterranean Sea.

Anchovies

1. *Engraulis encrasicholus* .... European North Atlantic and Mediterranean Sea.
2. *Engraulis mordax* .... West coast of North America.
3. *Engraulis ringens* .... West coast of South America along the coasts of Peru and Chile.
4. *Engraulis japonicus* .... Japan and Korea.
5. *Engraulis mystax* .... Indian coast.
6. *Engraulis anchoita* .... Coast of Argentina.
7. *Anchovia clupeoides* .... Cuba.
8. *Anchovia nigra* .... Venezuela.
10. *Anchoa naso* .... Chile and Peru.
11. *Anchoa nasus* .... Chile and Peru.
12. *Anchoa parva* .... Venezuela.
13. *Anchoviella epsetus* .... Gulf of Mexico and Caribbean Sea.
14. *Austranchovia australis* .... Australia.

Alewives

1. *Pomolobus pseudoharengus* .... Atlantic coast of the United States and Canada (Also landlocked).
2. *Pomolobus aestivalis* .... Atlantic coast of the United States.

Appendix B:

Table 1. *Total landings of herring and similar*

Country	Five-year averages 1920—24	1925—29	1930—34	1935—39
	Metric tons[1]			
TOTAL	2 489 888	3 113 563	3 775 857	4 127 490
Belgium	[2] 2 272*	[2] 8 939*	14 674	10 214
Canada[3]	103 777	185 039	150 487	184 096
Newfoundland[4]	(10 000)	(10 000)	(10 000)	11 844*
Denmark	13 982	16 692	14 991	16 164
France	65 411	76 734	97 012	84 433*
Germany	57 609	80 206	136 940	203 189
Iceland........................	19 002	39 380	66 590	131 625
Ireland	[5] 9 372	[5] 14 611	3 228	3 058
Japan	874 823	1 110 455	1 700 588	1 408 745
Netherlands	68 521	78 291	90 517	92 845
Norway	280 097	437 411	527 113	597 688
Portugal	(100 000)	98 645*	113 980	118 228
Sweden	50 576	45 723	52 863	74 223
United Kingdom[6]	356 473	411 825	290 913	[7] 266 830
U.S.A. and Alaska	477 973	499 612	505 961	924 308

Source: Data have been taken, wherever available, from the countries' official statistics as reported in FAO *Yearbook of Fisheries Statistics, 1947* (Washington, D.C., 1948). Data for 1938 and 1946—49 are mainly from official communications from countries concerned. Belgium, Germany, Ireland, Netherlands, Sweden, and United Kingdom, 1920—29 and Portugal, 1927—33, from Conseil Permanent International pour l'Exploration de la Mer, *Bulletin Statistique des Pêches Maritimes*, 1920—33 (Copenhagen, 1922—35). Figures within parentheses are wholly estimated, and those with asterisks (*) are partly estimated.

[1] Round fresh weight.
[2] Ostend only, 1920—26.

SYMBOLS used in the tables.

... Not available.
— Nil or negligible.
* Estimated.
ø Less than half the final digit.

species in fourteen countries, 1920—49

		Calendar years				
1940—44	1945—49	1945	1946	1947	1948	1949
Metric tons[1]						
3 206 120	3 250 153	2 823 997	3 057 597	3 247 851	3 632 960	3 488 362
25 571	29 399	32 268	37 947	33 042	24 785	18 952
251 950	247 174	244 511	222 855	232 403	297 483	238 620
25 193	50 970	61 591	73 541	41 720	51 707	26 289
28 751	28 868	20 040	26 000	30 100	30 200	38 000
34 460	69 700	12 500	56 400	98 000	96 600	85 000
(30 000)	138 845*	(30 000)	105 971	150 307	172 965	234 982
171 565	126 102	60 315	131 720	216 948	150 122	71 407
3 497	4 958	5 705	5 215	6 833	4 196	2 841
1 019 305	562 053	582 800	601 500	558 750	408 504	658 711
1 009	108 070	27 350	106 500	140 000	150 000	116 500
502 806	664 835	514 399	513 847	598 088	965 220	732 620
107 246	102 493*	(150 000)	113 438	106 243	79 353	63 432
74 090	91 922	83 335	81 771	82 743	107 275	104 484
[7] 74 899*	210 654*	130 213*	207 509	229 174	274 850	211 524
855 778	814 110	868 970	773 383	723 500	819 700	885 000

[3] Excludes Newfoundland.

[4] 1936—48 based on exports, converted to round weight plus estimated quantities domestic consumption; 1949 based on a direct estimate of production, landed weight.

[5] Includes Northern Ireland, 1920—25.

[6] England and Scotland, 1920—25; England, Scotland, and Northern Ireland, 1926—29; England and Wales, including the Isle of Man, Scotland, and Northern Ireland, 1930—37 and 1945; Scotland only, 1939—44; England and Wales, including the Isle of Man, and Scotland, 1938 and 1946—48; England, Wales, and Scotland, 1949.

[7] 1939—44: Herring only for Scotland from Scottish Home Departement; *Report of the Committee on the Herring Industry* (Edinburgh, 1944) for years 1939—42, and *The Fishing News* (London, 17 March 1945) for 1944.

Table 2. *Estimated disposition of landings of herring and similar species for 14 countries, 1948 and 1949*

Country	Year	A. Total landings	B. Marketing as fresh	C. Freezing	D. Salting, drying, smoking, etc.	E. Canning	F. Reduction to oils and meals	G. Other purposes	H. Offal for reduction[1]
		Metric tons[2]							
TOTAL	1948	*3 249 812*	*535 109*	*51 509*	*756 224*	*276 133*	*1 518 448*	*112 473*	...
	1949	*3 184 686*	*370 741*	*59 344*	*1 040 744*	*380 227*	*1 270 126*	*63 931*	...
Belgium[3]	1948	24 699	5 827	—	17 389	1 483	—	—	...
	1949	18 941	6 943	100	10 155	1 743	—	—	307
Canada[4]	1948	297 483	32 554	4 680	28 606	41 698	162 917	27 112	...
	1949	238 620	22 612	3 123	32 137	17 652	136 483	27 040	...
Newfoundland[5] ..	1948	51 707	1 461	10	44 400	506	5 330	—	...
	1949	26 289	907	2 714	16 038	370	6 260	—	—
Denmark[6]	1948	30 200	14 000	—	10 200	6 000	—	—	4 500
	1949	38 000	23 000	—	8 000	7 000	—	—	6 000
Finland	1948	21 000	13 580	1 300	5 000	620	500	—	...
	1949	30 000	20 800	1 000	5 000	500	2 700	—	—
France[7]	1948	96 600	49 500	—	33 100	14 000	—	—	...
	1949	85 000	31 900	—	34 900	18 200	—	—	...
Iceland	1948	150 122	3 023	2 855	14 255	229	129 760	—	...
	1949	71 407	20	7 050	[illegible]	[illegible]	[illegible]	—	[illegible]

Ireland	1948	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	1949	2 841	1 392	21	648	780	—	—	—
Italy	1948	43 290	22 990	—	14 300	6 000	—	—	...
	1949	61 290	41 290	—	15 000	5 000	—	—	—
Japan	1948	408 504	138 892	12 255	155 232	4 085	44 935	53 105	...
	1949	658 711	14 271	9 844	544 432	12 681	73 050	4 433	...
Netherlands......	1948	150 000	32 000	1 000	110 000	7 000	—	—	3 000
	1949	116 500	24 500	1 000	80 000	9 000	2 000	—	3 000
Norway	1948	965 220	122 080	22 797	149 428	43 227	611 122	16 566	...
	1949	732 620	107 234	28 752	159 657	41 144	381 480	14 353	11 000
Philippines	1948	8 441	4 411	—	3 225	130	—	675	...
	1949	7 943	4 064	24	2 818	1 037	—	—	—
United Kingdom[8]	1948	274 850	85 470	5 080	157 706	14 095	12 484	15	...
	1949	211 524	63 208	3 416	103 272	19 173	22 450	5	...
United States of America[9]	1947	723 500	8 200	1 500	10 900	136 500	551 400	15 000	900
	1949	885 000	8 600	1 400	11 300	245 900	599 700	18 100	131 500

Source: Official communications from the countries concerned.

[1] Quantities available as "offal" when fresh-weight quantities (columns A, B, C, D, E, and G) have been dressed and processed.

[2] Round fresh weight (columns A—G), unless otherwise indicated.

[3] Landings in Belgian ports only.

[4] Canada excludes Newfoundland. The aggregate figures in the disposition columns are not identical with the total-landings figures because Canadian landings do not include fish landed by foreign boats, whereas landings by foreign boats, when processed or re-processed in Canada, appear in the Canadian production commodity forms.

[5] 1948 data based entirely on exports plus estimated quantities for domestic consumption. 1949 data based on direct estimates of production, landed weight; no estimates are shown of quantities caught and used fresh by fishermen themselves, for bait and other purposes such as fertilizer.

[6] Excludes Faeroe Islands and Greenland.

[7] Metropolitan France only, excludes Algeria and other overseas departments.

[8] Excludes Northern Ireland and (in 1949) Isle of Man.

[9] Includes Alaska. 1947 figures used; figures not available on disposition for 1948.

Table 3. *Details of utilization of herring landings, 1938 and 1946—49*

Country, species, and item	1938	1946	1947	1948	1949
	Metric tons				
Norway					
Winter herring: Total	*486 275*	*357 633*	*494 270*	*819 224*	*567 467*
Fresh for domestic consumption	11 320	8 802	6 116	7 529	4 887
Fresh for export	70 559	51 765	85 816	104 906	94 162
Frozen for export	3 210	1 373	9 102	16 896	26 510
Salted	26 352	75 423	103 058	118 196	125 823
Canned	10 778	17 342	17 088	17 866	13 511
For reduction purposes	355 222	195 435	263 408	539 249	294 665
Bait	[1] 8 834	7 493	9 682	14 582	7 909
Fat and small herring: Total	*130 505*	*92 879*	*66 984*	*105 777*	*122 852*
Fresh for domestic consumption	[2]	2 085	1 784	2 766	1 816
Fresh for export	14 321	9 803	8 237	6 069	6 211
Salted	5 087	7 651	3 359	2 448	3 937
Canned	13 629	3 323	14 339	17 209	17 728
For reduction purposes	95 105	63 614	32 172	71 505	86 715
Bait	[3] 2 363	6 403	7 093	5 780	6 445
United Kingdom					
Herring.					
Domestic consumption: Total	*84 495*	*120 427*	*131 907*	*128 260*	*103 527*
Fresh	...	[4] 47 368	55 331	55 807	43 282
Quick-frozen	...	1 377	2 854	4 122	4 122
Kippered	...	65 797	64 051	58 819	42 806
Cured	...	2 876	2 537	1 744	1 268
Canned	...	3 009	7 134	7 768	12 049
Export: Total	*151 722*	*51 587*	*54 221*	*90 844*	*58 819*
Redded	—	8 563	7 768	12 842	8 720
Klondyked	[5] 36 477	9 432	12 842	[6] 25 842	10 781
Kippered	—	546	1 903	3 488	3 646
Cured	[7] 112 565	29 595	28 537	44 074	21 233
Canned	2 680	3 451	3 171	4 598	4 439
Marinated	...	*1 571*	*634*	*1 427*	*1 268*
For reduction purposes	...	*1 869*	*6 342*	*10 781*	*19 659*
Iceland					
Herring: Total	...	*131 720*	*216 948*	*150 122*	*71 407*
Exported iced in cargo vessels	...	—	847	3 019	—
For freezing	...	13	272	—	—

Table 3 (concluded). *Details of utilization of herring landings, 1938 and 1946—49*

Country, species, and item	1938	1946	1947	1948	1949
	Metric tons				
Iceland (concluded).					
Herring: (concluded).					
For domestic consumption	...	—	—	1	20
For salting	...	20 900	8 359	14 255	17 387
For canning	...	27	61	229	47
For reduction purposes	...	105 506	200 603	129 762	46 003
Frozen for bait	...	5 274	6 806	2 856	7 950
Canada[8]					
Pacific herring: Total	*64 528*	*102 153*	*116 273*	*175 365*	*146 545*
Fresh, round	1 420	409	698	—	—
Frozen, round			581	—	—
Kippered	—	204	814	—	—
Pickled	—	102	232	—	—
Dry-salted	13 422	6 333	6 279	175	1 172
Canned[9]	3 484	47 195	84 763	18 589	2 638
Non-food uses	46 202	47 910	22 906	156 601	142 735
Atlantic herring: Total	*45 369*	*68 212*	*62 496*	*58 033*	*54 702*
Fresh, round	5 716	9 550	7 687	10 852	6 510
Frozen, round			1 312	4004	2 790
Kippered	181	2 933	1 187	929	2 133
Vinegar-cured, round	—	477	500	1 683	3 501
Vinegar-cured, fillets	—	1 364	1 125	4 004	4 048
Pickled	2 405	9 891	6 000	4 468	[10] 4 321
Salted, smoked (bloaters)	2 586	13 165	3 875	6 384	[11] 8 205
Canned[9]	2 722	9 618	18 686	4 701	1 532
Non-food uses	31 759	21 214	22 124	21 008	21 662
Atlantic sardines: Total	*20 484*	*45 492*	*46 078*	*40 724*	*28 159*
Fresh and salted	12 680	30 935	26 541	22 561	14 924
Canned	7 804	14 557	19 537	16 330	12 869
Non-food uses	—	—	—	1 833	366

Source: Official communication and publications.

[1] Includes 931 tons for other purposes, n.e.s.

[2] Included with "Bait".

[3] Includes fresh fish for domestic consumption and fish for other purposes, n.e.s.

[4] Includes fish for bait.

[5] Comprises 36.132 tons fresh and 345 tons ungutted.

[6] Includes 158 tons quick-frozen.

[7] Comprises 102.690 tons pickled and 9.875 tons Mediterranean cure.

[8] 1935—39 average used instead of 1938.

[9] Including snacks.

[10] Includes 164 tons pickled fillets.

[11] Includes 328 tons salted, smoked (boneless).

Table 4. *Production of commodities from herring and similar species in twenty countries, 1938 and 1946—49*

Commodity and country	1938	1946	1947	1948	1949
	Metric tons[1]				
Salted herring and allied species[2]. Total	...	*545 406*	*493 353*	*543 663*	*610 018*
Belgium	3 080	18 647	16 230	12 102	7 087
Canada[3]	6 790	18 213	12 316	11 017	12 737
Newfoundland	[4] 3 015	29 897	[5] 15 063	[5] 19 564	[5] 5 858
Denmark [6]	1 380	4 100	4 100	3 700	2 000
Finland	...	6 500	6 000	4 000	4 000
France[5] [7]	30 000	13 000	36 500	30 000	25 500
Germany	67 161	29 186	29 888	34 130	40 122
Iceland	34 768	20 900	8 359	11 480	12 900
Ireland	214	254	85	1 430	947
Italy	14 000	10 000	11 000	13 000	12 168
Japan	...	139 100	69 750	44 935	193 358
Netherlands:					
Salted	[4] 75 849	45 000	58 000	74 000	60 000
Smoked		17 000	17 000	25 000	13 000
Norway	42 600	70 600	94 600	110 000	115 211
Philippines	...	1 546	3 884	1 608	1 266
Portugal	[4] 7 345	3 205	1 033	3 092	2 790
Sweden	[4] 3 731	[4] 17 761	[4] 7 990	23 819	20 000*
United Kingdom:[8]					
Salted	[4] 139 845	34 971	28 795	44 887	20 687
Smoked		59 226	66 460	69 599	54 087
U.S.A. and Alaska	...	6 300*	6 300	6 300*	6 300
Canned herring and allied species. Total	...	*242 042*	*254 699*	*259 040*	*323 079*
Belgium	560	3 036	2 643	979	1 046
Canada[3]	6 958	38 980	44 569	19 873	8 199
Newfoundland	—	54	45	303	222
Chile	...	500*	568	671	1 864
Denmark[6]	920	565	800	2 400	2 800
Finland	...	400	450	500	400
France[7]	[4] 1 938	5 300	13 500	12 980	16 750
French Morocco	[4] 12 779	10 000*	15 000*	20 000*	35 000
Germany	28 151	583	1 643	7 900	16 200
Ireland	...	100*	70	393	267
Italy	6 000	5 000	5 500	5 500	4 427
Japan	[4] 28 170	650	563	817	4 060
Netherlands	...	2 800	4 000	4 500	5 000

Table 4 (concluded). *Production of commodities from herring and similar species in twenty countries, 1938 and 1946—49*

Commodity and country	1938	1946	1947	1948	1949
	Metric tons[1]				
Canned herring and allied species (concluded).					
Norway	35 500	24 900	34 600	41 100	35 000
Philippines	...	200*	204	149	1 192
Portugal	[4] 30 477	27 793	37 536	18 199	13 372
Spain	...	10 000*	10 000*	9 000*	10 000*
United Kingdom[8]	[4] 3 005	5 080	6 990	10 571	14 380
U.S.A. and Alaska	59 130	98 312	68 541	93 932	145 200
Venezuela	...	7 789	7 477	9 273	7 700*
Oil. Total	...	*104 402*	*113 394*	*124 707*	*100 290*
Canada[3]	13 528	4 039	5 639	12 025	11 883
Newfoundland	1 038	20	147	533	1 218
Chile	...	1 100	27	50*	50*
Iceland	22 650	17 500	31 801	17 450	7 565
Japan	...	3 400	2 250	817	1 545
Norway	26 000	14 700	22 400	42 200	26 600
United Kingdom[8]	...	800*	762	483	1 829
U.S.A. and Alaska	90 932	62 843	50 368	51 149	49 600
Meal. Total	*283 449*	*215 424*	*224 383*	*293 708*	*246 624*
Belgium	28	379	320	101	62
Canada[3]	18 107	8 307	10 789	30 755	27 368
Newfoundland	118	166	933	953	1 044
Chile	200*	200*	267	22	600
Finland	—*	—	20	80	450
Iceland	23 260	17 550	33 975	22 900	7 700
Norway	88 300	49 980	55 600	111 000	72 000
U.S.A. and Alaska	153 436	138 842	122 479	127 897	137 400

Source: Principally communications from the countries concerned.
* FAO estimate.
[1] Product weight unless otherwise indicated.
[2] Includes smoked herring for some countries.
[3] Excludes Newfoundland.
[4] Exports.
[5] Smoked herring is or may be included.
[6] Excludes Faeroe Islands and Greenland.
[7] Metropolitan France only, except 1938.
[8] Excludes Northern Ireland and (in 1949) Isle of Man.

Table 5. *Exports of fresh and frozen herring and similar species from nine countries, 1920—49*

Year	Total	Norway[1]	Sweden	Denmark	United Kingdom	Nether-lands	Belgium	Germany	France	Canada[2]
	Metric tons									
1920	140 315	60 115	9 652	5 587	20 358	30 593	709	234	...	13 067
1921	114 161	56 099	22 185	3 486	17 995	5 984	1 269	—	246	6 897
1922	95 349	61 170	2 623	1 438	16 600	1 522	1 204	831	284	9 677
1923	126 612	86 446	7 073	4 483	15 414	2 390	579	2 055	589	7 583
1924	172 607	80 930	17 568	7 876	36 937	11 013	672	3 417	1 072	13 662
1925	181 826	94 342	13 429	6 599	53 254	803	261	2 306	921	9 911
1926	212 015	106 905	13 710	4 420	61 246	7 687	142	3 978	800	13 127
1927	207 750	89 548	14 443	7 380	65 070	10 383	361	4 787	3 811	11 967
1928	233 228	102 672	14 750	9 872	59 351	11 140	730	11 691	6 448	16 574
1929	262 650	120 402	13 189	7 082	58 997	13 635	11 248	21 864	3 013	13 220
1930	233 832	110 685	14 882	6 301	53 520	10 859	10 680	17 758	1 766	7 381
1931	196 559	75 086	11 682	6 322	42 491	20 136	17 869	15 979	2 816	4 178
1932	173 822	74 547	11 769	6 825	51 037	10 735	4 321	9 540	1 484	3 564
1933	195 499	110 188	12 076	7 771	31 422	14 539	3 792	7 644	1 184	6 883
1934	165 089	63 359	13 534	7 197	29 270	21 513	7 749	5 026	5 390	12 051

Table 5 (concluded). *Exports of fresh and frozen herring and similar species from nine countries, 1920—1949*

Year	Total	Norway[1]	Sweden	Denmark	United Kingdom	Nether-lands	Belgium	Germany	France	Canada[2]
	Metric tons									
1935	205 185	98 440	11 597	9 708	36 476	14 813	11 705	4 822	4 137	13 487
1936	219 880	102 430	14 242	9 301	51 438	14 473	7 416	5 420	1 218	13 942
1937	203 072	96 294	19 263	12 786	39 708	17 758	2 537	3 856	1 582	9 288
1938	195 449	96 116	19 335	11 209	40 485	13 890	1 690	1 152	4 644	6 928
1939	213 862	121 373	27 098	18 878	21 462	4 525	3 582	—*	2 396	14 548
1940	146 442	93 582	10 669	26 497	343	436	63	—*	234	14 618
1941	123 486	70 785	1 782	15 713	6	—	—	—*	ø	35 200
1942	113 413	81 120	—	4 020	—	ø	—	—*	—	28 273
1943	127 116	86 023	—	5 056	28	1	—	—*	—	36 008
1944	135 130	86 015	ø	11 088	35	—	2 785	—*	770	34 437
1945	73 763	44 814	279	620	62	—	69	—*	—	27 919
1946	117 597	55 827	3 641	1 251	11 593	3 304	116	—*	ø	41 865
1947	152 464	85 390	1 822	4 524	14 902	6 799	5 036	—*	16	33 975
1948	220 857	131 044	13 080	5 397	29 824	8 753	1 259	—*	...	31 500
1949	216 262	125 855	17 660	27 277	12 190	12 472	1 184	—*	...	19 624

Source: Official publications.

* Estimated.

[1] Does not include fresh sprats (not broken down by country).

[2] Excludes Newfoundland, 1920—1948; includes this province 1949.

Table 6. *Export of various kinds of salted herring from five countries 1938, and 1946—49*

Country	1938	1946	1947	1948	1949
	Metric tons				
Canada[1]					
Herring, smoked	1 627	6 329	4 749	4 898	3 999
Herring, pickled	831	10 635	5 132	7 991	11 572
Alewives, salted	1 804	4 230	1 634	2 773	2 793
Herring, dry salted	8 688	683	5 929	742	1 217
Newfoundland[1]					
Herring, dressed, pickled	258	4 308	1 552	1 590	...
Herring, pickled fillets ..	...	2 844	2 667	1 719	...
Herring, scotch cure	2 337	2 536	3 043	977	...
Herring, split	317	19 616	7 350	11 820	...
Herring, other[2]	104	731	455	965	...
Iceland					
Herring, salted	13 271	14 047	6 603	11 020	10 123
Herring, other[3]	19 617	1 818	[4] ...	[4] ...	[4] ...
Netherlands					
Herring, pickled and salted	69 898	13 269	46 465	44 018	48 209
Herring, smoked or dried ..	4 985	1 401	2 307	4 788	2 817
Anchovies, salted, in barrels	965	—	1	1	217
Norway					
Herring, seasoned and salted	985	2 184	2 950	3 527	2 683
Spring herring, salted	6 500	54 606	28 317	43 705	44 397
Large herring, salted	11 152	35 707	50 918	51 856	44 377
Icelandic herring, salted ..	11 608	5 408	10 012	10 433	13 253
Fat herring, salted	2 270	5 474	2 395	308	1 692
Herring, other[5]	2 090	189	1 232	643	2 324
Sweden					
Herring, salted	3 172	17 761	7 989	24 174	14 882
Small Baltic herring and brisling, salted	52	2 403	465	323	20
Herring, other[6]	508	385	23	95	203

Source: Official publications.

[1] Canada includes Newfoundland only in 1949.

[2] Includes smoked, round, saltbulk, vinegar cured, vinegar-cured fillets, pickled herring roe and milt.

[3] Includes salted young herring, seasoned, marinated fillets, smoked and other preparations.

[4] Included with herring, salted.

[5] Includes seasoned and salted sprats, North Sea herring, young herring cut, salted.

[6] Includes salted sprats, tuna and sardines, salted anchovies, seasoned herring, seasoned and sugar-salted small Baltic, seasoned sprats in barrels.

Table 7. *Exports of salted herring and similar species from six countries, 1920—49* [1]

Year	Total	United Kingdom	Nether-lands	Norway	Iceland	Sweden	Canada[2]	New-foundl.
	Metric tons							
1920	537 876	146 057	73 146	257 365	15 558	10 566	35 184	...
1921	526 103	244 865	80 605	148 895	11 217	3 613	36 908	...
1922	427 912	168 302	34 990	159 475	20 615	4 246	40 284	...
1923	479 974	217 131	49 426	150 673	21 499	6 139	35 106	...
1924	576 825	327 272	77 548	103 629	11 742	5 004	51 630	...
1925	483 805	235 888	60 665	97 322	20 135	2 567	67 228	...
1926	472 371	256 932	67 002	85 157	15 204	3 787	44 289	...
1927	518 679	274 319	68 694	87 811	24 631	4 502	58 722	...
1928	521 924	279 575	77 741	82 493	[3] 18 080	3 653	60 523	...
1929	553 776	303 719	80 246	96 302	13 873	3 020	56 616	...
1930	518 808	257 455	78 716	112 488	18 023	3 102	49 024	...
1931	411 199	185 349	83 077	79 675	16 502	1 382	45 214	...
1932	347 490	165 629	61 802	69 674	25 273	2 312	22 800	...
1933	310 173	132 511	59 959	60 444	23 228	2 456	31 575	...
1934	295 432	145 270	64 109	41 728	20 680	2 647	20 998	...
1935	287 553	157 747	54 472	35 186	15 008	2 329	22 811	...
1936	313 139	140 130	67 840	54 025	25 654	3 310	18 830	3 350
1937	301 988	121 292	85 792	48 864	20 457	3 913	18 782	2 888
1938	302 882	139 845	75 848	34 605	32 888	3 732	12 950	3 014
1939	181 884	55 457	36 565	38 532	27 141	5 734	14 126	4 329
1940	93 833	15 883	15 096	41 601	3 801	2 465	9 858	5 129
1941	71 853	141	118	49 431	7 576	1 543	7 966	5 078
1942	65 357	47	123	46 701	4 725	1 688	6 926	5 147
1943	64 294	9	117	42 468	3 163	ø	10 592	7 945
1944	87 235	ø	...	58 301	1 969	3 989	12 098	10 878
1945	89 218	9 966	...	24 198	11 454	4 320	15 385	23 895
1946	240 501	33 897	14 670	103 568	15 865	20 549	21 877	30 075
1947	230 850	38 617	48 773	95 824	6 603	8 477	17 444	15 112
1948	278 327	49 714	48 807	110 472	11 020	24 592	16 403	17 319
1949	258 611	47 833	51 243	108 726	16 123	15 105	19 581	..[4].

Source: Official publications.

[1] Including smoked, dried, spices and sugar cured.
[2] Excludes Newfoundland, 1920—48.
[3] Including 140 metric tons of boneless herring.
[4] Included with Canada.

Table 8. *Exports of canned products derived from herring and similar species from ten countries, 1930—49*

Year	Total[1]	Portugal	Spain	French Morocco	Algeria	France	Italy[2]	United Kingd.[3]	Norway	U.S.A.[4]	Canada[5]
	Metric tons										
1930	142 059	35 154	18 131	...	1 172	3 988	1 642	4 377	28 356	46 822	2 417
1931	125 276	45 416	20 612	...	803	3 226	1 579	2 628	25 098	24 152	1 762
1932	112 836	43 933	16 563	...	888	2 038	1 380	2 865	31 672	12 086	1 411
1933	100 549	29 274	17 120	5 085	1 276	1 716	1 825	2 704	28 222	11 631	1 696
1934	114 199	34 401	20 450	7 950	846	1 920	2 210	2 633	25 636	15 034	3 119
1935	132 726	39 508	21 762	7 238	612	1 615	2 956	2 939	32 070	20 618	3 408
1936	116 165	42 584	[6] ...	8 068	1 631	1 442	2 120	2 704	34 861	19 363	3 392
1937	121 452	39 284	[6] ...	10 904	2 996	1 909	1 970	3 019	32 916	23 586	4 868
1938	98 820	30 477	[6] ...	12 779	1 980	1 938	1 428	3 005	23 419	18 512	5 282
1939	125 522	40 784	[6] ...	12 711	2 249	1 812	—	2 205	32 777	25 770	8 214
1940	133 207	36 230	5 712	12 072	1 101	744	2 530	1 117	28 565	31 143	13 993
1941	175 130	49 902	8 004	6 903	324	36	1 274	222	18 687	60 358	29 420
1942	140 589	33 832	2 409	5 054	283	35	175	17	16 579	51 203	31 002
1943	145 876	38 964	2 002	5 865	35	6	—	28	9 792	63 345	25 839
1944	103 213	34 829	682	4 163	165	—	—	2	15 415	22 241	25 716
1945	102 998	32 209	1 853	1 735	38	—	—	10	4 780	35 232	27 141
1946	156 980	39 619	2 127	6 337	52	210	3	2 928	25 278	40 417	40 009
1947	153 770	30 688	1 820	10 057	126	586	39	3 707	28 661	32 288	45 798
1948	141 586	33 107	3 187	26 855	1 975	857	70	4 497	27 971	16 640	26 432
1949	...	37 316	...	...	...	...	118	6 777	25 334	48 816	11 152

Source: Official publications.

[1] Does not include Japan.

[2] Includes fish, marinated in oil, fish, pickled in oil and fish, otherwise prepared.

[3] Includes shellfish.

[4] Domestic produce but excludes re-exports of imported merchandise.

[5] Includes Newfoundland in 1949.

[6] Years for which information was not available; apparently effect of the Spanish Civil War years.

Table 9. *Herring and similar species: Average unit value to fishermen, by country and selected species, 1938 and 1946—49*

Country and species	1938	1946	1947	1948	1949
Canada[1]	(....Canadian dollars per metric ton......)				
Alewife	13	26	25	18	...
Herring	8	22	22	26	29
Pilchard	10	21	20	—	...
Sardine	20	35	34	54	44
Denmark	(.... Danish kroner per metric ton ....)				
Herring and sprat	244	511	472	470	...
Iceland	(.... Icelandic kronur per metric ton ....)				
Herring	44	...	...	...	...
Netherlands	(..Netherlands guilders per metric ton....)				
Herring, fresh	59	276	256	251	215
Herring, salted, young	—	26	67	53	294 (salted, young and sea-salted combined)
Herring, sea-salted	92	368	330	365	
Norway	(.. Norwegian kroner per metric ton ..)				
Herring:					
Fat	118	161	185	177	235
North Sea	96	467	442	615	300
Small	28	89	139	87	140
Winter	38	118	157	154	162
United Kingdom	(........ Shillings per metric ton........)				
England and Wales:					
Herring	122	394	417	384	386
Scotland:					
Herring	149	427	413	416	393
United States[2]	(...... U.S. dollars per metric ton......)				
Alewife	20	54	45	...	...
Menhaden	7	19	24	...	...
Pilchard or sardine	13	30	50	...	...
Sea herring	12	25	26	...	...
Shad	190	309	320	...	...

Source: Data computed from official sources.

[1] Excludes Newfoundland.

[2] Includes Alaska.

Table 10. *Average unit value per metric ton: Fresh and frozen, dried, salted and smoked herring and similar species — exports, 1938 and 1946—49*

Country and commodity form	1938	1946	1947	1948	1949
Canada[1]	(....Canadian dollars per metric ton ....)				
Herring, fresh and frozen ..	24.5	35.0	35.1	52.6	47.1
Herring, smoked	80.6	[2] 310.2	[2] 261.3	[2] 236.0	226.2
Herring, pickled	61.9	165.5	151.1	142.0	183.6
Alewife, salted	44.6	137.4	142.2	140.7	143.0
Herring, dry salted	25.5	95.3	112.9	111.2	104.0
Newfoundland[1]	(.... Canadian dollars per metric ton ....)				
Herring, fresh and frozen ..	5.6	57.3	88.4	53.1	[1] ...
Herring, dressed, pickled ..	54.8	151.6	150.4	163.2	[1] ...
Herring fillets, pickled	...	197.4	221.7	216.9	[1] ...
Herring, Scotch cured	61.9	156.3	156.0	156.8	[1] ...
Herring, split	39.1	159.8	132.9	132.6	[1] ...
Iceland	(.... Icelandic kronur per metric ton....)				
Herring, fresh and frozen ..	234.4	1141.9	514.8	540.0	831.8
Herring, salted	[3]	[3]	2005.0	2068.5	2050.6
Herring, salted	235.6	1706.2	[4] ...	[4] ...	[4] ...
Young herring, salted......	354.0	2268.7	[4] ...	[4] ...	[4] ...
Herring, seasoned, salted ..	318.3	2232.6	[4] ...	[4] ...	[4] ...
Herring,salted and marinated	344.6	2105.4	[4] ...	[4] ...	[4] ...
Herring fillets, salted	675.9	6570.0	[4] ...	[4] ...	[4] ...
Netherlands	(.... Netherland guilders per metric ton..)				
Herring, fresh and frozen ..	85.3	411.3	409.3	387.3	346.2
Herring, pickled and salted	82.2	469.4	416.8	530.7	516.4
Herring, smoked and dried.	132.9	1035.0	834.4	872.8	824.3
Anchovies, salted in barrels..	429.3	—	2000.0	2000.0	1424.0
Norway	(.... Norwegian kroner per metric ton ..)				
Herring, fresh	135.6	334.9	360.5	378.0	396.6
Herring, seasoned and salted	247.8	1127.7	1203.1	1166.1	1139.4
Spring herring, salted	146.4	521.0	577.7	579.3	603.4
Large herring, salted	158.1	561.1	637.4	629.9	652.9
Icelandic herring, cut, salted	259.2	1200.8	1310.0	1314.5	1254.8
Fat herring, salted	532.8	1073.8	974.1	1120.1	962.2
Small herring, cut, salted ..	354.2	1076.3	1097.1	1000.0	1193.2
North Sea herring, salted ..	309.5	...	870.3	833.6	806.6
Sprat, seasoned and salted	341.6	—	2200.0	1998.0	1456.3

Table 10 (continued). *Average unit value per metric ton: Fresh and frozen, dried, salted and smoked herring and species — exports, 1938 and 1946—49*

Country and commodity form	1938	1946	1947	1948	1949
Sweden	(.... Swedish kroner per metric ton ....)				
Herring, fresh	220.8	444.6	520.3	434.7	376.0
Herring, salted	279.1	509.4	669.6	582.8	621.5
Small Baltic herring and brisling, salted	227.2	474.8	387.3	447.9	650.0
Sprat, fresh	190.7	523.2	577.6	551.1	447.9
Kind of herring, salted	267.6	707.3	—	709.3	728.6
Herring, seasoned and sugar-salted	327.4	1516.9	—	1025.0	1048.2
Sprat, seasoned in barrels .	333.3	717.3	1195.8	1008.7	1060.0
United Kingdom	(.... Pound sterling per metric ton ....)				
Herring, fresh or frozen....	9.4	35.5	33.3	33.3	34.1
Herring, cured or salted ..	14,6	46.9	51.9	50.7	51.2
Pilchard, cured or salted ..	21.9	62.2	64.6	—	—

Source: Official publication.

[1] Canada excludes Newfoundland 1938, 1946—48; includes Newfoundland in 1949.

[2] Includes smoked kippers and bloaters.

[3] 1938, 1946: "Herring, salted" subdivided into several categories.

[4] Included in "Herring, salted".

SYMBOLS

used in the tables.

... Not available.
— Nil or negligible.
* Estimated.
ø Less than half the final digit.

EFFORTS TO INCREASE SALES AND EXPORTS OF HERRING PRODUCTS

A paper presented by *H. H. Goodwin,* Chief Executive, Herring Industry Board, Edinburgh, Scotland.

In several of the papers presented by British scientists in this book, references are made to new products and to methods of processing which might enable herrings to be distributed far more widely than has hitherto been possible. To a considerable extent, the lines along which efforts to increase consumption should be directed have been indicated and it seems unnecessary again to go over technical ground which has already been covered. The scope of this paper is, therefore, limited to a brief account of the work actually done, being done or planned to be done by the Herring Industry Board and by the trade itself in attempting to widen and increase the distribution and consumption of herrings and herring products.

The Herring Industry Board is the Government agency charged with the duties of re-organising, regulating and developing the British herring industry. It is not a Marketing Board; but its constitution imposes on it the duty to organise and assist the industry so that the fishermen are assured of the maximum outlets for their catch and the processing and distributive sides of the maximum degree of activity, with consequent economy of operation to all and benefit to the consumer.

Generally, the Board does not participate in the processing or trading activities of the industry; but, if a task is too great for the individual members of the industry, or if the industry fails to interest itself in particular problems, the Board then enters the field.

In 1946, the Board enunciated a policy of expansion in herring catching and processing, based on the suppositions that circumstances would be more propitious than they had been in pre-war years for increasing mutual trade between producer and consumer nations and that the development of backward countries (with consequent improvements in standards of living) was likely to be a matter of prime concern to all interested governments. In the years 1946, 1947 and 1948, there was every indication that this policy was right. In 1949, however, evidence began to accumulate that, although the real demand for herring and herring products in European markets might continue to expand, distribution and potential consumption were likely to be frustrated by politico-economic factors beyond the control of the Herring Industry Board or of the industry itself.

Fully appreciating the consequences of a contraction of the traditional export markets, the Board has first turned its attention to the home market, which seems to be capable of considerable development.

It is a surprising fact that, in Britain, which is a heavily railroaded country, with a highly developed transportation system, where no town or village is more than about 120 kilometres from the sea, there are consumers who cannot be certain of obtaining supplies of fresh herrings and herring products as and when they want them.

This situation has existed for many years; but it was aggravated by the deterioration in distribution methods, in standards of quality and in transportation services which occurred during and after the recent war. Between 1939 and 1949, the consuming public were all-too-frequently supplied with stale herrings and equally stale and, in addition, poorly smoked kippers. These factors have caused the demand for fresh herrings and kippers to decline as the supply af alternative foodstuffs has improved and rationing has been relaxed. Between the spring of 1948 and the winter of 1949, home-market consumption fell below its post-war peak by about one third and, in the 1950 Scottish summer season, it was on a level below that of 1938.

The steps which have now to be taken to stimulate and develop demand in the home market are so many and various as to be beyond the capacity and resources of individual traders and the Board has, therefore, accepted responsibility for the task. Propaganda of all kinds; the co-ordination and improvement of distributive arrangements; the education of retailers; the production and maintenance of buffer stocks of quick-frozen products at strategic centres to ensure regularity of supply; are all included in the Board's plans for ensuring that every potential domestic consumer shall be both encouraged and able to buy herrings and kippers in first-class condition when and where he or she wishes.

Processing and distribution facilities of certain kinds, for example quick-freezing and low-temperature cold storage, are at present insufficient to provide and market all the herrings and kippers that the Board believe will be needed when the machinery of distribution has been overhauled and public confidence in the products of the industry re-established. Steps are, however, being taken to provide these facilities on an increased scale.

The difficulties which are now being experienced in marketing herring have caused a slowing down in the rate of construction of new fishing craft and are forcing out of service many of the older and less economic catching units. If catching power is thus reduced, so that the high level that was envisaged in 1946 is not attained, the availability of herrings for export purposes may also be reduced; particularly if the Board's efforts to expand home-market consumption are successful.

Notwithstanding the shift of emphasis from exports to the home market, the Board has not and does not intend to lessen its efforts to find new and re-develop traditional outlets abroad for their cured, red, canned and kippered herrings.

So far as the first of these is concerned, although there has been and is likely to continue to be a recession in the demand for hardcure, there is no reason to think that there will be a corresponding fall in the demand for cured herrings of the kinds that can be classed as delicacies — for example, matjes, — provided that no new artificial barriers to trade are erected by those countries in which the bulk of the consumers are found. Indeed, it is considered that, if particular attention is paid to packaging and to the opening up of those channels of distribution which will become available as a result of changes in packaging methods, a considerable increase in the sales of cured herring in the form of delicacies and specialities can be effected.

British red herrings continue to find ready acceptance in traditional markets and new outlets have been developed since the war in East and West Africa and in the Caribbean Islands. In this last area, however, demand appears to be due mainly to the (perhaps temporary) lack of dollar purchasing power, which has interrupted the long-standing trade between the British West Indies and Canada.

British canned herring are consumed throughout the world; but, whilst the development of all markets proceeded satisfactorily during the three or four years immediately after the war, the canners are now finding it increasingly difficult to sell in the face of competition which appears very much to resemble the "dumping" practices experienced in some pre-war years.

The Selected Scotch kipper can justly be claimed to be without equal in the world. Nature has, unfortunately, put a limit on production, since the herrings from which these kippers can be produced are caught for only a relatively short period each year. The contribution that this outlet can make to the usage of British-caught herrings is, however, important and a vigorous campaign has been launched in the U. S. and Canada to increase its sales. Distribution in other countries is envisaged; but, at any rate for the time being, the markets for this product must be of the "luxury" rather than the "mass" class.

It is unnecessary to give here an account of the techniques of market research and development which are being applied in those countries in which it is known that there is a potential reservoir of demand for orthodox types of herrings and herring products, since such techniques are widely known. It may, however, be of some interest to the Conference to learn how the problems of the African markets — to which it has been suggested that particular attention should be paid — are being approached by the Herring Industry Board.

Experience has indicated that only some of the usual techniques of market research can be applied in the case of native peoples. One of the most useful and informative methods of ascertaining the likes and dislikes of the consumer — that is, question-and-answer — cannot be used because the instinctive reaction of natives to questioning is to give the answers that they think will please the questioner. Similarly, product-testing is of relatively little value in Africa, since peoples on a bare-subsistence level, to whom food of any kind represents one of the most important elements in living, are apt to accept with every evidence of enjoyment anything that is recognisably edible — for which they are not asked to pay. There are, of course, exceptions to both the foregoing generalisations; but they are so substantially true in the great majority of cases that it has been considered prudent to adopt, in the African markets, methods of research which, although laborious, are likely to prove more reliable than those which have been brought to so complete a pitch of perfection in Europe, the Americas and Australia.

In British Colonial Africa — as, no doubt, in other parts of that continent — up-to-date official information is available about local fish production and imports. Published statistics provide the first clue to market-development possibilities, since they reveal the overall pattern of supply and dietary habits. Much valuable information about the local production and consumption of fish; about the sufficiency, or otherwise of local supply in relation to local needs; about the form in which local supplies are supplemented by imports; and about sources of supply of imports can be had from what may appear to be an uninteresting assemblage of facts and figures. Although statistics of this kind can be most helpful, however, their full significance can only be evaluated by further enquiries on the ground. Trade sources can often provide useful information about local tastes; but it has been found advisable to hesitate before accepting such information at its face value. It is by no means uncommon to discover that what sells is merely what is made available and not necessarily what is most covetable. There is an element of fatalism in the make-up of native peoples which seems to account for their apparent readiness to accept something which they do not really covet because the possibility that anything nearer to their desires might be procurable is completely beyond their comprehension.

The accumulated knowledge of those officials in the Government Service who come into daily contact with the native peoples and who know their likes and dislikes intimately is invaluable to reinforce or to contradict trade information and statistical indications.

One of the purposes of this study is to explore the suggestion that herring might provide a part of the protein in which the diets of many African and Asiatic people are thought to be deficient. Research of the sort which has been briefly mentioned in the foregoing paragraphs gives an indication of the acceptability or otherwise of fish as a foodstuff and suggests the forms in which herrings could be presented. The official reports of the various health authorities show the extent to which the general level of nutrition falls short of what is desirable. Armed with this information, it has been possible to assess the requirements of the markets. The word "requirements" is used here because the statistics which disclose the purchasing power of the potential consumers reveal, in those cases into which the Board has enquired, that the satisfaction of their needs is likely to be frustrated by economic causes. A clear distinction has, therefore, to be drawn between what is needed ("requirements") and what is marketable under normal commercial conditions ("demand").

Parallel with its market-research activities, the Board has been engaged in attempting to discover means of processing herrings caught in British waters so that the products would be distributable in the extremes of temperature and humidity encountered in Africa and, at the same time, acceptable to the consumer. Progress has been slow; but, although it is too early to draw firm conclusions from the work that has been done so far, it is established that there are relatively "orthodox" products of the British herring industry which are suitable for distribution in Africa. Costs of production and distribution have not yet, however, been brought down to the level at which the products can be assured of a market large enough to warrant large-scale production. In brief, the politico-economic factors which are frustrating the full development of demand for herring in Europe have their counterpart in the social-economic problems of Africa. Whether or not it is feasible to put native peoples into the economic state which would allow them to bring their diets up to a satisfactory nutritional level is a question which really falls outside the scope of this paper. It is mentioned, however, because it must be appreciated that the major problems of the herring industries lie less in the technical sphere than in the realm of economics. Granted access — in the fullest sense of the word — to the potential consumers of the world, not only in Africa and in Asia, but also in the traditional herring-eating countries of Europe, there are no technical problems which are incapable of solution by those engaged in the industry. It is not for a moment suggested that the need for technological improvements and advances has been lessened by the tendency of markets to contract. Indeed, at every stage from sea to consumer, there are virtually unexplored fields for research. But, unless the researches lead to substantial savings in costs of production and distribution, the benefit likely to be derived from them will be relatively small and enjoyable by an insignificant fraction, only, of the population of the world.

Chapter 4

POSSIBILITIES FOR FINDING MARKETS FOR HERRING PRODUCTS IN ASIA AND AFRICA

This chapter contains:

POSSIBILITIES FOR EXPORTING HERRING PRODUCTS TO ASIA AND THE FAR EAST, a paper prepared by *G. L. Kesteven*, FAO Regional Fisheries Officer for Asia and the Far East, Bangkok, Thailand;

USE OF HERRING PRODUCTS IN THE BRITISH DEPENDENCIES, a paper prepared by *C. F. Hickling,* Fisheries Adviser to the Colonial Office, London, England;

Extracts from FISHERY PRODUCTS OF INDOCHINA, a paper submitted by *J. Westenberg* in charge of the Service of Sea Fisheries, Paotere-Makassar, Indonesia, originally presented at the FAO Indo-Pacific Fisheries Council's Meeting, April 1950;

POSSIBILITIES FOR IMPORTING FISH INTO TROPICAL COUNTRIES, notes prepared by Dr. *A. G. van Veen,* Nutrition Division, FAO;

PRICES, FREIGHT RATES, YIELDS, ETC., FOR SOME FISHERY PRODUCTS, information collected by *Mogens Jul,* Fisheries Division, FAO, Rome, Italy;

and information from the discussions of the meeting.

Introduction

As mentioned in the introductory chapters, one of the main purposes of the meeting was to explore the possibilities of finding new markets for traditional herring products or of developing new herring products, which could find outlets where the traditional ones were not in demand. Of special interest here were the possibilities of developing herring products acceptable to protein-needy population groups, presumably especially in Asia and Africa. In the main, these products would probably have to be inexpensive, stable products, of a type quite different from those which appeal to the North Western European palate.

POSSIBILITIES FOR EXPORTING HERRING PRODUCTS TO ASIA AND THE FAR EAST

G. L. Kesteven's paper

This paper has been prepared with the objective of bringing together whatever data could assist in permitting a conclusion on the possibility of exporting herring products to Asia and the Far East. It takes as a starting point the two incontrovertible facts, firstly that Asia generally stands in need of a greatly increased supply of protein food such as fish, and, secondly, that certain countries, especially European and North American, have generally a surplus of herring catch, disposal of which could bring many economic and other advantages to those countries. The paper seeks to furnish the data by which a decision might be reached as to whether the European countries could, in technical and financial terms, meet the requirements of the Asian consumer. It does not attempt to approach the question of the political implications of the promotion of such trade.

The paper makes the following fairly simple approach: in the first place Asian food habits and the requirements of the Asian consumer are examined; the ways in which these requirements are met by the local industry are considered, and finally the trade in fishery products in the area is examined.

The Role of Fish in Asian Diet

It is unquestionably true that fish[1] is a foodstuff of major importance in Asia and that in the diet of the Asian people, as a total, it ranks second only to rice. Some people in the region do not eat fish at all, either because of some social considerations or because there is none available. There are others who eat fish only occasionally, because it is only occasionally available. But it is true that the majority eat fish frequently and that for very large numbers, the majority, fish is the major, if not the sole source of animal protein.

Numerous nutritional reports emphasize the importance of fish in Asian diet and recommend that steps be taken to increase the supply. Thus the Nutrition Committee at the FAO Meeting at Baguio in the

[1] The term "fish" is taken in the widest possible sense to mean all foodstuff of aquatic origin (except minerals) and conversely, the resources from which these are drawn.

Philippines in 1948 (FAO 1948), and the same Committee meeting again in Rangoon in 1950 (FAO 1950), has recorded the simple fact that fish is a valuable source of protein and that, therefore, its production should be increased in most countries in the East. The Famine Inquiry Commission (India 1945 A) reporting on the Bengal Famine of 1942 made similar observations and the Committee on Nutrition (in the Colonial Empire) of the Economic Advisory Council (United Kingdom 1939) found unquestionable importance attached to fish in the greater part of the British colonies of that time.

In addition to this undoubted significance as a source of protein, fishery products play an important role as a diversifier of diet.[2] This applies particularly to the sauces and the pastes which are produced in considerable quantities and are consumed very generally in at least the eastern half of the region; these products are used in small quantities at each meal as condiments to flavor the more neutral foodstuffs such as rice and vegetables.

It may be accepted that fish is a staple item of Asian diet and that Asian cooking makes extensive use of it. As an example may be quoted the work of Canton and others (1940) who surveyed the foods of Singapore and found that of nearly eight hundred dishes sold in restaurants and served in private homes more than 25 per cent made use of some fishery product or other.

At this point too it may be well to stress that the range of fishery products in use in Asia covers many very highly flavored items and that this flavor aspect is one of much importance.

The Market for Fish in Asia

There seems to be little reason to doubt that this situation, in which fish is quantitatively and qualitatively of great importance in the area, is one which has developed more or less of necessity. Fish is used as the major protein source because supplies of fish are most easily obtained: beef, mutton and other meats are generally scarce and where fish also is scarce, there is protein deficiency in the common diet. Again because of climatic conditions and technical circumstances only a limited proportion of the total catch can be delivered fresh to the consumer at the rate at which he is likely to consume. The situation today is undoubtedly

[2] It had been suggested that the expression "diversifier of diet" is inadequate and that this part of the role of fishery products is "to render neutral foodstuffs more appetizing".

improved over the situation of the past but even today transport and storage facilities are grossly inadequate. As a consequence of this situation special modes of preservation have come into use and, it may be noted, are multifarious. These preservation methods are generally rather primitive and do little beyond exploiting natural circumstances: much use is made of salt and of fermentation controlled within broad limits; the scope is generally indicated as an intelligent exploitation of limited technical facilities. Nevertheless, despite the fact that the primary need for preservation methods is probably the same now as ever it was, namely to hold excess supplies, it is also true that the products which result now command a definite market and must be recognized as a separate commodity distinct from fresh-fish. That this is so is indicated by the consumer preference, the range of forms, and of prices paid, and the operation of the saltfish markets independently of the fresh-fish markets. The situation may be recognized as one in which there is a widely and firmly established acquired taste for which supplies should be made available. This is not to say that the taste could not be modified; it is intended at this stage only to indicate that the taste exists and that the demand is qualified thereby.

Forms in Which Fish is Consumed

The following is a brief classification of the forms in which fish is sold to consumers in Asia:

1. Fresh fish
   a. alive
   b. killed but not iced or otherwise preserved
   c. iced
   d. frozen
2. Processed
   a. dried
   b. salted
      wet
      dried
   c. boiled
   d. converted to paste
   e. converted to sauce
   f. fermented
   g. smoked
   h. canned

Within each of the above categories there are not only the different species of fish delivered in these forms, but also the very many different ways, in the case of processed fish, of carrying out the general process. Of the fresh-fish, much is sold in the round, some is gutted, gutted and headed, and some is sold filleted or cut into steaks. Many of the modes of processing are listed in a paper by Westenberg (1950) extracts of which is found later in this chapter; many more could be added. It seems that there is a need for a comprehensive description of the modes of processing in Asia. Special note should be made here of certain specialty products which should be considered in any examination of the fish trade of the area: reference is made *inter alia* to such products as sharks fins, fish maw (stomach), dried eggs (of fish and crab), dried mussels, dried squid, bêche-de-mer, and seaweeds.

In terms of actual utilization it may be reported that the Asian fish consumer has, in general, a considerable skill in the preparation of fish (as well of course, as of other foods) for consumption. Every possible mode of cooking is employed. Some fish is eaten raw and in this case various condiments and naturally highly flavored vegetables are used. Cooking in the more usual sense of the word involves boiling, broiling, steaming, baking, frying and roasting; sauces, condiments, vegetables and meats may be used to supplement or to emphasise the flavor. Rice is usually consumed with dishes which are almost solely fish and with curry preparations and similar dishes containing fish. The so-called fish-sauces ("nam-pla", "nuoc-nam", "patis") are used in the usual manner of sauces, for flavoring other dishes. The pastes may be cooked, by baking or other method, for straight consumption with vegetables; or they may be used as condiments to flavor other main dishes or mixed with other condiments, or used as a substantial flavoring of special dishes made up with principal base of rice. In general, fish in the various forms available may be taken simple supplemented by more or less neutral-flavored foodstuffs such as rice or vegetables, or may be taken fairly simple among a number of foodstuffs of more or less equivalent flavor value, or it may be mixed with other foodstuffs to contribute to a special dish, such as fish balls, curries and so forth, or it may be taken itself in quantities such that it is a flavoring supplement to other main dishes. A fairly representative, but small, schedule of "recipes" is given in *Appendix A*. Others may be obtained from such sources as Canton and others (1940).

Quantities of Fish Consumed

Although dieticians have probably accumulated substantial data on the amount of fish consumed by Asian people, there is very little of such information available in this office and accordingly the following statement is based largely on general impressions and isolated pieces of information.

It might have been thought that a first approach could be made to this question by way of comparison of production figures with estimates of population, but unfortunately the statistics are rarely contemporaneous or usefully comparable. Estimates of the population of Asia[3] set this at roughly one thousand million persons (*Table 1*); recent estimates of fish production suggest an amount in the order of ten million metric tons (*Table 2 B*). These figures indicate an average availability of 10

Table 1. *Asian population*

Territory	Population 1938	Population 1948
	Millions	Millions
Burma	16 250	17 000
Ceylon	5 810	7 095
China	545 425	463 493
Formosa	5 575	6 100
Jehol	....	6 100
Manchuria	....	38 200
Sinkiang	....	3 700
Tibet	....	3 700
India	308 095	342 114
Japan	70 318	80 171
Korea	23 684	28 200
Pakistan	66 825	73 321
Philippine Republic	15 814	19 125
Thailand	14 755	17 666
French India	0 305	0 348
Indo-China (French)	23 400	27 030
Ryukyu Island	0 799	0 886
Indonesia (including Netherlands New Guinea)	68 409	76 360
Portuguese India	0 611	0 667
Portuguese Timor	0 482	0 440
British Borneo	0 780	0 923
Federation of Malaya	4 495	5 000
Hong Kong (British)	1 479	1 800
Singapore (British)	0 722	0 964
Various Islands	1 222	1 419

[3] The term "Asia" here includes all Middle East countries and Russian territory.

Table 2 A. *Availability of fishing products in some countries*[1]

Unit: 100 kg. Estimates of availability

Country	Export/Import Balances					Totals		
	(1) Fish Fresh	(2) Dried	(3) Otherwise Preserved	(4) Crustacea	(1)+(2)+(3)+(4) Total	(1)+(2)+(3)+(4) = (5) adjusted to round fresh weight	(6) Domestic Production	(5)+(6) Total Availability
Ceylon	+ 226	+237 919	+ 9 621		+247 766	+ 495 000	400 000	895 000
China	+ 30 240	+298 450		÷ 7 270	+321 420	+ 613 000	27 000 000	27 613 000
India/Pakistan		÷ 23 202	+ 8 308	÷ 23 989	÷ 38 883[2]	÷ 78 000	9 072 000	8 994 000
Indochina	÷ 5 420	÷322 000	+ 3 830	÷ 13 000	÷336 590	÷ 668 000	2 660 000	1 992 000
Indonesia						+1 000 000	4 720 000	5 720 000
Japan	÷163 640	÷142 110	÷887 450	÷122 220	÷1315 420	÷2 467 000	56 370 000	53 902 000
Malaya	+ 51 907	÷ 10 090	+ 23 228	—	+ 65 045	+ 78 000	420 000	498 000
Philippines	+ 1 110	+ 11 423 + 8 704[3]	+133 709	+ 6 625	+161 571	+ 322 000	2 700 000	3 022 000
Singapore		÷ 9 835	+ 10 821		+ 986	+ 2 000	131 379[4]	133 000
Thailand	÷ 5 926	÷250 736	+ 6 856		÷249 806	÷ 494 000	1 950 000	1 456 000

[1]) Most of the data are for 1938 or 1938/39 and are either official statistics, republished in the FAO Fisheries Yearbook, or are estimates. [2]) This figure is not crustacea but manure made from fish. [3]) This figure is for fish meal imported. [4]) This figure, which is for 1936, represents total landings in the Colony and includes landings from outside, much of which is nowadays counted as "imported" fish.

Table 2 B. *Availability of fishing products in some countries*

Estimates of per capita consumption

Country	Availability	Population	Per capita Consumption
	metric tons	millions	kg
Ceylon	88 500	5 810	15.2
China	2 761 300	454 425	6.1
India/Pakistan	899 400	374 920	2.4
Indochina	199 800	23 400	8.5
Indonesia	572 000	68 409	8.4
Japan	5 406 600	70 318	76.9
Malaya	49 800	4 495	11.1
Philippines	302 200	15 814	19.1
Singapore	13 300	0 722	18.5
Thailand	145 600	14 755	9.9
Total	10 438 500	1 033 068	
		Grand average:	10

kg (22 lb.) of fish[4] per person per year. Of itself, considering the enormous size of the population, the considerable distances, and the economic, social and geographic diversity of the region, this figure is most impressive. There is every reason to believe that the production figures are low by virtue of an inability to assess the subsistence (or familial) catch, which is considerable both along the seaboard and on inland waters. Whilst there is an appreciable volume of fish-oil and fish-manure production which diverts a proportion of the landings away from human consumption, and a small amount of export to countries outside Asia, it is probable that these diversions are more than off-set by the unassessed catch and the importations. It is, therefore, assumed with confidence, that the average availability of fish in the round to Asian consumers is not less than 10 kg (22 lb.) per person per year.

However, this is, of course, merely a statistical mean availability. It would be preferable to ascertain the real availability which, conceivably, could be expressed in forms indicating on the one hand the physical availability and on the other the ultimate, consumers' availability meaning what lies within the consumers' purchasing power, being determined by conditions of supply, cost of procurement, transport and so forth.

It is known that there are some groups which do not consume fish

[4] It is hardly necessary to point out that this is the calculated average availability of round fish, the nutritional significance of which would be extremely variable.

at all. In making an estimate of fish consumption of pre-partition India, the Marketing Adviser to the Government of India (India 1946) counted as non-consumers of fish: (a) Jains, (b) Buddhists, (c) 15 to 35 per cent of the total Hindu population depending on the tracts, (d) children under 5 years of age (13 per cent) and people aged 65 and over (2 per cent) and (e) Hindu widows of Bengal; in this way was excluded (for statistical calculations) 30 per cent of the Indian population from sharing the available fish supply. Such broad categories would certainly not be valid elsewhere in the region and it is reasonably doubtful whether the proportion of Asian peoples who do not consume fish (because of objection or rule) would be as high as 30 per cent. However, the numbers of non-consumers of fish are greatly increased by the non-availability, in economic and/or geographic sense, to large areas of interior country. The same source (India 1946) says "Enquiries have shown that in every province and state there is hardly any town which does not receive some supply of fish, however small, for consumption, while there are vast tracts of rural areas where no fish is ever seen." A similar situation exists in China and to a lesser extent in respect of the hill-tracts of Thailand and Indochina. It is however impossible to set any figure for proportion of population to whom fish is actually available and by whom it is consumed. Nor would it be of much value, for the purposes of the present examination which is essentially comparative, to reduce all population figures by any constant factor, say to 70 per cent, as in the case of India.

The gross availability of fish varies greatly from country to country. *Table 2 B* gives some very approximate estimates which range from a figure of 2.4 kg (5.3 lb.) per person per annum, for India, to 76.9 kg (169.5 lb.) per person per annum for Japan. The former is probably too low and the latter too high. It is extremely interesting that four countries, Ceylon, Indonesia,[5] Indochina, Malaya and Thailand have figures fair close to one another, for two of these countries (Indochina and Thailand) are major exporting countries and one (Ceylon) imports approximately half of its requirements. It is no doubt significant that these are small countries with inland depth in the case of only one, and that there exist substantial inland fisheries. Both of these facts mean

[5] Dr. de Jong in personal communication informed the author that average consumption of about 12 kg. (26½ lb.) per annum was found to be rather characteristic of certain communities on small islands. He thought that perhaps this level of consumption was what might be regarded as "average", making use of some fish for eating as fish and some for flavoring — — above this level would be characteristic of communities which were distinctly fish-eating, whilst below it fish would be a "flavorer".

Table 3. *Estimated per capita consumption of fish in different areas*

	Quantity of fish available for consumption	Population (1941 census)		Per capita consumption	
		Total	Estimated number of persons who have no objection to eating fish	On the basis of total population	On the basis of number of persons who eat fish
	Maunds, omitted 000	000 omitted		lb.	
Assam	482.9	10 930	8 785	3.64	4.52
Baluchistan	81.0	858	729	7.77	9.14
Bengal	5 027.4	61 460	45 618	6.73	9.07
Bihar	882.7	36 340	23 621	2.00	3.08
Bombay	1 736.9	20 850	13 498	6.85	10.59
Central Provinces	165.0	18 606	12 568	0.73	1.08
Cochin	251.8	1 205	1 059	17.19	19.56
Delhi	10.0	918	650	0.90	1.27
Hyderabad	41.6	14 436	10 314	0.24	0.33
Kathiawar	71.3	4 904	2 223	1.20	2.64
Madras	4 946.2	49 840	29 886	8.16	13.62
Mysore	101.7	6 557	4 710	1.28	1.78
North-West Frontier Province	8.7	5 416	4 603	0.13	0.16
Orissa	565.8	13 370	10 331	3.48	4.51
Punjab	36.6	34 310	28 535	0.09	0.11
Sind	435.9	4 535	3 675	7.91	9.76
Travancore	1 087.0	6 080	4 826	14.71	18.53
United Provinces	139.9	56 346	35 928	0.20	0.32
Total India	16 072.4	388 800	—	3.40	—

that fish supplies could be more readily available than in the case of broader countries and of countries without inland fisheries. Whilst insufficiency of fish supplies is undoubtedly general for the area, it is probably most acute in the two countries of greatest population, China and India. In respect of the latter there is available, in the report referred to (India 1946), analysis of *per capita* consumption.

The gross average for the country was then estimated at 3.4 lb. (1.54 kg); this figure was reached before any adjustment in respect of those by whom fish was thought not to be eaten; this adjustment brought the average consumption to 4.9 lb. (2.22 kg). The examination proceeds further to consider variations in consumption in different areas; the results of this examination are given in *Table 3*. It shows a range of adjusted *per capita* consumption from 0.11 to 19.56 lb. (0.05 to 8.87 kg). The highest figures relate to those states "with long stretches of coastline and immense inland-fishing resources". Within these areas there was a further extreme variation and the case is quoted of Bombay Province which had an overall average of 10.59 lb. (4.80 kg) whilst certain coastal districts of that state had consumption greatly in excess of this, estimated at about 82 lb. (37.2 kg) per person.

Availability of fish, as a function of distance from producing area, generally diminishes rapidly inland; it is true, no doubt, that this decrease occurs at a greater rate in India, and other Asian countries, than in many countries of the West. The decline, of course, is not only away from sea fisheries, but has relationship also with freshwater fisheries and since these are diffuse (and not geographically linear in relation to population) their effect in making fish available is more noticeable. Again, the presence of transport and other facilities serving towns and cities makes fish available to the urban populations of states whose rural population may be entirely denied fish supply. This is shown in the following rather striking *Table 4* from the same source (India 1946).

Detailed information, such as the foregoing from India, is not available in respect of any other country of the region but relatively the same situation prevails throughout the region, having regard, that is, for levels of supply and the geographic distribution of the industry. In the

Table 4. *Per capita consumption of fish in various areas*

Name of the centre	Per capita consumption	
	Urban consumption	Corresponding provincial consumption
	(lb.)	(lb.)
Bombay	16.02	6.85
Calcutta	21.38	6.73
Calicut	52.10	8.16
Cuttack	13.29	3.48
Delhi	1.02	0.90
Jubbulpore	1.38	0.73
Lahore	0.69	0.09
Madras	15.89	8.16
Bangalore	38.57	8.16
Peshawar	2.64	0.13

Table 5. *Fish consumption in certain towns in ceylon*

In ounces per consumption unit per day

	Uduy-am	Tahw-atta	Goha-godu	Talai-manar	Nol-Pum	Koh-dan	Mora-wala	Pade-miya
Fresh Fish	1.1	0.0	0.0	6.4	2.8	1.1	3.2	0.1
Dried Fish	0.8	1.1	0.7	0.7	—	0.9	0.4	0.6

province of Bataan in the Philippine Republic, a dietetic survey reported by Salcedo and others (1948) showed that "Two thirds of the families surveyed reported the use of meat only once a week; fish was consumed by 90 per cent of the families 6 or 7 times a week; vegetables of some sort were used, by more than half the population, not more than twice a week". For certain towns of Ceylon the consumption rates were found to be as shown in *Table 5.* This indicates a range of consumption from nothing to 66 kg (146 lb.) per unit per annum of fresh fish, and of 4.1 to 11.3 kg (9.0 to 24.9 lb.) of dry fish per unit per annum. Using a factor of 3 for conversion of the dry-fish figures to equivalent round wet weight, the figures of the above table indicate a gross consumption of fish ranging from 17 kg (37.5 lb) per annum per unit to 88.2 kg (194.5 lb.) per unit per annum. The latter is considerably greater than the figure quoted above for coastal towns of Bombay Province.

Detailed dietary studies have been made in Indonesia, some results of which have been published in a recent paper by Portmus and Van Veen (1949). These showed per capita consumption in various districts, ranging from 80 kg (176 lb.) per annum to 41.25 kg (90.9 lb.) per annum.

The total effect of the evidence on fish consumption in the area is that there is a very considerable range of rates, with most people eating some fish, a few eating a great deal, and moderate numbers eating none.

The Production of Processed Fish in Asia

Methods of Production. The methods of production of various forms of processed fish by the fishing industry of Asia have been reasonably well-documented in a number of papers, but these accounts have not been brought together, except for the industry of Indochina and adjacent territories, and there is a need for a comprehensive compilation. The following papers will furnish a fair idea of the main features of the methods

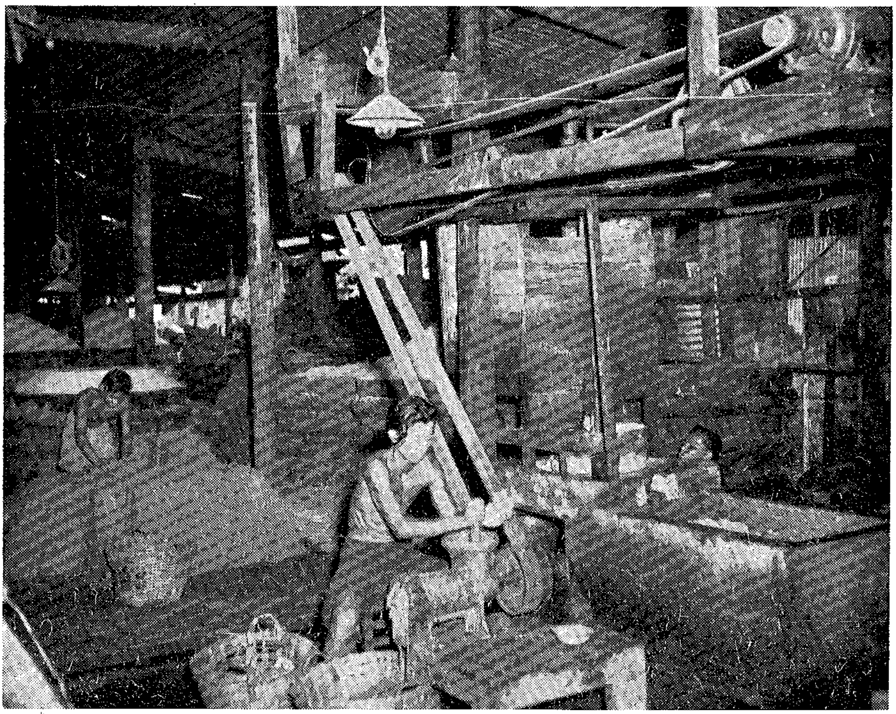

Fig. 1. *General wiew of a shrimp-paste factory in Thailand, showing heaps of paste, paste grinder, and salt grinder. (Kesteven, FAO, Bangkok).*

employed: Westenberg (1950), Anonymous (India 1946), Le Mare (1950), Deraniyagala (1933), and Lemasson (1949).

The most important method is drying and salting; the Indochinese methods are summarised by Westenberg (1950), and a more detailed account, prepared for the use of administrators concerned with the identification of processed fish, is being prepared by Lemasson (1949). These descriptions are valid for the most of the eastern part of the region, *i.e.,* from Burma eastward. Deraniyagala (1933) gives an account of Ceylonese methods and the Indian methods are described in a Report of the Agricultural Marketing Adviser of the Government of India (India 1946). On the western side of the region much use is made of sun-drying techniques, even without the use of salt. The methods in use here seem to be primitive and frequent attempts have been made to change them. The methods of the eastern half are more complex as will be seen from the account of them given by Westenberg (1950); a special note should be made of the degree to which fermentative processes are combined with the curing and drying.

Smoking is a method which is practised throughout the region, but only on a very small scale. Cooking, for commercial purposes, especially boiling in brine, is practised in Malaya, Thailand, Indochina and Indonesia.

Pastes and sauces are manufactured chiefly in the centre of the region and the Phillipines, and for these the accounts given by Westenberg (1950) are valid. There is a roughly similar distribution of the fermentation methods.

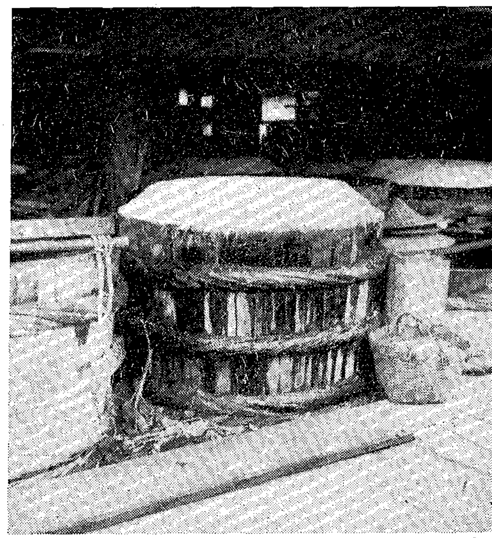

Fig. 2. *Tub containing shrimp paste with heaps of salt on top. From a Thailand shrimp-paste factory. (Kesteven, FAO, Bangkok).*

It is difficult to convey by words a picture of the conditions under which these products are manufactured. In the west the largest proportion of the output which is cured and dried, comes from the established curing yards; an account of these is given in the Marketing Adviser's Report referred to (1946). The conditions here are generally primitive and provoke comment such as the following, from a Special Committee Report (India 1945 B): "The arrangements for the drying of fish are very primitive and highly unsatisfactory". Yet it is also true that attemps to "improve" the methods, especially in respect of the quality of the salt used, have met with resistance, especially from the consumers who refused to buy the product.

Establishments for curing and drying are generally the same, whether they are those in the central countries or those on the Chusan Islands off the Yangtze mouth. Similarly the establishments for the production of pastes and sauces are mostly smallish, primitive, unclean, dark, and exceptionally odorous. The "nam-pla" factories in particular are very smelly and the sight of the vats of fermenting fish is displeasing to most western observers.

Quantities of Processed Fish Produced. It is impossible to form an accurate estimate of the amount of processed fish produced in the area. Statistic are available in most instances only in respect of the exports and imports of these items and not only is it impossible to measure the total commercial production, but there is also the quantity of domestic production of which no measure has ever been taken. Most households which have access to adequate supplies of fish undertake some domestic processing by which to hold supplies for a few months. On the evidence of the trade it is clear that there is really very considerable production. The exporting countries before the World War II (Japan, Indochina, Thailand and India) used to supply processed fish in the order of two hundred thousand tons per annum. There is no basis on which an estimate might be made of the ratio between these exports and the local consumption of these products, but it is clear that production must have been considerable. And whilst the trade has undoubtedly fallen off considerably, there is every reason to suppose that local consumption has increased some, to take up part of the surplus thus released, and that prodution is still substantial.

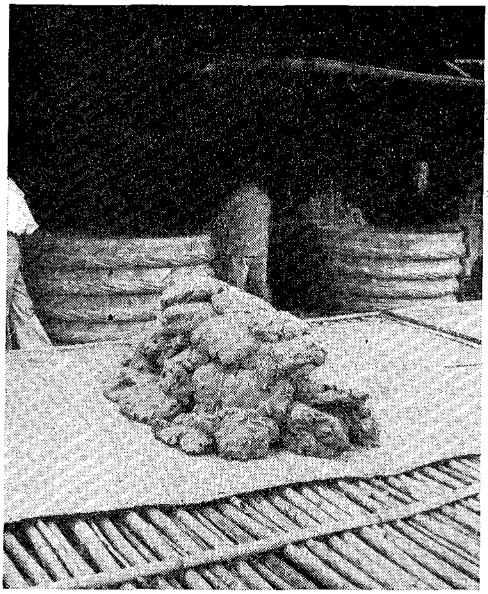

Fig. 3. *Shrimp paste spread out on bamboo mats for exposure to the sun. From a Thailand shrimp-paste factory. (Kesteven, FAO, Bangkok).*

Economics of Production. There is a considerable range in the size of the establishments in which the products are manufactured. Much of the production is on virtually a cottage-industry basis and there are innumerable small establishments. In a centre such as the Chusan Islands, there is to be found production going on in almost every house whilst some large-scale establishments are also to be seen; in such a locality, in fact, practically the entire village is organized for this industry. In Thailand, Indochina, Malaya and India there are to be found centres where the industry is concentrated.

Because of insufficient time available for the preparation of this paper it has been imposible to make an analysis of the relation of the

Table 6. *Utilization of Fish in India.*

	Annual quantity (Thousand maunds)
Consumed as fresh fish	8 968.3
Converted into sun-dried fish	3 713.7
Converted into salted fish	3 390.5
Converted into fish manure, etc.	1 852.6
Total	17 925.0

processing industry to the fresh-fish trade nor to attempt any analysis of the costs of production. Doubtless the level of supply of fish, coupled with the ability of the fresh-fish market to attract supplies and with the strength of the demand for processed fish, determines the amount of fish which is processed. Some indications of the amounts of fish used for processing in India are given in *Table 6.* (1 maund = ab. 25 lb.).

Trade in Processed Fish in Asia

There is a fairly complex pattern of trade in fishery products in the region. At the present time there is reduction or even elimination of the movement along certain lines.

The trade can be discussed in relation to three principal complexes, namely those of the west, the centre and the east. In the west there was substantial traffic from Pakistan (west) and India to Ceylon and Burma. The Pakistan supply included shark's fins as well as dried fish and much of the former continued east, to China. The Ceylon supply came from southern India, Pakistan and the Maldive Islands. It is probable that the Burmese supply, which before partition was described as Indian, is now drawn from East Pakistan.

In the central complex there is the export from Thailand, Indochina and Malaya, through Singapore to Burma and Indonesia. From Thailand and Indochina, and also from Singapore, quantities of fish moved into the Eastern complex, through Hong-Kong. Certain commodities went from Hong-Kong direct inland through Canton, others went to Shanghai. The other part of this eastern complex is the movement southwards from the shores of the Gulf of Chihli (Korea and the Shantung Peninsula) and from Japan, some of which went to Shanghai and some

Table 7. *Exports by commodity groups for 20 Asian countries, prewar and most recent year available*

Country	Year	Total	Fish, fresh or frozen	Fish, dried, salted or smoked	Fish, canned	Crustaceans and mollusks, fresh, frozen, dried or salted	Crustaceans and mollusks, canned	Other edible aquatic animal products	Fish Oils	Aquatic mammal oils and fats	Fish meal and fertilizer	Other aquatic mammal products	Miscellaneous aquatic animal and plant products
		Metric quintals (100 kg)											
Aden Colony and Protectorate	1936/37[1]	13 062	—	9 819	—	—	—	330	—	—	325	—	2 588
Burma	1938/39[1]	18 384	—	5 768	—	—	—	1 268	—	—	10 709	—	639
Ceylon	1938	468	—	309	—	—	—	150	—	—	—	—	9
	1947	1 635	—	394	—	—	—	1 072	—	—	—	—	169
China	1938	83 131	32 751	15 875	—	[2] 23 746	...[2]	—	—	10 759	—	—	—
	1940	77 030	10 040	60 602	—	—	—	20	—	6 368	—	—	—
Formosa (Taiwan)	1938	10 996	6 795	3 287	—	[2] 501	...[2]	—	—	—	—	—	413
Formosa (Taiwan): to Japanese territories	1938	50 838	[3] 46 253	621	—	—	—	—	—	—	—	3 964	—
India/Pakistan	1938/39[1]	218 744	—	167 651	—	—	—	—	[4] 137	...[4]	47 856	—	3 100
	1945/46[1]	322 839	—	285 124	—	—	—	—	[4] 2	...[4]	33 763	—	3 950
Indochina	1938	363 152	5 424	322 754	—	22 668	—	926	[4] 9 528	...[4]	—	—	1 852
	1948	49 760	—	21 840	—	8 080	—	—	19 520	—	—	—	320
Indonesia[5]	1938	61 965	21 001	15 388	708	16 776	109	3 028	—	—	—	—	4 955
	1940	63 051	22 512	15 017	806	14 986	38	5 240	—	—	—	—	4 452
Iran	1938	11 781	7	11 766	—	—	—	8	—	—	—	—	—
	1943	7 990	ø	7 990	ø	—	—	—	—	—	—	—	—

Table 7 (concluded). *Exports by commodity groups for 20 Asian countries, prewar and most recent year available*

Country	Year	Total	Fish, fresh or frozen	Fish, dried, salted or smoked	Fish, canned	Crustaceans and mollusks, fresh, frozen, dried or salted	Crustaceans and mollusks, canned	Other edible aquatic animal products	Fish Oils	Aquatic mammal oils and fats	Fish meal and fertilizer	Other aquatic mammal products	Miscellaneous aquatic animal and plant products
		Metric quintals (100 kg)											
Iraq	1939	7 790	[3] 7 790	—	—	—	—	—	—	—	—	—	—
	1945	1 450	[3] 1 450	—	—	—	—	—	—	—	—	—	—
Japan	1938	2135 227	[3] 163 640	[3] 222 620	887 447	17 404	112 244	18 271	455 959	1 030	—	—	256 612
Macau	1938	74 644	39 982	34 662	—	—	—	—	—	—	—	—	—
Malaya	1938	551 956	518	529 645	[6] 14 529	—	...[6]	—	—	—	—	—	7 264
	1948	73 532	132	55 844	4 770	—	—	—	—	—	—	—	12 786
Manchuria	1937	11 024	9 361	1 663	—	—	—	—	—	—	—	—	—
Philippines	1938	6 132	—	1 958	1 802	—	—	1 046	—	—	—	—	1 326
	1946	12 917	—	684	30	83	—	2 023	—	—	—	—	10 097
Portuguese India	1938	9 026	4 084	4 942	—	—	—	—	—	—	—	—	—
(Damao, Diu, Goa)	1945	7 167	3 779	3 328	60	—	—	—	—	—	—	—	—
Portuguese Timor	1938	19	—	—	—	—	—	—	—	—	—	—	19
Sarawak	1938	4 159	—	3 366	—	383	—	215	—	—	—	—	195
Thailand (Siam)	1938/39[1]	271 006	5 926	265 080	—	—	—	—	—	—	—	—	—
	1946	48 559	53	48 506	—	—	—	—	—	—	—	—	—

[1] 12-month period. 1 April to 31 March.

[2] Canned crustaceans and mollusks are included with fresh, frozen, dried or salted crustaceans and mollusks.

[3] May include some crustaceans and mollusks.

[4] Mamal oils and fats included with fish oils.

[5] Includes Java, Madura, and Outer Provinces

[6] Canned crustaceans and mollusks are included with canned fish.

Table 8. *Imports by commodity groups for 19 Asian countries, prewar and most recent year available*

Country	Year	Total	Fish, fresh or frozen	Fish, dried, salted or smoked	Fish, canned	Crustaceans and mollusks, fresh, frozen, dried or salted	Crustaceans and mollusks, canned	Other edible aquatic animal products	Fish Oils	Aquatic mammal oils and fats	Fish meal and fertilizer	Other aquatic mammal products	Miscellaneous apuatic animal and plant products
		Metric quintals (100 kg)											
Aden Colony and Protectorate ..	1938	17 439	22	12 969	139	—	—	868	27	—	—	—	3 414
Burma	1938/39[1]	106 276	—	81 751	21 433	—	—	395	[2]2 428	... [2]	254	—	15
Ceylon	1938	314 537	226	238 228	9 711	—	—	—	206	—	65 224	—	882
	1947	360 580	90	306 881	13 313	—	—	—	206	—	40 017	—	73
China	1938	580 703	62 994	318 763	—	16 902	—	18 424	—	—	—	—	163 620
	1940	749 625	129 323	308 158	—	29 777	—	20 815	2 311	—	—	—	259 241
Formosa (Taiwan)	1938	237 086	—	236 975	—	1	—	54	—	56	—	—	—
Formosa (Taiwan): from Japanese territory	1938	268 494	20 784	219 869	—	25 936	—	—	—	—	—	—	1 905
India/Pakistan ..	1938/39[1]	91 264	—	44 449	6 731	—	—	1 577	3 168	—	23 867	—	11 472
	1945/46[1]	137 628	—	14 230	3 805	—	—	—	2 764	—	101 564	—	15 265
Indochina (French)	1938	7 508	7	1 270	3 984	1 587	27	523	[2] 110	...[2]	—	—	ø
	1948	16 700	—	—	15 030	—	—	—	—	—	—	—	1 670
Indonesia [3]	1938	726 607	4 642	617 423	[4] 95 340	6 284	2 422	70	—	—	—	—	426
	1940	690 349	910	602 672	[4] 78 355	5 482	2 603	7	—	—	—	—	320
Iran	1938	447	—	145	160	—	—	—	142	—	—	—	—
	1943	261	—	ø	250	—	—	—	1	—	—	—	—

Table 8 (concluded). *Imports by commodity groups for 19 Asian countries, prewar and most recent year available*

Country	Year	Total	Fish, fresh or frozen	Fish, dried, salted or smoked	Fish, canned	Crustaceans and mollusks, fresh, frozen, dried or salted	Crustaceans and mollusks, canned	Other edible aquatic animal products	Fish Oils	Aquatic mammal oils and fats	Fish meal and fertilizer	Other aquatic mammal products	Miscellaneous apuatic animal and plant products
		Metric quintals (100 kg)											
Iraq	1939	46 180	[5] 40	[6] 260	[7] 260	...[6]	...[7]	—	45 370	—	—	—	—
	1945	4 480	—	[6] 190	[7] 190	...[6]	...[7]	—	4 100	—	—	—	—
Japan	1938	139 948	—	75 673	—	—	—	—	—	—	—	—	64 275
Macau	1938	46 627	1 012	45 615	—	—	—	—	—	—	—	—	—
Malaya	1938	614 180	51 615	519 555	[7] 37 757	—	...[7]	—	—	—	—	—	5 253
	1948	259 831	98 565	117 448	[7] 28 092	—	...[7]	—	—	—	—	—	15 726
Manchuria	1937	767 328	119 792	380 182	31 819	9 290	1 905	5 003	558	—	—	—	218 779
Philippines	1938	166 991	1 110	13 381	135 511	3 430	4 238	3	...	—	8 704	—	614
	1946	213 525	234	5 554	81 223	2 443	123 325	6	596	—	1	—	143
Portuguese India (Damao, Diu, Goa)	1939	173	7	166	—	—	—	—	—	—	—	—	—
	1947	213	8	100	105	—	—	—	—	—	—	—	—
Sarawak	1938	14 953	—	7 277	—	142	—	—	—	—	—	—	7 534
Thailand (Siam)	1938/39[1]	21 200	...[8]	[8] 14 344	6 856	—	—	—	—	—	—	—	—
	1946	1 857	2	1 750	105	—	—	—	—	—	—	—	—

[1] 12-month period, 1 April to 31 March.
[2] Mammal oils and fats are included with fish oils.
[3] Includes Java, Madura and Outer Provinces.
[4] Includes quantities of salmon, not canned.
[5] Includes some crustaceans and mollusks.
[6] Fresh, frozen, dried or salted crustaceans and mollusks are included with fresh fish and with dried, salted, or smoked fish.
[7] Canned crustaceans and mollusks are included with canned fish.
[8] Fresh fish and crustaceans and mollusks, where applicable, included with dried, salted or smoked fish.

south to Hong-Kong and Taiwan; these supplies were joined by Chinese supplies, chiefly from the Chusan Islands.

There has not been sufficient time to make any detailed analysis of these movements in connection with the preparation of this paper. As indicated above, the prewar volume of the trade was probably in the order of at least two hundred thousand tons, more than half of which came from Japan and the territories under Japanese control. Since the war the Japanese exports fell and have not yet recovered. The Thai and Indochinese exports also fell to negligible levels and still lie far below prewar levels. The entrepot trade of Singapore has fallen to about 10 per cent of its prewar level. The Indian supply to Ceylon has continued virtually without interruption; there is no information yet on the status

Table 9. *Exports of dried fish, salted and unsalted fish and fish maws and shark fins from India*[1]

	Average for the quinquennium ending 1940—41			
	Quantity	Export price per cwt.		
	Cwt.	Rs.	A.	P.
Fish, dry, unsalted	199 824	20	10	9
Fish, dry, salted	141 587	16	10	1
Fish maws and shark fins	5 840	88	9	7
Fish, wet salted	7 394	8	2	3
Total preserved fish	354 646		...	

[1] Excludes exports from Kathiawar ports.

Table 10. *Imports of preserved fish into India*

	Average for the quinquennium ending 1940—41			
	Quantity	Cost per cwt.		
	Cwt.	Rs.	A.	P.
Fish, dry, unsalted	44 264	3	7	7
Fish, dry, salted	2 486	7	15	10
Fish maws and shark fins	5 292	6	7	6
Fish, wet salted................	29 587	9	10	9
Fish, other sorts	2 767	57	10	2
	84 396		....	

Table 11. *Countries consigning preserved fish for import into India*
Percentages to total by weight

Name of the country from whence imported	1939—40	Quinquennium end. 1939—40
British Empire Countries:		
United Kingdom	2.6	3.8
Ceylon	1.1	0 8
Burma	0.4	2.9
Other British possessions	0.6	0.9
Total	4.7	8.4
Other Countries:		
Muskat Territory and Trucial Oman	72.7	69.1
Other Native States in Arabia	20.1	17.5
Iran	2.1	2.4
Others	0.4	2.6
Total	95.3	91.6
Total quantity imported into India	101 004	70 752
Value of imports, Rs.	7,29 514	5,94 538

Table 12. *Countries despatching canned fish to India*
Percentage to total by weight

Name of the country from whence imported	Average for the quinquennium ending March 1940
British Empire Countries:	
United Kingdom	28.2
Canada	29.5
Other British possessions	0.4
Total	58.1
Other Countries:	
Japan	10.2
United States of America	20.6
Norway	7.6
Portugal	1.1
Others	2.4
Total	41.9
Total quantity imports, cwt.	12 210
Total value of imports, Rs.	5,92 976

Table 13. *Prices on the Singapore retail market*

Commodity	Malayan dollars per Kati		U.S. dollars per Kilogram	
	Average 1950	Sept. 1951	Average 1950	Sept. 1951
FISH FRESH	$ c.	$ c.	$ c.	$ c.
Baual Puteh (Pomfret) large	—	—	—	—
—»— medium	1 86	3 30	1 01	1 78
Bunga Ayer (mixed small fish)	39	—	21	—
Chencharu (hard tails)	63	1 01	34	55
Kembong	61	1 17	33	63
Kuran (threafins)	1 92	2 82	1 04	1 52
Merah (snapper)	1 13	1 90	61	1 03
Parang (dorab)	1 12	1 78	61	96
Pari (ray)	39	53	21	29
Prawns, large, salt water	2 06	3 55	1 11	1 92
Selar	1 15	1 68	62	91
Tamban	37	50	20	27
Tenggivi (Spanish mackerel)	1 24	1 96	67	1 06
Terubok (herring)	78	1 19	42	64
FISH, DRIED AND SALTED				
Aruan, (ikan Thailand)	95	1 23	51	66
Bilis	79	1 42	43	77
Kuran	1 27	2 14	69	1 16
Kembong	39	58	21	31
Parang	66	—	36	—
Prawns, 1st quality	2 13	2 97	1 15	1 60
Prawns, 2nd quality	1 73	2 45	93	1 32
Sepat, Saigon, large	68	1 02	36	55
Sotong (cuttlefish) Chinese	2 68	—	1 45	—
—»— Japanese	86	1 02	46	55
—»— Trengganu	1 94	—	1 05	—
Tenggivi	1 36	2 07	74	1 11
Terubok (fish roe)	1 76	—	95	—
FISH PASTE				
Belachan No. 1	31	50	17	27

Source: Malayan Statistics, monthly digest of economic and social statistics relating to the colony of Singapore and the Federation of Malaya; October 1951.
Conversion rates: 1 Kati = 0.6048 Kilograms.
—»— 1 U.S. $ = 3.061 Malayan dollars.

of the Burmese supply from India and Singapore, but there is evidence that it too has descreased substantially.

Some of the more important features of the import and export trade in fishing products in Asia are shown in *Tables 7 and 8*. These tables are based on data collected by the Fisheries Division of FAO. Details regarding certain areas are given in *Tables 9—13*.

The trade statistics give some gross information on the types of commodities which move in this trade but they do not give an adequate idea of the intricacy of the trade. In the Malayan report referred to, (Le Mare 1950), reference is made to the fact that over one hundred varieties of salt fish, each sub-divided by grades and country of origin, were recognized in 1941. *Appendix B* gives a tabulation of the factors which determined the grading of salt dried fish in the Singapore trade. Similar rules applied in the trading centres of the eastern complex. It is to be recognized that this grading and sorting, in respect of which Singapore traders furnished a specialist service, was done in response to market requirement. It is important to recognize that the Asian consumer is very selective and buys particularly according to his wants; and he is prepared to pay for his supplies.

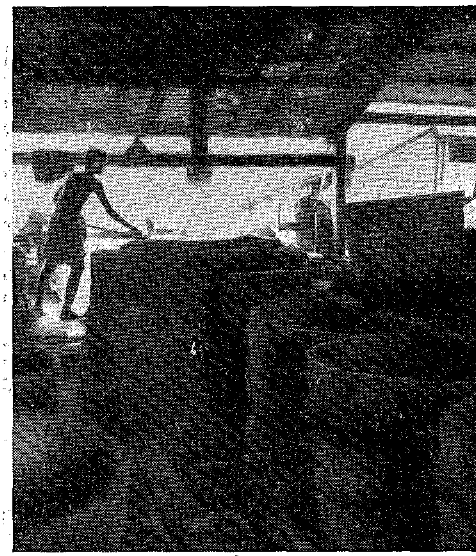

Fig. 4. *View of "nam-pla" factory showing the boiler in which the fish is cooked. "Nam-pla" is a fish sauce.* (*Kesteven, FAO, Bangkok*).

Discussion and Conclusion

The foregoing preliminary analysis confirms the view that fish is an important food commodity in this region. It indicates a complex demand for a range of commodity types, the consumer preference for some of which is strongly entrenched.

Whilst the overall supplies of fish, in all forms, are inadequate in all countries, both technical and market considerations make the processing of fish a permanent feature of the industry. There is every reason to suppose that most of the forms of processed fish will always find a market, and it is possible that if the current programmes for development of the fishing industries of this region should succeed, they will result not in a replacement of the present forms of processed fish by fresh-fish and new forms of processing, but in a general increase in supplies with expansion in the volume of supplies of both fresh and processed fish. If this conclusion were valid then it would be reasonable to expect that, for the time being at least, part of the unsatisfied demand could be met by supplies from outside the area.

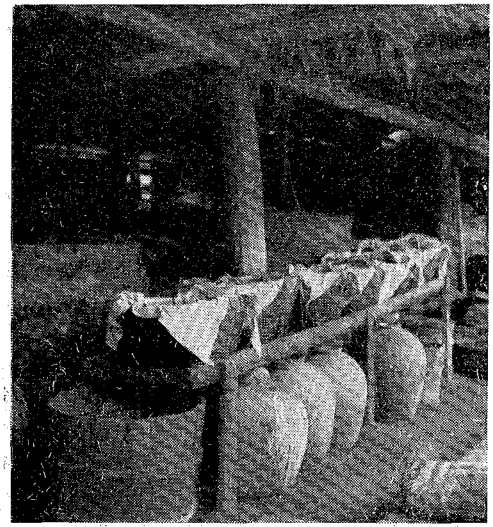

Fig. 5. *View of filtration stage in "nam-pla" (fish sauce) maufacturing. (Kesteven, FAO, Bangkok).*

The material in this paper, together with that contained in the paper by Westenberg (1950) may suffice to indicate the type of market for which herring products would have to be prepared. There is no way, however, of indicating the flavors and odours which belong to these Asian products and it would be necessary to consider these closely for they, of course, constitute the basis to the consumer preferences referred to. Again the material of this paper indicates approximately the price scale within which such products would have to be supplied. There is no question that herring products can be sold in the East, for they have been sold in small quantities. But whether the present market can be induced, by price concessions or other means, to acquire a liking for these products, or, conversely these products could be modified so as to resemble those at present on these markets and could be sold at appropriate prices, is a question which could not be answered on present evidence.

Recommendations

1. The foregoing analysis of the existing market for fish, of the Asian fish-processing industry and of the trade in processed fish, should be pressed further.

2. Special studies should be made of the characteristics of the various products and of the techniques by which they are produced.

3. If the preliminary study of the financial aspects of this trade, *vis-à-vis* the situation in the European industry, should suggest that the European industry might possibly be able to supply the Asian market, then from the price viewpoint trials should be made of the feasibility of meeting the established consumer requirements, or of modifying those requirements. Samples of the products of Asia and Europe could be exchanged; trials could be made of the reception of European products by Asian consumers; and experiments could be made in the modification of the European techniques with the object of obtaining products nearer Asian samples.

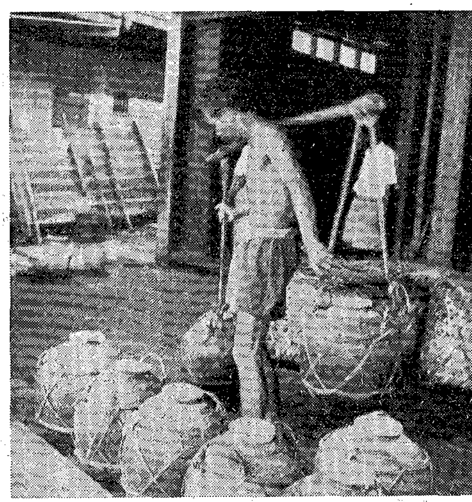

Fig. 6. *Jars of "nam-pla" (fish sauce). (Kesteven, FAO, Bangkok).*

Appendix A: COOKING METHODS

By *S. W. Ling.*

METHODS FOR COOKING FRESH FISH

Steaming

a. *Simple steaming.*

Arrange dressed fish in tray, sprinkle salt on the fish and steam for about 10 minutes. This is a very common method for cooking pla-thu and other small fish. The steamed fish may be fried after steaming. Very common among all families.

b. *Steaming with condiments.*

Place dressed fish on a plate, add salt, soybean sauce, spices, wine, onion, slices of lemon, and mushroom, place small pieces of pork on top of the fish, then steam for about 10 minutes. Common among well-to-do families.

Frying

Lard, peanut oil, or vegetable oil may be used.

Fry fish (either fresh or steamed) with oil until the skin turns slightly brown. Small fish are fried whole, big ones are either cut into cross sections or with a few deep cuts on each side. Lemon, sweet-sour sauce, chili sauce or any other condiment sauce may be used for flavoring. Common among all families.

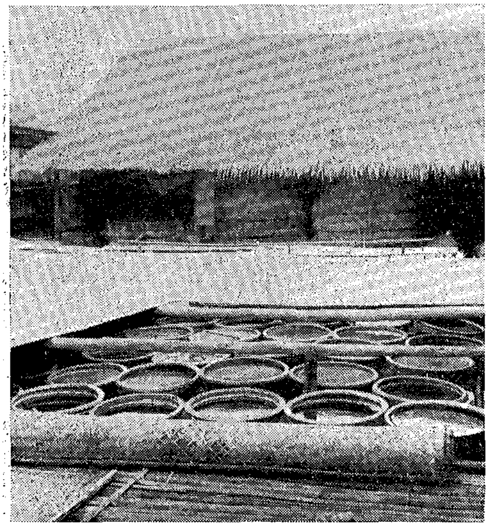

Fig. 7. *Tubs with "nam-pla" (fish sauce) exposed for sun drying. (Kesteven, FAO, Bangkok).*

Baking

Insert long bamboo rod through the cleaned fish and bake over charcoal fire. Nam-pla and chili sauce are used for flavoring. Common among all families.

Boiling

a. *Simple preparation.*

Place water in a cooking pot. Add salt, lemon, any condiment sauce and bring the mixture to a boil. Place cleaned fish in the boiling water and cook for 5—10 minutes according to the size of the fish. Common among all families.

b. *Curry preparation.*

(1) *Kaeng som (sour curry) preparation.*

Fish are usually cut into small pieces before cooking. Put pieces of fish and ingredients of curry and condiments. Into a small amount of boiling water add juice from tamarind-seed pod. Keep the mixture boiling for about 5 minutes. Common among all families.

(2) *Kaeng khua preparation.*

Follow the above procedure until the stage where the pieces of fish are well cooked then add some coconut juice to make the preparation thick and slightly sweet. Common among all families.

Raw fish flesh

Only very fresh fish of good grade are used. The skin and flesh are removed and the flesh cut into very thin slices. Eaten with onion and a mixture of vinegar, soyabean sauce, chili sauce, sweet sauce and other special sauces. This is considered a delicacy but eaten only occasionally.

Fish balls.

The fish flesh is chopped up very finely, mixed with some potato starch and then made into balls.

METHODS FOR COOKING SALTED FISH

Steaming

Remove scales and place the cleaned salted fish on a plate. Add a few slices of fat pork, some pieces of garlic and steam for about 8 minutes. Common among all families.

Frying

Cut cleaned salted fish into sections or slices (for small fish fry without cutting) and fry with oil until the surface is brown. Very common among all families. Eaten almost everyday.

Baking

Bake cleaned salted fish on charcoal fire until brown. Cut into small pieces and mix with chili sauce.

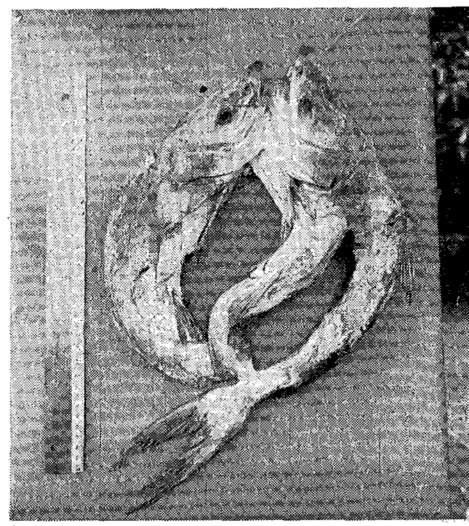

Fig. 8. *Dried catfish* (Gachysurus). (*Kesteven, FAO, Bangkok*).

METHODS FOR USING NAM-PLA

Use straight

Nam-pla may be used straight like soyabean sauce for cooking and for flavoring dishes. Used everyday by all families.

Chili sauce

Put finely cut chili into nam-pla and add some lemon or lime juice. Use as condiment sauce. Very common among all families.

METHODS FOR USING SHRIMP PASTE

Baking

Place a lump of shrimp paste on a piece of loaf and bake over charcoal fire for a few minutes. It is then ready to be eaten with vegetable or any other kind of food and rice. Very popular among the middle- and working-class people.

As condiment

Shrimp paste is being used extensively as a condiment to flavor fish and meat dishes either steamed or cooked. Very popular among all families.

In "Nam-plic"

Place a lump of baked shrimp paste in a bowl, add some nam-pla, sugar, lemon juice, finely cut garlic and chili. Mix well. Ready for use after about 10 minutes. A very appetizing condiment sauce, very common among all families.

In "Kao bluk kapid"

Mix baked shrimp paste with boiled rice, add onion and chili and nam-pla to taste. This is a very popular preparation used extensively among the middle- and working-class people.

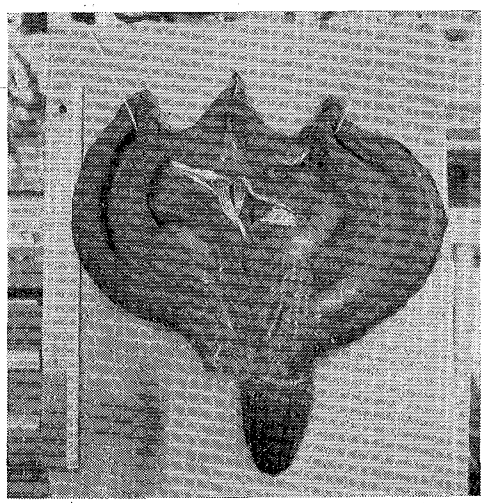

Fig. 9. *Dried snake-head* (Ophiocephalus, *fresh-water fish*). (*Kesteven, FAO, Bangkok*).

METHODS FOR USING FERMENTED FISH

Uncooked

Fermented fish may be eaten straight with rice and vegetable, without cooking or adding any other sauce. This method is practiced only among the labor class and farmers.

Cooked

Mix fermented fish with some milk of coconut, add 1 or 2 red chilies and boil over fire. A small amount of sugar and lemon juice may be added. A favorite dish among common people, eaten with rice.

METHOD FOR USING DRIED MUSSEL

Dried mussels are eaten with rice, either directly or mixed with other material. They may be steamed, boiled or fried and are especially esteemed for use in soups. Used by all families.

Appendix B: FACTORS DETERMINING THE GRADING OF SALT FISH

Size

Size is an important factor in grading but no universal rule can be formulated. Generally in species which do not grow to a large size, the larger the fish the better the grade. This applies, for instance, to "kembong" (*Scomber sp.*);

with "ikan bilis" (*Stolephorous sp.*), however, the "fry" are the more costly. On the other hand, fish, which will normally grow to a great size are sorted according to their size — the smaller generally being the more popular, *e.g.*, "kurau" (*Polynemus sp.*) and "tenggiri" (*Cybium*) roe. This is not grading, as prices vary little on size differential alone, but rather sorting for the various markets outlets. Very large salt fish are not in demand by the consumer as it might take months to consume and, therefore, offers no variety of diet. Similarly retailers who sell it by the piece do not want large fish unless their turnover is large, as there is a definite risk of deterioration.

Fig. 10. *Sacks of dried shrimp on sale in Thailand retail store.* (*Kesteven, FAO, Bangkok*).

Salt Content

Generally the lower the salt content the better the grade. With excessive salt the fish has a whitish, powdery appearance. In the case of dried "bilis", fish which have been dried without previous boiling in brine are the more popular in Java.

Dryness

Quality is determined to a great extent by the moisture content of the fish. Relatively dry fish are graded higher, apparently as the result of the better keeping qualities of such fish combined with the higher percentage of total solids.

Appearence

In order to be graded as first quality, the fish must be of attractive appearance, unbroken and undamaged. The presence of the head and fins in some types, *e.g.*, "sepat Siam", is a disadvantage.

Smell

The smell should not be offensive. There are, however, two basic process varieties for large fish such as "ikan merah" (*Lutianus*), "kurau", etc. One is a slow dry-salting process during which controlled decomposition is allowed, giving a "stronger" smelling product ("mui heong"), particurlarly popular with the Cantonese. Another more usual is a wet, salting process giving a "fresh smelling" product, more popular with the Hokkiens. As the "mui heong" salt fish is more difficult to prepare it is naturally the more expensive.

Taste

This is not used as a factor for grading, as the quality of the fish can be established by other factors.

Consumers Preference

Grading of the fish is undertaken to meet the preference of the consumer. This adds a further complication as grades for the various market outlets are often based on different standards.

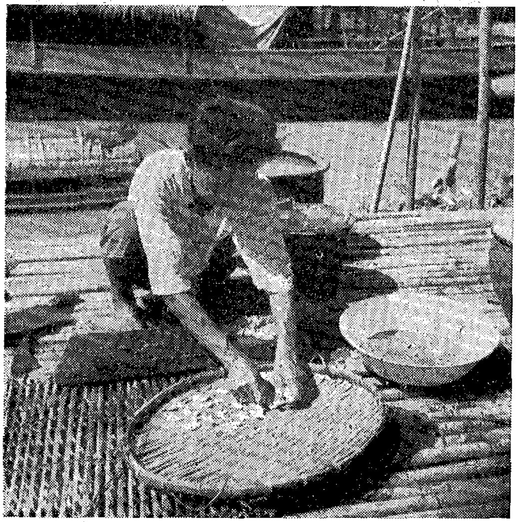

Fig. 11. *Fisherwoman tearing swim-bladders for drying.* (*Kesteven, FAO, Bangkok*).

USE OF HERRING PRODUCTS IN THE BRITISH DEPENDENCIES

C. F. Hickling's paper

I understand that, before 1914, there was a large export of "red" herrings from the United Kingdom to West Africa, and especially Nigeria. But in 1925, only some 2 000 cwt. (102 metric tons) salt or cured herrings were exported, at an average price (presumably F. O. B., in the statistics of the Ministry of Agriculture and Fisheries) of £ 1.8 per cwt. In 1948, this had fallen to 1 200 cwt. (61 metric tons), at a price of £ 4.4 per cwt. There has been a curious change of taste in recent years among Nigerian consumers. The demand, in earlier days, must have been for salt fish, and, indeed, with the continuous loss of salt through perspiration, one would expect that the salt in the cured fish would be especially valued, as is still the case, for example, in Java. But I am assured that, in both Nigeria and the Gold Coast, the demand is not for salt fish, but for fish preserved without salt, such as the locally prepared hot-smoked fish, and imported stock-fish, that is, cod which has been wind- and sun-dried.

It would therefore appear that there might be a very large market in Nigeria, which has a population of some 23 millions, for herrings or herring products prepared in some way other than by the use of salt. This also applies, though in a lesser degree, to the Gold Coast.

It should be pointed out that the foodstuffs of these peoples are predominantly carbohydrates, and therefore rather flavourless. Fish not only provides protein, to balance this diet, but should also act as a relish, in stimulating the salivary glands, and thus assisting in the digestion of large quantities of stodgy food such as cassava, rice, *etc.* This is well-recognized in Malaya and China, for example, where cured fish is very powerfully flavoured (indeed, offensively so, to European palates). Any attempt to market herring products in the big potential African market should, therefore, aim at a strongly flavoured article, whether by the addition of condiments, or by allowing some fermentation of the fish during curing.

Small-scale consumer tests in Sierra Leone, and Sarawak, have been made with dehydrated herring, alone, or mixed with dehydrated cod. The samples were obtained through the good offices of Dr. G. A. Reay, Director of the Torry Research Station, Aberdeen, Scotland, and Mr. Lawrence, Head of the Dehydration Division, Ministry of Food, London, England. Below are given abstracts of the reports received from these two territories.

Sierra Leone. A sample of lightly smoked dehydrated herring was placed on sale in a small shop in Freetown. After a few customers were given small samples to taste, they were offered this product at 6 d. per cigarette tin (a common unit of measure). Within 39 minutes, all the fish was sold, and a queue of disappointed would-be purchasers was turned away.

Sarawak. Dehydrated herring was preferred to dehydrated cod, and the former was usually used without reconstruction. Favourable opinions were received from Malays and Dayaks in Kuching, Sibu, and Miri; from a Sea Dayak Chief and his followers, from a Mission School for Chinese, and from many individual Chinese.

There appeared to be a fairly firm foundation for the use of dehydrated herring and herring meal. Most urban and rural communities, constabulary, prisons, and some schools liked it. Only Chinese food shops had no use for it. It lacked sufficient taste to compete with salt fish, where available, and appealed to those who cannot afford or obtain supplies, due to high prices and long distances.

The *West Indies* would also appear to present a good market for herring products at the present time. For example, in 1945 Jamaica alone imported some 1217 metric tons of pickled herring. These came from dollar sources, mainly Canada; and since devaluation the British West Indian territories have become interested in non-dollar sources of herrings. There appears to be some doubt, however, whether pickled herrings would not spoil during the freight from Europe, unless placed in a chilled hold. The North American herrings have a more direct and shorter journey to make under warm climatic conditions, and shipping facilities are better for direct sailings than from Europe.

In *East Africa* there is no objection to salted fish, but I have not heard of any considerable export of salt or pickled herrings from Europe to this region.

As this Meeting is concerned with herrings, there is here no place to speak of the trade in herring-like species, such as the Gold Coast fishery for sardinellas, the great West African fisheries for the Bonga, *Ethmalosa fimbriata,* the very important winter fisheries for sardinellas and anchovies in the Gulf of Aden, the fisheries for sardinella, hilsa, and anchovies in Malaya, Sarawak and Hong-Kong. The smaller fish, such as sardinellas and anchovies, are usually sun-dried, frequently on the hot sand. Dried anchovies are a substantial article of trade for human consumption in Malaya and Hong-Kong; in Aden and southern Arabia both sardinellas and anchovies are sun-dried on the sand for use as fodder for stock in those pastureless regions, and as fertiliser for tobacco and dates. Experiments are continuing, however, to produce a lightly salted shade-dried sardinella for human consumption. An unexpected problem, is the scarcity and high cost of fuel for cooking in these arid, treeless countries; there should be a future for lightly salted pre-cooked sardinellas, possibly using solar heaters for the pre-cooking.

FISHERY PRODUCTS OF INDOCHINA

Extracted and summarized from *J. Westenberg's* original paper[1] by Dr. E. Hess, Fisheries Technologist, FAO

A review of the literature on the fisheries products of Indochina was presented by J. Westenberg at the Second Meeting of the Indo-Pacific Fisheries Council, held in Cronulla, Australia, 17—28 April 1950, and was published in the Proceedings of the Meeting. Reprints of the paper were distributed at the Bergen meeting. A condensation of this report, with emphasis on those parts considered of special interest to the North-western European fisheries industries is presented herewith. For bibliographic references, the original paper should be consulted.

Salted, Dried and Smoked Fish

Salted fish. The salting of fish, without subsequent drying is sometimes practiced especially in *Cambodia* but practically only for local demand.

Usually medium-size fish are used for the procedure; head, scales and viscera are removed and the fish split open, according to the local custom, depending on traditions and the species used. The dressed fish are then placed in jars with alternate layers of salt. Information on the quantities used appear not to be available in the present literature. The jars are completely filled and covered with a mat of twisted bamboo, weighed down with stones. In this way the fish may be kept as a family store to be used when needed.

Along the coast of *Siam,* the same procedure is applied to *Scomber neglectus* C. V. Prior to the preservation, the fish are eviscerated without opening the bellies; entrails and gills are skilfully pulled out in a single movement. The salting is carried out in large concrete tanks, in which the fish is kept under pressure. The half-wet product is exported in wooden cases and in Java it is well known as "pedah-kembung".

A special procedure of fish salting has been reported from Siam, in which roasted and pounded rice or rice bran is added; the preparation is know as "pla-ra" (pla = fish; ra = awfull small). The freshwater fish Pla-kadi (*Trichopodus sp.*) and Pla-soi (*Cirrhinus sp.*) are headed, scaled, gutted and washed, and then thoroughly mixed with fine salt; transfer-

[1] Westenberg, J.: Fishery Products of Indochina. Indo-Pacific Fisheries Council, Proceedings, Vol. 2, 1950.

ıed into a jar and kept under pressure for 1 to 3 months. After this period the pickle is rinsed out and the fish is mixed with roasted and pounded rice or with rice bran, and a small amount of fine salt. The mixture is then put back into the jar and left to ferment for 6 to 12 months. The roasted rice is added in a proportion of 1 to 40 in volume, and the rice bran in a proportion of 1 to 20. The product is prepared either for home use or for sale.

The application of roasted rice or maize is also practiced in South Borneo. When preparing their so-called "wadi", the Dayaks along the Barito salt their (freshwater) fish with the addition of the roasted ingredient. The product is stored in tightly sealed earthenware pots, and is kept for family use.

The addition of cooked rice is known among the Dayaks along the Barito and along the Kapuas (West Borneo). The product is known as "pekasam", and is stored in sealed pots.

A similar preparation with cooked glutinous rice instead, is reported from the Kapuas region.

Salted and dried fish. The manufacture of salted and dried fish is an active industry, especially on the lakes and rivers of Cambodia.

Preparatory to the procedure, the heads are severed as soon as the fresh catch is brought in. The fish in then held for 12 to 16 hours in an open-work bamboo container, floating in the lake. This treatment brings about a slight disintegration which is said to yield the desired bleached and high-flavored product.

Baskets of fish are removed from the receptable, and handed over to the women who accomplish the dressing by pulling out the entrails and making a slit from head to tail, according to custom established for the different kinds of fish, and depending on local tradition. Certain species are scaled with a crude brush before being split and eviscerated.

After a thorough washing in tubs,in which the water is renewed several times, the larger fish of first quality are salted flat, both sides of the flesh being treated with salt. The fish then remain under slight pressure in the salting vats, until they are "struck through", which takes 12 hours for the larger species, and 6 to 9 hours for young They-pra *(Varias* sp. div.). After a second washing they are transferred to the drying platforms. As a rule one part of salt is used to obtain two parts of dried fish, proportionate to weight. For oily species as Ca-su (*Pseudosciaena sp.*) more salt is used, namely 1½ parts of salt to 1 part of dried Ca-su. Other deviations from the usual proportion occur according to weather, and to size, condition and destination of the fish.

The second-quality and small fish are brine-salted for a period of 12 hours and then spread out directly on the drying platforms, without being washed again.

The drying of the fish requires 36 to 48 hours of full sunshine. From time to time the fish is turned in order to ensure equal desiccation. The women who attend to the drying also watch for maggots which occur especially during rainy weather. These invaders are removed and the affected spots are rubbed with salt.

In the preparation of dried fish, the average loss in weight is estimated at 75 per cent: waste 30 per cent and evaporation 45 per cent.

The finished product is baled either in matting or in bamboo baskets, and in this form more than 20 000 tons are exported annually from Saigon, 1919—1922. During later years the market has shown considerable fluctuations. Here, as nearly everywhere in the Far East, the trade in dried fish is in the hands of Chinese. A major part of the commercial trade was directed through Singapore.

In a variation of the above procedure the fish immediately after being landed, are placed in a pickle which may not be renewed during the whole season, and after 4 to 6 days the fish are exposed to the sun to dry.

In still other cases, the fish remain in the pickle till they are sold. The required quantity is then washed and dried. This treatment really constitutes a variation of the simple salting of fish, as described in the first part of this section.

In the Gulf of Tonkin fisheries the fish is treated in similar ways as on the lakes of Cambodia. The larger species are cut open from the back, eviscerated and washed with sea water, piled up with alternate layers of salt in tubs or pots and kept under pressure for 7 days. Then the fish is dried in the sun for 3 days. The quantity of salt used amounts to one half of the fresh weight of the fish. 100 kg of fresh yield 70 kg of the dried product. For brining the dressed fish is soaked in brine for 12 hours and then dried in the sun for 3 to 4 days; the quantity of salt is about one quarter of the weight of the fish.

Fishermen of Indochina have, just as anywhere else, a preference for certain portions of the fish, which they reserve for family consumption. These include, for example the two dorsal muscular masses found immediately behind the skull of Trey-pra, which they call "touv", and also "komphlien", which is taken immediately behind the jaws from Trey-ras and Trey-chhdor (an *Ophiocephalid* fish). These pieces, measuring 3 to 5 cm (1¼ to 2 in.) in diameter, are slightly brined and then dried. After immersion in the pickle for 5 minutes, they are strung on split bamboos and placed in the sun.

Dried fish. The drying of fish for home use without previous salting is practiced in Cochinchina, where the sun is hot enough to desiccate the product before putrefaction can set in.

Smoked fish. On the shores of certain bodies of water, in particular the Tonle Sap, a small quantity of fish is smoked. The fish destined for smoking is not decapitated but only scaled and eviscerated by opening the belly. No salt is used in this preparation. The product is kept for local use.

Groups of five or six fish are skewered by the heads on a split bamboo, some space being left between, and the tails are tied together. Then they are placed on three superimposed and slightly inclined bamboo racks under which a smoky wood fire is maintained day and night. In order to obtain a uniform product, the position of the fish is changed regularly.

Fish Pastes (Mam's)

In addition to the usual methods of preservation, applied all over the world, such as salting, drying and smoking, other processes are utilized in the country, yielding products which are typical for this part of the world. A number of these condiments in the nature of pastes are indicated by the general designation "mam". According to the material used, and to local differences in the preparation, several varieties are distinguishable, for instance, "pra-hoc" from Cambodia and Siam, "paâk" or "mam-chao" from Cambodia, "padec" from Laos and "mam-tom" from Cochinchina and Annam.

Pra-hoc (Cambodia). Two methods of preparation are described by *Le Poulain.*

In the first the Trey-changvar *(Cyprinid* species, belonging to *Rasbora* and allied genera) is beheaded and eviscerated and is then, without being scaled, put into a wicker basket, called cheal. The heads are either thrown away or may be preserved for the extraction of oil. The fish, which half-fill the cheal, are trampled upon in much the same manner as grapes in a winepress. The purpose of this treatment is to scale the fish by friction and to empty the entrails by compressing them. Then the fish are washed by plunging the cheal into a river or pool. For half an hour the fish are stirred by hand till they are completely scaled. Then they are again pressed in the cheal in order to remove the water.

The upper part of the cheal is covered with banana leaves, upon which a weight (*e.g.*, heavy stones) is placed in order to compress the fish. They are left under pressure for 24 hours.

Next day the fish are taken out of the cheal and, for about a half hour they are mixed with coarse salt. About 2 to 3 kg of salt are needed for 20 to 30 kg of fish. When the fish are well impregnated with salt they are spread out on matting in the sun for 24 hours. Then the fish, salted and dried, are put back into the cheal, care being taken to leave as little space between as possible. The first process of preparation for the manufacture of "pra-hoc", carried out in the fishing places, is now finished. The cheals, filled with the prepared fish, are transported to the villages. Upon arrival the villagers take the cheals from the carts and the process of pounding begins. The fish, prepared as described in the foregoing, are placed in small quantities in heavy wooden mortars, operated either by hand or by foot.

The pounded fish form a salted paste which the Cambodian tastes to judge whether it is salt enough. The pounding takes about 20 minutes. The paste is then packed in earthen jars of 1 picul (= 60 kg = 132 lb.). These jars are placed in the sun and left open in the day-time; in the evening they are closed to keep out the maggots. As seasoning takes place gradually a pickle appears on top of the paste. This liquid is removed every day until no more collects; it is kept aside, for the Cambodians use it as "nuoc-mam" and call it "teuk-prahoc". This process may last a month. When there is no pickle left, the preparation of "pra-hoc" is finished and the condiment is ready for immediate consumption. According to Le Poulain, 3 piculs of Trey-changvar yield 1 picul "pra-hoc". It is used principally in the preparation of soups, the many varieties of which play an important part in Cambodian cooking.

Manufacture by the second method is more aristocratic, since it is more expensive. Only one variety of fish is used, either Ca-bong, Ca-loc, Ca-ket or Trey-kahek, but never the four of them together. This product is not on the market and is consumed by the elite of Cambodia.

The fish are headed, scaled and gutted, the bones are removed, and only the flesh is preserved. This is put into pails of water and left for three days and three nights; then as in the first method of preparation, the fish are placed in cheals to drain, and are pressed out. The fish are not trampled upon, as they have already been scaled and eviscerated. The process of salting is the same as in the first method, but the fish are not pounded, and the morsels of flesh are carefully placed in the jars, the whole being well compressed by hand.

Another description is given by *Bremond.* For the first quality product, the following fish are used:

Trey-pra = *Clarias (Silurid).*

Trey-ras = *Ophiocephalus striatus* Bl. *(Ophiocephalid).*

Trey-pruol = *Cirrhinus microlepis* Sauvage (= *Labeo pruol* Tirant) *(Cyprinid).*

Trey-andong = *Synbranchus bengalensis* Mc. Clelland *(Cobitid).*

For "pra-hoc" intended for consumption in Siam, Trey-andong is used exclusively.

The dressing of the fish is begun by removing the scales. The heads and viscera, with the exception of livers, are then cut away. The gutted fish are sliced and soaked in fresh water overnight. Next morning they are taken out of the water and dried in the sun for the whole day. At about 5 o'clock in the afternoon they are mixed with salt and placed in a basket, to allow the pickle to drain. Next day the fish, which have been reduced to a paste, are once more exposed to the sun and in the evening salted again. The mass is then stored in a pot and during the first three days the collecting pickle is poured off and may be used as "nuoc-mam". Finally the pot is sealed with a wooden cover or a piece of cloth, tied with string and covered with a pulp of wet wood ashes. "Pra-hoc" of first quality is ready for use after two to three months and will keep for two years.

The analysis of a sample of this product revealed a salt content of 17 per cent.

For "pra-hoc" of second quality, little fish *(Cyprinids)* are squeezed and pressed under water and in this way divested of their scales and viscera. They are then washed and soaked in fresh water overnight, mixed with salt and placed in pots to season for one month. "Pra-hoc" thus prepared is consumed by the lower classes.

An inferior quality "pra-hoc" is occasionally produced by the Annamites and destined for Cambodian consumption. The Annamites manufacture this product from small fish. Trey-real or C-linh *(Thynnichthys sp.* and *Albulichthys sp.-Cyprinids),* when bad weather prevents the use of nets.In addition when the catch cannot be returned in time because of unfavourable winds, the stale fish may still be utilised for this production. The coolie fishermen manufacture with these fish a "pra-hoc" of inferior quality; they use principally Ca-son *(Ambassis sp.-Percoid)* which is placed in brine overnight. Next morning the fish are taken out and dried in the sun for two days. Finally they are pounded with salt and stored in a jar for ten days. The proportion of salt to fish is about 15 per cent.

There exists on the other hand a product manufactured by the Annamite fishermen and sold to the Cambodians, known as "prahoc-youn". They utilize for this the residue of the great fisheries. The proportion of salt is usually less than in the preparation of the Cambodian product, which makes a modification in the odour.

Fish pastes containing glutinous or roasted rice. In the preparation of "paâk" or "mam-chao", the fish are usually beheaded and eviscerated, without being scaled. If too large, they are cut longitudinally, retaining the vertebral column; large fish may also be cut transversally in three parts.

After washing and the usual compression the fish are salted. This is done by hand, as with "pra-hoc", the proportion of salt to fish being 2 kg of salt to 10 kg of fish, or at times only 1 kg of salt is used to 30 kg of fish. No accurate measure can be given as this is entirely dependent on personal taste. After salting, the fish are placed immediately in a jar, which is filled completely. The jar is covered with leaves of the fan palm and crossed bamboo sticks. The fish are left in the jar for 20 to 30 days.

The fermented rice (several methods are described) is mixed with the fish, previously prepared, and the mixture is placed in a jar. To this end, about 30 to 40 morsels of fish at a time, are put into an earthen cup, the rice is poured over them, and the whole mass is well kneaded and then packed in the jar. The "mam" is covered with leaves of the fan palm and small pieces of bamboo matting, which is sprinkled with slightly salted water (about one litre or ¼ gal.). The water, which prevents contact with the air, penetrates slowly into the mixture. When it has been absorbed or evaporated, more water is added. About one litre of water is needed every 20 days for a jar containing 1 picul (= 60 kg = 132 lb.). The preparation of "paâk" usually takes about three months. The jar is closed by means of matting, leaves of the fan palm or banana leaves.

"Paâk" may be consumed after one month of fermentation and it is not absolutely necessary to await the prescribed period of three months.

The "mam-ca-sat" is manufactured with small fish which are headed, gutted and washed thoroughly for half an hour. They are cut in pieces, which are salted in proportion of 1 kg salt to 6 kg fish. The whole mass is mixed well and put in a jar. As in the manufacture of "pra-hoc", the mass is pressed under twisted bamboo with stones on top, and remains for six to ten days in a jar. After that time the fish is transformed to a paste, which is then mixed with roasted and pounded rice. The paste is returned to the jar and is ready for consumption in ten days. The "mam" is offered to the public in the form of round lumps, which are for sale in every Cambodian market.

This "mam" may be kept for several years if the jars are hermetically sealed. In order to give an agreeable flavour, certain Cambodians add to the preparation green papaya fruit *(Carica papaya* L.) or pineapple *(Ananas comosus* (L) Merr.) and pounded ginger *(Zingiber officinale* Rosc.).

Similar pastes are also manufactured in Thailand, Malaya and Sumatra. Many pastes are made from shrimp.

Nitrogen partition in fish pastes. The following limits are given, based upon relatively few samples, for moisture: 52—63 per cent; soluble fraction: 26—30 per cent; insoluble fraction 8—17 per cent.

In "pra-hoc", of the total soluble nitrogen 80.0 per cent is organic N, 52.5 per cent formol-titratable N, 32.5 per cent amino-acid N and 20.0 per cent volatile-bases N (incl. ammonia). The insoluble N amounts to 47 per cent of the total N.

Liquid Condiments, Fish Sauces, Fish Pickles

Nuoc-mam. The most important of the fish sauces is "nuoc-mam", from the coasts of Indochina and Thailand.

These products do not constitute a principal food, but serve as a relish to the meals which consist chiefly of rice, vegetables, salted fish, dried shrimps and various soups. The flavour of all of these condiments is highly appreciated by the natives but seems to be unpalatable to Europeans.

The manufacture of "nuoc-mam" has been described in detail and adequately investigated.

"Nuoc-mam" is a fish pickle obtained by salting small fish, usually *Clupeids* not over 20 cm (8 in.) long. Literally the name "nuoc-mam" means "salty fish water".

The production of "nuoc-mam" is an active industry, the most important centres of manufacture being situated in the province of Binh-Tuan (South Annam) and on the island of Phu-Quoc. Other centres of production exist all along the coast and it is not an exaggeration to say that wherever the people fish, "nuoc-mam" is manufactured in more or less large quantities.

In the primitive manufacture small fish are first kneaded and pressed by hand and then placed with salt in earthenware pots which are tightly sealed. These are then buried in the ground, and left there several months. Finally they are dug up, opened and the pickle that has formed is carefully decanted. This is the "nuoc-mam".

The procedure of large-scale manufacture, as practiced at Mui-Ne in South Annam, is described by *Rose*. In this industry the following fish are used as raw material:

Ca-com	*Stolephorus spp.*	*Clupeids*
	Clupeoides lile Blkr.	
Ca-lep	*Engraulis mystax* (Bl. Schm.)	
Ca-moi	*Dorosoma nasua* (Bloch.)	
Ca-nuc	*Decapterus spp.*	*Carangids*
Ca-tap	mixture of various species	

The manufacture of "nuoc-mam" requires for equipment only one or more series of vats; five vats constitute the minimum number in a series. The vats, which are of cylindrical shape, are made of the native wood "bang-lang" (*Lagerstroemia sp.*) and "chui-lieu" (*Termimalia sp.)*, encircled with braided or twisted bamboo. Their dimensions are the following: diameter 1.25 m to 1.70 m (49¼ to 67 in.) and heigth 1.40 m to 1.50 m (55¼ to 59¼ in.).

These vats are provided at the base with one or two taps, simple tubes of bamboo closed with a wooden spigot covered at the end with a piece of cloth. At the inner side the opening of the tap is buried beneath shells sometimes mixed with rice husks. This heap of shells is piled against the wall covering the tap to a height of about 40 cm (15¾ in.). The inner opening of the tap is filled with a tuft of hair in order to improve the filtering power of the apparatus, and the liquid escapes only in a small stream.

The relative quantity of salt to fish varies with the species of fish used, and also with the different strata of the vat. To some species of fish proportionally more salt is added to the stratum than to the middle or the bottom. The relative number of baskets of fish and salt are the following:

Baskets of fish		Baskets of salt		
		bottom	middle	top
Ca-com, Ca-lep or Ca-nuc..	6	3	4	5
Ca-moi or Ca-tap	6	5	5	5

A small quantity of salt is added to each measure of fish and stirred to bring about uniform salting. After the vat is filled to the brim, a mixture of salt and fish is placed on top of the vat to form a conical heap, and more salt is added to cover the whole mass completely.

After the salted fish have stood for three days, the initial pickle, the so-called "nuoc-boi", is drained off slowly during about three days. The turbid and reddish brown pickle loses its colour easily and becomes clear on contact with the air.

Meanwhile the fish have settled below the top of the vat, and the pile of salt has almost disappeared. The fish are now tamped thoroughly so that the upper surface is smooth. Finally the fish must be placed under pressure. In order to do this, the surface is covered with a layer of cocoanut leaves and two semicircular bamboo trays with the parallel touching. Then some salts are placed on top, and pressure is obtained by forcing wedges between the slats and two bars fixed transversally to form a clamp.

Next the "nuoc-boi" at first kept aside, is poured over the fish in order to maintain a layer of liquid of about 10 cm (4 in.) over the fish. This is said to prevent the fish from becoming contaminated with fly larvae. The fish are left standing to macerate; the length of time depends upon the species of fish used:

Ca-nuc 4½ months; Ca-com and Ca-lep 3½ months; Ca-moi and Ca-tap 1 year.

After this lapse of time, the pickle is permitted to run off at a rate of 40 to 60 jars (of 7 litres [1.54 Imp. gal.] each) per 24 hours. The first pickle to be drawn off, is "nuoc-mam" of first quality or "nuoc-nut". The quantity of "nuoc-nut" recovered from each vat may be as much as 60 to 80 jars.

The vats emptied of the first harvest of "nuoc-mam" are then leached in order to increase the yield with a second-quality product. In order to obtain this increased yield, fresh brine is poured over the fish in the first vat of a series; the second-quality "nuoc-mam" so obtained is then tapped, again at a rate of 40 to 60 jars a day. As soon as the quality becomes inferior, the extract from the first vat is used to leach the second vat and so on, leaching each vat of a series with a fluid which has already passed through the foregoing vats in succession. In this way, 500 to 800 jars of liquid are passed through each of the vats.

Before leaching, the covering layer of leaves is removed, and the exposed fish must be again covered with salt. Sometimes a hole is made in the centre of the residual mass, then caramel is added. This ingredient darkens the colour and imparts a certain flavour to the product. At the same time this procedure is said to improve the keeping properties of "nuoc-mam" of the poorer quality.

The undissolved fish residuum, the so called "xat-mam" or "nuoc-xat" is obtained as a by-product, and is usually sold as fertilizer.

There are many variations in the preparation of "nuoc-mam" in various parts of Indochina, some involving the salting of large fish in the round.

The most important markets for this product in the South are those of Saigon and Cochinchina, which consume the well-known products of Binh-Tuan and of the island of Phu-Quoc. For the North (North Annam and Tonkin) the markets of Nam-Dinh and of Hanoi may be mentioned, which are, however, far less important than those of the South.

During the World War of 1914—18, the shipping of "nuoc-mam" became urgent for the supply of Annamite troops in Europe. The earthen pots of 5 to 6 litres (1.1 to 1.3 Imp. gal) proved to be rather unsatisfactory. In order to meet the difficulty, the volume of the "nuoc-mam" was reduced by evaporation and the heavy syrup thus obtained, could be easily packed in tins. The evaporation was carried out in pots placed in hot sand over a fire, and a continuous stirring prevented the boiling mass from scorching. For use, 1 kg (2.2 lb.) of the condensed product was diluted with 3½ litres (0.77 Imp. gal.) of water, yielding 4 litres (0.88 Imp. gal.) of "nuoc-mam". 50 cm^3 (1¾ fl. oz.) of the diluted product make a man's ration.

Chemical analyses of "nuoc-mam" have shown it to contain 0.21 to 1.35 g. of tryptophane per litre. Since 1933 the minimum total amount of nitrogen, by regulation, is 15 g. per litre for "nuoc-mam" of the South and 5 g. per litre for that of the North; a tolerance of 4 g. is allowed for the former and one of 2 g. for the latter.

A "nuoc-mam" of 20 g. total nitrogen should contain at least 240 g. NaCl per litre, whereas 200 g. per litre is sufficient for qualities richer in nitrogen. A slight salting of the fish causes putrefaction, in other words a predominance of ammonia nitrogen over the amino acids. Excessive salting on the other hand, reduces the ammonia-amino acid ratio to a minium, but at the same time retards the digestion of the proteins, thus keeping down the nitrogen content of the "nuoc-mam".

The proportion of nitrogen of volatile bases (ammonia, *etc.*) to amino-acid nitrogen may be roughly judged by the pH, for the reaction should be acid to phenol-red.

A bibliography of legislation on the manufacture and trade of "nuoc-mam" and allied products, from 1905 to 1939 is included in Westenberg's paper.

Dialysis experiments have demonstrated that in "nuoc-mam" the proteins have been digested practically 100 per cent.

Enzyme studies. Many variations in the methods of "nuoc-mam" preparation have been reported, but they all come to the same conclusion, that the meat of the fish is dissolved. The pickle contains in the beginning, therefore, essentially dissolved proteins (biuret reaction). The proteins are slowly decomposed and there are given off principally amino acids (and ammonia).

Since the solution of the proteins and the subsequent decomposition into amino acids takes place even if the entire process is kept sterile by the use of chloroform, it was believed that the action was due to enzymes.

Investigations were, therefore, towards enzyme action. Salt-free glycerine extracts of fish meat and fish organs were made and their action, studied under toluene, upon gelatine, coagulated egg white and peptone. Only the juices of the organs were able to decompose the proteins from the very beginning, while those prepared from the meat were only active when decomposition had already begun; the latter being able to decompose the intermediate products such as peptone. The fish pickle is not the active agent, since most of the process takes place in the body of the fish. The principal function of the pickle is to hold the decomposition products in solution and to retard the growth of the aerobic bacteria. Thus the juices of the organs prove to be the most important solvent in the preparation of the "nuoc-mam" and for that reason a further study was made of the glycerine extract of these organs.

The optimum temperature for the action on gelatine proved to lie between 36° and 44° C. (97 and 111° F.). Furthermore, it was found that the glycerine extract was active exclusively in a neutral or alkaline medium. A weak acid reaction hinders the digestion of coagulated egg white very markedly and less amino acids are formed.

Salt also slows up the enzyme action. 20 per cent of salt (NaCl) reduced the activity of the enzyme to one third. A "nuoc-mam" of good quality contains from 20 to 25 per cent of salt. If a specimen contains less salt the enzymes can react better, but unless some disinfecting medium is used the aerobic bacteria multiply so rapidly that putrefactive action predominates.

Autolysate. By using a sterile method (2—3 per cent nitrochloroform) to reduce the amount of salt necessary, an autolysate has been obtained by a patented process, in as many days as required months by the native process.

After two weeks the solution contained 1½ times as much autolysed products as good "nuoc-mam" that conforms to the legal requirements. The autolysate was then concentrated *in vacuo* at a low temperature, which drove out the dangerous preservative. When the volume has been reduced to one quarter of its original amount the product is protected by its own amino-acid content from further disintegration and is therefore durable.

The autolysate obtained by this sterile process, has not been well received by the natives, in spite of the original high expectations. The excellent food value was demonstrated by several tests made in garrisons, hospitals and on estates, but where the choice of food was left free, the powerfully penetrating fishy odour that is typical of the native fish products, proved clearly enough to be more acceptable.

Bacteria studies. The failure to find local markets gave impetus to fresh investigations that showed that the characterstic odour so desired by natives was caused by the action of bacteria. In the native preparation of "nuoc-mam" and "pra-hoc" from the second day there develops a homogeneous flora of an anaerobic spore former, especially in the fleshy parts of the fish, before a considerable quantity of salt has penetrated. Pickle and viscera, on the other hand, appear to offer no suitable medium for the development of this organism. Isolation of this spore forming organism was rendered somewhat difficult by its anaerobic properties, so that former attempts had remained unsuccessful. This must have been one of the reasons that no thought was given for so long to anything except enzyme action.

The proteolytic action of this newly found *Clostridium,* has been investigated more closely because of its bearing on the "nuoc-mam" manufacture. Proteolysis was, therefore, tested on sterilized fish meat in an equal volume of water under a vaseline layer. Though the published data of this investigation are rather scanty, the authors arrive at the conclusion that so far as the formation of formol-titratable nitrogen is concerned, there is no essential difference between bacterial action and the digestion by enzymes from the muscles and the intestinal tract of the fish. Against this a marked difference seems to be exhibited in the production of volatile bases, as indicated by the proportion of nitrogen from volatile bases to formol-titratable nitrogen. This ratio will amount to 50 per cent in the products of bacterial proteolysis, whereas in sterile enzymatic proteolysis, this ratio will range from 10 to 15 per cent.

The analysis of some 200 samples of native "nuoc-mam" has given ratios ranging from 35 to 60 per cent. This character, together with the characteristic odour of "nuoc-mam", shows that besides enzymatic dissolusion, bacterial action is also instrumental in the manufacture of native "nuoc-mam".

Flavouring and marketing of autolysate. In preparing autolysates the inclusion of bacteria was, therefore, also tried. After expulsion of the nitrochloroform the sterile autolysate was inoculated with the essential microbe, either in pure culture or not, and then tested occasionally for flavour. If, after 24 to 40 hours, the liquid was saturated with salt, the product seemed to be identical with the ordinary "nuoc-mam". The preparation of the autolysate took 4 to 5 days and the expulsion of the nitrochloroform but a few minutes so that this might indeed be called a quick process as the native preparation takes months and months.

The manufacture of fish meal was also altered, the stirring being carried out at moderate temperature. The mash resulting from this treatment was still moist from its own water content. It was spread out in the open, and soon the desired odour developed. A fragrant fish meal was then obtained by subsequent drying in the sun or *in vacuo* at a low temperature.

In order to present an unaccustomed product to the people, it was provided in a familar form rather than in a powder. The fish meal was, therefore, mixed with the fermented autolysate which was condensed to a syrup, and this was mixed again with tapioca flour. The flat, cheesy lumps were cut into slices, in which form it was presented to the customers at the rate of 1 piaster per kg. A daily ration of 100 g. (3½ oz.) of this highly nutritive and palatable product was considered to be an ideal supplement to the ordinary menu.

Keeping Qualities

The amount of formol-titratable nitrogen should amount to at least half of the total nitrogen. Should a "nuoc-mam" contain less amino acids it is unstable because of the ammonia formed, which may occur even when the product is sterile.

This criterion of Rose appears indeed to be a guarantee of durability. The amino acids themselves act as preservatives, a fact that is clearly shown in the case of the condensed, salt-free "nuoc-mam" prepared in the laboratory under sterile conditions, and reduced to one quarter of its original volume. This liquid may be kept for an almost indefinite time, which is ascribed to a high content of amino acids. A low ammonia-amino acid ratio in the solution procures an acid reaction.

The durability of commercial "nuoc-mam" also coincides with an acid reaction (low pH). Good "nuoc-mam" diluted with distilled water in the proportion of 1 to 10 or 20, should give a clear yellow colour with phenol-red. If there is a tinge of red, it cannot be kept for long without undergoing putrefaction.

PRICES, FREIGHT RATES, YIELDS ETC., FOR SOME FISHERY PRODUCTS

Information collected by *Mogens Jul*

Some estimates of the cost of marketing frozen products are given on page 214. Further information regarding the prices of certain Asian fishery products is given on pages 118 and 120. Further pertinent information will be found in the chapters devoted to the specific products, *e.g.*, for dehydrated herring on pages 294 ff.

For the purpose of enabling European manufacturers to estimate very roughly some of the possibilities of marketing European fishery products in the Far East, FAO has collected some additional information on cost of transportation, *etc.*

Fish Prices in the Philippines

The following information has been made available to FAO from the Institute of Nutrition and the Department of Commerce and Industry, Bureau of Nutrition, Manila, the Republic of the Philippines. The conversion rate used is 1.00 Philippine peso equals U. S. $ 0.50.

Retail Price for Fresh Fish

(U.S. $ per kg)

	Prewar	1949	1950
Bass (Apahap)	0.45	1.29	1.39
Milk fish (Bangus)	0.24	1.30	1.33
Sardines	0.08	0.36	0.28

Wholesale Price for Dried Fish

(U.S. $ per kg)

Herring, dried (Tunsoy)	1st class	0.77
—»—	2nd class	0.73
—»—	3rd class	0.67

Retail Price for Dried Fish, August 1950

(U.S. $)

Herring, dried (Tunsoy)	big	per 100 pieces	1.62 to 1.95
—»—	medium	—»—	1.12 to 1.45
—»—	small	—»—	0.88 to 0.95
Anchovies, dried		per kg	0.80

Canned Fish Prices, August 1950
(U.S $ per can)

	Retail	Wholesale
Sardines in tomato sauce (15-oz. oval can) ..	0.25—0.33	0.20—0.27
Sardines, domestic (8-oz. cans)	0.12—0.18	0.11—0.14
Sardines, Portuguese (8-oz. cans)	0.25	....
Salmon (1-lb. tall can)	0.50—0.75	0.40—0.68

Fish Prices in Thailand

Information from the FAO Regional Fisheries Officer for Asia and the Far East indicates the following prices for fishery products in Bangkok, Thailand.

Prices, August 1950
(U.S. $ per ton)

	Retail	Wholesale
Cured fish	240	160
Fish paste	300	200
Fish sauce	195	130

Yields in the Manufacture of Cured Product in the Far East

Figures for the yield in the manufacture of the various fishery products in use in a region are necessary if an estimation is to be made of the possibilities of importing them from elsewhere at competitive prices:

1. *Indochina.* 100 kg (220 lb.) of fresh fish (*Cyprinides, i.e.,* carps, *etc.*) yields 33 kg (73 lb.) fish paste. According to government regulations of 1933, nuoc-mam (fish sauce) should contain 15 g. total N in the South and 5 g. total N in the North of the country. Assuming that the fish protein is dissolved and extracted completely, and assuming a protein content of 19 per cent, *i.e.,* 3 per cent N, 100 kg (220 lb.) fish would yield between 200 and 600 liters (53 and 158 U. S. gal.) of nuoc-mam.

2. *Sumatra.* 100 kg (220 lb.) fresh shrimps or small fish yield 67—80 kg (148—176 lb.) fish paste (trasi).

3. *Thailand.* 100 kg (220 lb.) fresh fish yields 70 kg (154 lb.) fish paste or 90 kg (198 lb.) fish sauce.

Cost of Shipping Fishery Products from Europe to Far Eastern Ports

The East Asiatic Company, Copenhagen, Denmark, has quoted the following freight rates. The rates have been converted on the following basis: 1 U. K. £ equals U. S. $ 2.80; 1 hundredweight equals 112 lb. or 0.050802 m. ton; 1 cubic ft. equals 0.02832 cu. m.

Freight from North European Port, July 1950
(U.S. $ per m. ton)

	Bombay or Colombo	Singapore	Hongkong
Salted dried herring in wooden boxes	18	11	12
Salted herring in barrels, ordinary storage ..	...	23	24
Salted herring in barrels, refrigerated storage.	...	44	45
Canned herring in corrugated or wooden boxes	18	22	23

It should be noted that where 20 hundredweights exceed 40 cu. ft., that is, where 1 m. ton exceeds 1.1 cu. m., the freight rate quoted above applies to 1.1 cu. m. instead of to 1 m. ton. For goods in refrigerated storage, the freight rate will be the above or 3 per cent of the value of the shipment, whichever is the highest.

All the above freight rates are approximate and subject to change at any time.

Shipping Weights of Canned Fish in Shipping Containers

When considering the freight rate for canned herring, it may be useful to note that one case containing 48 cans of canned fish in "1 lb." (15 oz., 425 g.) oval cans weighs about 30 kg gross weight and one case of 100 cans of canned fish in ¼ Dingley "4 oz." (3¼ oz., 92 g.) cans weighs about 16 kg gross weight.

GENERAL CONSIDERATIONS REGARDING OVERSEAS EXPORT OF INEXPENSIVE HERRING PRODUCTS

Note by *van Veen,* FAO:

In most underdeveloped tropical countries the average daily consumption of animal protein is very low. Usually the greater part is made up of fish protein. Fish consumption is considerable in Japan and in the Philippines, at least compared with other Far Eastern countries. Elsewhere, the consumption averages are very low.

There are several reasons for this: limited fish production, lack of means of preservation and consequently much spoilage. Moreover, very often inland transportation of these products, liable to rapid spoilage in a tropical climate, makes the prices for fishery products too high for the great mass of the people, who usually are very poor. Imported fish is generally too expensive.

From a nutritional point of view it is highly desirable to raise the consumption level of animal protein. Therefore, it would be useful if more fishery products could be made available at sufficiently low prices and with good keeping quality.

The problem of imports of fishery products is primarily a price problem. There would probably not be so many problems in connection with acceptability. Japanese canned sardines were quite acceptable in the Far East before World War II, notwithstanding the fact that most people there were accustomed to eating dried and salted fish only, which have a rather pronounced flavor. The same holds for pickled herring in Java before the war, which was an expensive delicacy.

If one considers importing fishery products into underdeveloped tropical countries, one should keep in mind that there are two possibilities:

(a) The higher social classes in the underdeveloped countries can pay much more than the lower ones. However, they only constitute a very small part of the whole population. Nevertheless, in regions such as India, China, Java, this very small percentage may comprise a great number of people because of the enormous population concerned. Therefore, one might consider the possibilities of an importation at a moderate price on behalf of the more well-to-do persons in these regions, including perhaps a great part of the population of the large coastal centers, plantation workers, *etc.*

(b) In order to reach the greater part of the whole population — which might increase the potential consumption of imported fish perhaps twentyfold — the product has to be very cheap.

In the Orient, fresh fish is generally preferred by people living near the coasts, rivers and lakes. Iced fish can only be bought by well-to-do people. Salted and dried fish and shrimp are used mainly in areas where fish has to be imported. Fish pastes, sauces and smoked fish are products used in certain areas and regions but their use is not as universal as that of the salted and dried products. For example, fish sauces are not common in most parts of India. Fish sauces are not in use in Indonesia, neither is smoked fish, but salted fish is very acceptable there. There are probably no technical reasons for this. Food habits vary in every part of the world and so do the many native ways of preserving or preparing foods.

Most, possibly all, of the usual preserved fishery products are likely to be found acceptable. Fish flour might not be, but here the possibilities of using fish meal as a feed might be considered. On the other hand, salted and dried herring might become too rancid during the prolonged transportation and storage at tropical temperatures.

From discussions:

Le Gall, France, considered the possibilities for shipping herring products from Europe to Asia and Africa.

1. *Fresh:* The possibilities of shipping fresh herring to Africa or Asia would hardly prove practicable because it would be much too expensive and because it would not be possible to preserve the fish during shipment.

2. *Frozen:* To ship herring frozen would probably be impossible due to the high cost of shipment and storage (*cfr.* page 214). Another difficulty was that herring as a fat fish turned rancid very easily with the result that after a period of 4 to 6 months in the frozen state it was completely rancid. However, research might extend the period for which such frozen herring could be kept wihhout turning rancid.

3. *Salted:* The herring might be preserved by the old-fashioned method of salting. One of the characteristics of this method is that it extracts 18 to 20 per cent of the water from the flesh. This reduced shipping cost and improved keeping qualities. It makes it possible to store the herring catch as long as the period from one season to the next one. Salted herring could be shipped to tropical countries, provided it was salted and dried. One could possibly improve the keeping quality by resalting or adding fresh salt at some stage during transportation. In the receiving countries salted herring might be further processed according to local customs and preferences.

4. *Light-cured or acid-preserved:* Then there was the possibility of preserving the herring as semi-preserved, *i.e.,* delicatessen, *etc.* It could keep then for one to two months, provided that chemical preservatives are added, but the use of these chemical preservatives should be studied further. For instance, boric acid is sometimes used, but its use is forbidden in France. One additional difficulty would here be introduced by the fact that the product was semiperishable. Retailers might keep it too long until the product was partly spoiled and then sell it, which would result in cases of food poisoning.

5. *Canned:* Canning was considered a good preservation method, provided that the product could be sold at a sufficiently low price. Canned herring products were very well received by the local population. In Algeria, for instance, in the earlier days nobody ate canned sardines or other canned fish products. Those living near the seashore ate fresh sardines. Nowadays, however, canned sardines were eaten throughout Algeria in considerable quantities, proving that this product can easily find new markets. The situation is the same in French Western Africa.

It was likely that there in this process was room for much further development.

He suggested that the problem be further explored according to the outline presented here.

Heen, Norway, added to Mr. Le Gall's list that one could freeze light-cured herring. This, however, would introduce additional shipping and storage cost. One might also consider various methods of sterilization, but these would all introduce additional cost of packaging and containers. Heat sterilization would normally not be suitable for these products, as it impaired their appearance and consistency. Another possibility was irradiation. No existing method could be used, but one might be developed in the future. Irradiation would not preserve the products completely. A certain ripening would still take place. The possibility of using chemical preservatives should be further explored. Some such chemicals were, of course, already in use, but new and better ones might be developed. In this respect, one should consider recent Canadian experiments where certain antibiotics were used.

Reay, United Kingdom, felt that the production of hard-cured salted herring and also dehydrated herring was the most promising for the manufacture of herring products acceptable to less-developed areas. However, even for these products, the problem of reducing cost was still a vital one.

Jul, FAO, concluded that as far as dehydrated products were concerned it seemed that a considerable amount of work had already been done and that the work that lay ahead would be more in the line of adaption of the methods already worked out than in basic research with regard to manufacturing processes.

van Dijk, the Netherlands, said that one should consider shipping fresh herring to overseas areas where processing might be cheaper due to lower labor cost. The use of fresh herring would also make it possible to produce a wider range of products than when the products had to be manufactured from salted or otherwise-preserved raw material.

Crowther, United States, suggested that smoked products should be included in any marketing study for overseas areas.

Bartz Johannesen, Norway, mentioned that in one instance he had put up a filleting arrangement in a herring plant to produce smoked herring fillets. There were plenty of customers who wanted them, but difficulties in the existing trade agreements made it impossible to sell the product. He felt that such considerations often might make it difficult to introduce new products.

Jul, FAO, mentioned that the trade in fish sauces and fish pastes is quite considerable in the Far East. Dr. Kesteven estimated a consumption of fish of about 10 kg per person per year in Asia. This meant a total consumption of about 5 million tons of fishery products a year. It seemed clear that quite a considerable amount of these were fish sauces and fermented products. Many of the factories in the Orient, making these products, were very large industrial establishments, which also indicated that trade was of considerable size. Therefore, it was undoubtedly worth while to explore whether such products could be manufactured from herring and marketed in these countries.

Note from *van Veen,* FAO:

In discussing these possibilities, the use of fish meal as a basis for making fish sauces, *etc.,* should be considered. Fish meal has a high nutritive value, it contains valuable proteins as well as important minerals and vitamins, particularly the animal protein factor. Fish meal is, generally speaking, not directly acceptable as food. In many of the tropical countries, *e.g.,* Southeast Asia, however, fermented fish pastes and sauces are in high esteem by the population and form a regular ingredient of the diet. They are usually not consumed in great quantities at each meal, but as millions of people use these products every day, the consumption is still very high. They are usually manufactured from whole fish, with or without entrails. Many ways of preparation of these products have been described, but in general not much is known about the enzymatic and chemical processes during their fermentation. Well-described is mainly the manufacture of a few products such as "nuoc-mam", a fish sauce from Indochina, and "pedah Siam", a salted and partially dried fish, exported from Thailand to Malaya and Indonesia.

It appears as if the very characteristic flavor of these products is developed partly or wholly by the action of microorganisms. These may be characteristic of the fish itself. In addition, however, they depend on the action of autolytic and other enzymes and on the numerous bacteria which are ubiquitous in the tropical environment, the entrails, slime, *etc.,* and which invade the fish flesh soon after death. The presence of salt may of course play an important role in the type of process which takes place.

It is well conceivable that if one could get a better knowledge about the microorganisms, the action of enzymes and other factors which play a role in these fermentation processes, inexpensive ways could be found to produce these products from fish meal.

From discussions:

Le Gall, France, recommended that FAO should undertake a study, which should be carried out as quickly as possible, of the possibilities of marketing preserved herring products in Asia and Africa. Here the preferences of the local populations played a very important role. For instance, the population in some countries would eat salted but not dried fish, while that of others would eat dried fish but not salted. Other countries also have to be taken into account. In one French colony the population did not eat salt-water fish which they considered sacred. Native populations often preferred fish which had a very strong taste because they added it to other foods which are not tasty enough. This was very similar to the use of "nuoc-mam" in Indochina where this sauce is used as a flavoring material for rice dishes.

For obvious reasons, most of the statements presented during the discussions referred to some specific product, and will be found in the chapter dealing with the product in question.

Recommendations for Future Investigations

At the end of the discussions it was recommended that the following action should be considered:

1. FAO should study the manufacture, distribution and sale of fermented, dried, salted, smoked, canned, *etc.*, fishery products in Asia and Africa, with due consideration of the economic questions involved.

2. FAO should then endeavor to obtain samples of products which might be used as a guide in an attempt to manufacture similar products of herrings, *etc.*, which could be sold at sufficiently low prices.

3. These samples should be submitted for the use in a cooperative program of technological research.

4. If this research reveals that similar products can be prepared from herring, samples produced experimentally should be sent through FAO to the Indo-Pacific Fisheries Council and a report obtained on the possibility of their sale in the Far East market.

5. This study should include consideration of the possibility of sending salted or otherwise prepared herring to the consuming centres for processing there.

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Chapter 5

FISH PROTEIN PRODUCTS MADE BY FERMENTATION OR CHEMICAL HYDROLYZATION

This chapter includes:

FERMENTED FISHERY PRODUCTS, *(Questions des Autolysats de Poissons)*, a paper presented by *Professor Schaeffer* and *Miss Le Breton*, University of Paris (Sorbonne), France,

and information from the discussions of the meeting.

Introduction

In the last chapter, reference was given to the extensive manufacture of fermented fishery products in Asia and the Far East. It was, therefore, worth while to consider whether such products could be manufactured in Europe for export to these countries. Closely related to this problem was, however, consideration of other hydrolyzates from herring, designed for use in other markets, as food adjuncts, *etc.* The material presented at the meeting relating to these problems is collected in this chapter.

Manufacture of Fermented Fishery Products in France

Schaeffer and *Le Breton's* paper

The authors have been interested since 1924 in certain nutrition problems which appeared very important from a sociological viewpoint, namely: the deficiency in proteins and the vitamin-B group in the food of the equatorial populations of Asia and Africa. It seemed that in the more advanced countries in Europe, the United States, and certain regions of South America there was great waste of by-products in many industries — by-products rich in important proteins and often in vitamins of the B group.

Two of these by-products attracted our attention:

1. The brewery yeasts, which at that time often were discarded (containing proteins of high quality and vitamins of the B group, *e.g.*, ergosterol).
2. Fish-surplus catches, fish-plant waste.

Since 1925—27 a number of processes were developed and patented. The French Association of Nitrogenous Products has put these processes into industrial use and two model plants functioned several years. Their products were:

1. At *Strasbourg:* fermented products from brewery yeast, concentrated to a water content of 30 per cent and 10—12 per cent total nitrogen, occuring mostly as free amino acids, the remainder as polypeptides. These pastes, rich in essential amino acids and vitamins of the B group (not identified at the time) were usually mixed with fermented fishery products, for marketing (no preservatives were added).
2. At *Boulogne-sur-Mer:* fermented fishery products from fish waste and entrails, concentrated to a water content of 30 per cent and consisting of polypeptides and amino acid. These pastes contained practically no sodium chloride.

Both these processes were based on the proteolytic activity at 37° C, of the digestive enzymes which were obtained in large amounts when the proportion of entrails in the fermenting mixture reached 30 per cent.

In one of the processes fermentation took place at constant pH and in the presence of toluene-chloroform. These volatile antiseptics were completely removed before the concentration of the product in the vacuum. The paste thus obtained was low in salt content and was used for the products sold in Europe (as fish soups; sandwich fillings, after mixing with the nitrogenous paste of yeast) or in Africa.

For the fermented products intended for Asian populations sodium chloride was used as a preservative. In this way a product similar to "nuoc-mam" is obtained which has a much higher nutritive value, however, than the fermented product made by the Asian people from the combined autolysis and bacterial decomposition of sea- and freshwater fishes. The fermented products obtained without bacterial contamination contain only small amounts of ammonia salts and all the essential amino acids remain intact. The fermented pastes were often mixed with ⅓ of their weight of fermented yeast paste, which decreased their salt content and added valuable constituents, such as the yeast vitamins.

On arrival overseas, *i.e.,* the Orient, Indochina, China, these pastes were diluted, sold as "nuoc-mam" by adding native "nuoc-mam" products of specific flavor.

These fermented products, "nuoc-mam", represent for the Asian populations an assured nitrogenous food, complementing the insufficient protein intake of a rice diet. The people deprived of these products of fish origin show characteristic symptoms of protein deficiency and avitaminosis.

The *Société des Terres Rares* (rares elements) has, in collaboration with Miss Le Breton, developed and patented, during the World War II, a new process which is explained in detail in the following:

Process of the "Terres Rares"

I. *Principles of the autolysis*

The process of the Société de Terres Rares (S.T.R.) consists essentially of a self-digestion or autolysis of the raw material (recently caught fish or frozen-fish waste), carried out under such conditions that, without addition of salt or preservatives, the development of putrefactive bacteria is made impossible.

In a single operation the three main constituents of the fish and fish waste are separated into:

1) albuminoids
2) oils and fats
3) bones.

1) The *soluble albuminoids* are concentrated into a nitrogenous syrup, containing most of the total nitrogen, especially proteinic, of the raw material.

The S.T.R. process does not cause destruction of any of the essential free amino acids, needed by man to build up the albuminoid molecules of his tissues.

The pastes thus obtained are assured food sources of nitrogen. They are four to five times as rich in nitrogen as meat and will keep practically indefinitely, even if exposed to a very humid atmosphere.

This paste contains: 40 per cent water, which can be lowered as far as 20 per cent; 9 per cent total nitrogen, including 0.2 to 0.4 per cent ammonia nitrogen; and 10—15 per cent salt.

2) The oils, which have been separated from the autolysed liquid are recovered and treated by the usual methods. Since the fat-soluble vitamins are not destroyed, these oils may be used for pharmaceutical purposes.

3) The bones are used for fish meal.

In short, the process creates a source of foods which are more nutritive than meat, easier to digest and of constant keeping quality.

II. *Study of a plant producing 100 kg (220 lb.) paste from 1300 to 1400 kg (2850 to 3100 lb.) fish waste, including 25 to 30 per cent of entrails*

Raw material: 1 300 to 1 400 kg (2 866 to 3 086 lb.) fish waste; hydrochloric acid; caustic soda; activated carbon for clarifying and deodorizing.

Products obtained: 100 kg (220 lb.) paste, containing 40 per cent water, 9 per cent total nitrogen (including 0.2 to 0.4 per cent ammonia nitrogen); 10 to 15 per cent salt.

The materials necessary for such an installation consist of currently manufactured equipment; meat grinders, autolyzing tanks with agitators, bowl centrifuges, deLaval centrifuges, vacuum-concentrating apparatus, and storage tanks of stainless steel or enamel.

III. *Manufacture*

a) *Preparation of entrails and fish waste*

The raw material consists of all the entrails, heads, fish skins, injured fish, small fish, unsaleable fish, and fish from stomachs of large fish.

It must be noted that sharks can be used but give the product a strong odor, especially the blue skin which should be discarded before the grinding process. It is necessary to grind the materials well so that the enzymes are well distributed throughout the mass.

b) *The autolysis requires an acid reaction of the material*

The ground-up fish has a pH of 4.5 to 5.0 to begin with, but during the autolysis the reaction tends to become alkaline which necessitates the adjustment of the reaction by adding hydrochloric acid.

When the autolysis is finished there have been 5 layers formed: at the surface the oils; below it a layer of light fats; then the fermented liquid; then the heavy fats; and at the bottom the bones.

c) *Drawing-off and first centrifugation*

The liquid is allowed to run into the centrifuge, and gives a yield of about 70 per cent, with little residue. The centrifuge with two outlets allows to draw off the autolyzed liquid at the top and the oil at the bottom.

d) *Sterilization and neutralization*

The clear liquid is introduced into a reservoir above the second centrifuge. There it is heated to 100° C ((212° F) to sterilize it and thus to prevent its putrefaction. Activated carbon is added for deodorizing and clarifying the liquid. The liquid is neutralized to a pH of 6.5 to 7.0 with caustic soda. Since the neutralized liquid is susceptible to spoilage as it is an excellent medium for bacterial growth, neutralization must be carried out at the last moment before concentration is started.

e) *Second centrifugation*

A cream separator of the Sharples or deLaval type is used. The liquid is allowed to stand in the reservoir for 1 hour, and is then run into the clarifyer which it must leave absolutely transparent and limpid.

f) *Concentration*

The liquid is concentrated to a density of 32° Baumé at a temperature of 66°C. (151°F.), corresponding to a water content of 40 per cent in the condensed product.

It is added that since the patent for this process was issued, additional research has led to the introduction of modifications of certain conditions in the autolysis, which resulted in a simplification of the equipment.

From discussions:

Sarraz Bournet, France, mentioned that Dr. Shaeffer was formerly professor in Strasbourg and later at the Sorbonne, Paris. He was assisted in Strasbourg by Miss Le Breton, who was now professor at the Sorbonne, Paris. To the information in the paper he added, that several thousand tons of this product had been manufactured yearly in Boulogne, France, between 1927 and 1933. It was sold in French Indochina and also in Belgian and Portuguese colonies. The volume of sale was good, but the plants had to be closed down eventually due to financial reasons which had nothing to do with the sales but rather were connected with the depression in 1932—1933. The product itself was very good, and it was easy to find a market for it. In Indochina it competed so efficiently with the locally manufactured fish pastes that the producers there started the rumor that the imported product decreased the sexual capacity of people eating it. This caused some marketing difficulties. The demand for the product had been growing in Africa, and the French Government had at one time purchased large quantities of it to be used as food for

Senegalese troops quartered in Southern France. The necessary original investment was at that time 10 million French francs but would now be 100 million francs.

Le Gall, France, mentioned that hydrocloric acid was added during the process. It was neutralized at the end. The finished product was neutral but the salt content was quite high.

Sarraz Bournet, France, said that the product was mostly marketed in tin cans. It was used directly or as an addition to other foodstuffs. This use is possible because the product has absolutely no foreign odor. When compared with certain commercially produced meat extracts, no difference was found. The food value of the product was high and it was for that reason used as food for convalescents. In one case excellent results were obtained by a supplement of 10 grams per day for a child. The product kept well even when standing in the open, some samples were kept for several years without noticeable deterioration in a damp climate. It also stood up very well during shipments to the colonies. The price for the fish used for such manufacture in France was, at the time of the meeting, about 20 to 25 French francs per kg, which makes the manufacture uneconomic. However, the Norwegian price for raw herring, presumably the equivalent of about 6 to 7 French francs per kg, should make production profitable. He also mentioned that if a product like the one described by Dr. Schaeffer and Miss Le Breton were made, then 1 million tons of herring would yield only 70 000 tons. He felt that one gram of this product would have a nutritional value equivalent to 10 grams of ordinary meat extract. He mentioned that a production of a protein hydrolyzate would, of course, not solve the whole problem of getting herring proteins to protein-needy populations. It might be one of many possibilities which could contribute to the solution of the much bigger question. The product made in France was sold in Indochina for prices which were only half of those charged by local manufacturers, in spite of the superior quality of the French product, derived from the fact that it had not been exposed to bacteriological fermentation.

Borgström, Sweden, called attention to the fact that there in the manufacturing process as described by Dr. Schaeffer and Miss Le Breton seemed to be a loss of 75 to 80 per cent, presumably because the autolysis is very rapid or because of a loss due to ammonia formation.

Other Productions

Sparre, Norway, mentioned that protein hydrolyzates had been manufactured for more than 40 to 50 years. One German manufacturer normally made this product from casein, but just before and during the World War II, it was also prepared from fish waste and many other products. The products were very expensive and normally sold in small dices. These products might not solve the problem of making the herring-protein available for the lower income groups of the Asian or African countries. Here one needed to manufacture soups in very large quantities; for instance, using 1 million tons of herring with about 180 000 tons of protein, would give more than 300 000 tons of a hydrolyzate with 40 per cent moisture. It was a question whether such quantities could be sold.

Roskam, Netherlands, referred to protein hydrolyzates obtained not by proteolytic fermentation but by chemical means, *i.e.*, acids or alkalies. This gave quite another type of product than the fermented hydrolyzates. They did not have a strong flavor; for instance it is known that there was a considerable production of that type of product in Germany during the World War II, the so called "Viking Eiweiss". It was made from lean fish, especially cod fillets; it was used in ice cream and bakery products. He felt that it might be possible to make such products from fat fishes, such as herring, but further research was needed. It might prove to be very difficult. His experience with such products, made by alkali hydrolysis of fat fish, had been that they contained various breakdown products from the fats which were difficult to remove. He felt that more information was needed also regarding the economic possibilities of such processes.

Lassen, United States, mentioned that he had engaged in extensive experiments regarding this proposed manufacture of chemical hydrolyzates from fat fish, mainly California pilchard. The result he had obtained was not very promising and it did not seem that the hydrolyzate could be produced cheaply enough to be available for low income groups. Nevertheless, it might be of interest to know that his company was producing amino-acid hydrolyzates by the ton for pharmaceutical purposes; in that field price is of course of less importance than it would be if the product were produced as food. The hydrolysis took place by the aid of acid. His company also manufactured certain amino acids, hydrolyzates, which are hydrolyzed by enzymatic action. Hydrolysis by the use of alkali had also been tried by his company, but had been discarded in spite of its many obvious advantages, one of them being that the tryptophane is retained.

From an economic point of view, enzymatic hydrolyzation such as previously described, seemed much more promising than chemical hydrolyzation. In most cases where fish proteins were found one had a great amount of proteolytic enzymes already present; thus some of the materials needed for processing were available at no cost. An amino-acid hydrolyzate in which the proteins to a very large extent were broken down to the individual amino acids might be produced relatively cheaply. It seemed that by using the enzymes of the fish itself one could get a hydrolyzate with a very pleasant flavor. This has been proved in experimental acceptability tests not only with white men, but also with Philippines, who all were very delighted with the flavor. He therefore felt that the manufacture of hydrolyzates by the use of enzymes, although one would encounter many difficulties if one would employ them in a large scale, still might contain some real promises of success. He felt that it was likely that such a product could be cheap enough to be exported to low income groups such as those in the Far East.

Harms, United Kingdom, felt that the cost of production would be too high to make fish amino acids or fish hydrolyzates available to low income groups. This, of course, is very much dependent on the price of the primary product used. He mentioned that the United Kingdom Ministry of Food had made considerable experiments with regard to alkali hydrolysis in order to prepare a product similar to the German "Viking Eiweiss". The material turned out to be rather high-priced, due to the fact that good quality of fish was used. But even with such good quality of fish it was difficult to make a product which had no undesirable flavor or odor. The marketing of this product was also difficult, because in the ice cream or bakery industry where this product should primarily be used, any product which was manufactured out of fish was considered suspect. He felt that manufacturing difficulties would be even greater with fat fish such as herring and that the chances of preparing a product without undesirable odor or flavor were almost negligable. On the other hand, he felt that more research should be carried out with regard to hydrolized products from white fish.

Heen, Norway, reported that in Norway a water-soluble hydrolyzate of herring was already in production on a pilot scale. He felt that the main technical problems involved in this production were already solved. The remaining problems were economic ones. The product was not intended as a cheap food product but rather as an emulsifying agent for baking and food industry. He found that there would be no serious difficulties in making such a product from herring. Even where white fish was used, all fat had to be removed. He thought, however, that the manufacture of these products would be still more attractive to the industry if a way was found to manufacture them with the heat-coagulating properties intact. This would open up new possibilities of use of this product in industry. He recognized that this was a very difficult task. At the time of the meeting marketing studies of the product produced at that time were being made by two Norwegian companies.

Hanson, United Kingdom, mentioned that in the experiment which had been carried out in the United Kingdom with regard to alkali hydrolysis of herring one one was left, after the separation of the oil, with a solution of alkaline hydrolyzate of herring proteins. Experiments were at the moment going on with the object of trying to utilize this product but no final results had as yet been reached. In particular, the economic aspects had not been explored sufficiently. Both the whole alkaline hydrolyzate and the same solution after neutralization with acid had been dried on roller-driers and the latter product had been fed to farm animals. More interesting products had been prepared in the laboratory; for instance, part of the proteins had been precipitated by acidifying the solution; that protein could be washed and treated in such a manner that it became practically white. It could be mixed with water and beaten up to a foam. It was felt that this might eventually be used as an egg-albumin substitute. The protein which was recovered in that way amounted to about 50 per cent of the original herring protein. Attempts had also been made to retrieve the rest of the protein which was left in solution; the main problem was to remove the salt from it, this was done by extraction with acetone. The product thus produced was very similar to beef extract. No fishy flavor was detectable at all. This means that at any rate on the laboratory scale, all the proteins had been recovered. Little is as yet known regarding the biological value of these proteins. It is known that they are broken down considerably and undoubtedly racemized, but experiments with animals have shown that the altered proteins, including even the racemized components, are more available to animals than had been expected. Hanson had also carried out other experiments with the manufacture of hydrolyzates from herring, similar to those described by Dr. Schaeffer and Miss Le Breton, but manufactured by a different method. The product was used as meat extract. Tasters, who did not know the origin of the product, noticed no difference between it and the meat extracts they were used to. But the flavor reverted after a short storage period. It was assumed that the change in flavor was connected with the oil left in the product, centrifugation not being effective in removing the oil, especially not such compounds as lipoproteins.

Recommendations for Further Investigations

On a proposal made by Dr. *Reay*, United Kingdom, the meeting agreed to the following conclusions:

A study of protein hydrolyzates produced according to chemical and similar methods should be carried out in addition to the previously recommended study of the manufacture of fermented fish products of the type normally in use in the Far East.

Chapter 6

FRESH HERRING

This chapter includes:

THE PRESERVATION OF FRESH HERRINGS[1], a paper presented by *G. A. Reay* and *J. M. Shewan,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland,

and information from the discussions at the meeting.

Introduction

From *Reay and Shewan's* paper:

This paper is concerned with the preservation of the herring in its "wet" condition, as it comes from the sea. Consideration of processing methods, which alter the nature of the fish, although preserving it as an edible product, is excluded. Freezing, which, as is now well known, can, if properly applied, preserve herrings in all their pristine freshness for a period of months, is dealt with in a special shapter (pp. 190—216).

Since the herring is a most perishable fish, its transport and distribution from sea to the ordinary consumer in the unprocessed condition or to the curer, kipperer, canner or freezer for processing must needs be of relatively short duration, even when chilling with ice is employed, and it, therefore, begins and ends as a domestic operation in each fishing country or at most involves speedy export to a closely neighbouring country.

The present paper deals only with the British situation and its problems, and gives an account of some investigations aimed at improving the condition of "fresh" herrings raching the consumer of the processor, a basic and vital consideration for any herring industry.

That the need exists to improve quality can readily be verified by

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Departement of Scientific and Industrial Research. Paper for Publication No. 50/18/2. Also published in "The Fishing News" (Reay, Shewan 1951).

partaking of meals of herrings in inland places distant from the ports, and is endorsed by every one of the official enquiries on the herring industry during the past twenty-five years and the Reports of the Herring Industry Board. Ministry of Food figures show that in 1948 about 295 metric tons of fresh and 265 metric tons of processed herrings were condemned at inland wholesale markets as unfit for consumption, and doubtless a proportion of the rest was near the border line. The herring, one of the most nutritious and cheapest of fish, is one of the most delicious to eat in the fresh condition, and yields a variety of processed products that are equally delicious, if made from really fresh fish. The proportion of the population that has frequent opportunity of eating herrings of such high quality must be small; and it is fair to assume, as various past reports have contended, that the frequently expressed distaste for herrings by many consumers is in part to be attributed to poor quality, and that sustained improvement in the general quality of herrings would lead to a considerable increase in demand.

The British Herring Catch

Herrings are caught close round the coasts of Britain mainly by drift net on overnight voyages, although ring netting has now come to account for about one quarter of the catch, and trawling is quite considerable. The bulk of the catch (204 797 metric tons in 1949) is taken between May and December — the warmer part of the year. During this period about 40 per cent of the Scottish herring catch (130 801 metric tons in 1949), accounting for more than half the British total, is landed at the North East ports of Lerwick, Fraserburgh, Peterhead and Aberdeen. West Coast areas near Stornoway, Loch Broom and Fort William, and the Clyde ports account for most of the balance, which includes, however, a substantial proportion of winter- and spring-caught fish. By far the most important English fishery is based upon Yarmouth and Lowestoft in the late autumn. The fishing season in any of the main areas lasts for only three months at most.

Seasonal Variations in the Quality of Herrings

There is a wide variation in nutritional quality throughout the year, related to food supplies and to the spawning cycle. The protein content remains all the time relatively stable around 16 per cent; but the fat and water contents vary markedly, and inversely — their sum remaining constant around 80 per cent. In spring, when food is very scarce, the fat content may fall to as low as 2 per cent. In early June when zooplankton flourishes, there is a short period of voracious feeding during which the fat content shoots rapidly up to levels above 20 per cent. With maturation of the gonads and the cessation of feeding, the fat content gradually falls, spawning generally producing a further sudden drop. Fat contents mostly range from, say, 8 to over 20 per cent in the main fishing season of the year (Lovern, Wood 1937).

The tendency towards spoilage in its broadest sense, or loss of "quality", varies very considerably throughout the season. Thus, during the period of intense feeding upon zooplankton, a considerable portion of the fat rapidly accumulating in the flesh still retains the characteristics of the plankton oil, in particular a higher degree of unsaturation and therefore of oxidizibility, than that of herring oil proper, although this too is readily oxidizible (Lovern 1938). Ingestion has outrun assimilation; and physically the fish is "bloated" with unconsolidated fat, and is very soft and easily broken or torn. A few weeks later the fish with not much lower a fat content is found to have firmed up and to contain oil of predominantly herring character.

During the main period of feeding also, digestion in the gut swollen with food persists *post mortem* and very rapidly brings about enzymic and bacterial breakdown of the viscera and the belly walls, which rupture readily under even moderate pressure in handling and stowage. Summer "feedy" fish are thus the most perishable of herrings. Fortunately the period in which fish so extremely difficult to handle are caught is a relatively short one. In contrast, fish caught, say, in the middle of May, still quite lean (*e.g.,* 5 to 10 per cent fat) and not feeding heavily keep extremely well and can be handled with little risk of damage.

General Practice

Handling Aboard and in Ports of Landing

From *Reay and Shewan's* paper:

Broadly, in the United Kingdom, general practice in the industry and its technical problems are the same now as before World War II. The herring drifter leaves port during the day, fishes during the night, and lands her catch next day. At landing the fish may have been anything from a few to twelve hours out of the sea, the average time probably being about eight hours. During this time the fish lie in stowage at atmospheric temperature. A small number of drifters have resorted to stowage of the catch in crushed ice, usually staying at sea, however, for a few days.

It has long been common practice for trawled herrings to be iced at sea, the vessels often staying out for about a week.

In the hold, which even in the smallest ships will carry 60 to 80 crans (10 700—14 300 kg) of fish, often no attempt is made to break vertical pressure in stowage; but horizontal shelving is sometimes used to divide the pound in two. It is probable that the occasions when vertical stowage with unbroken pressure exceeds 5 ft. (152 cm) are comparatively rare, but a depth of 3 or 4 ft. (91 or 122 cm) is fairly common — a very considerably one for the stowage of soft, oily, uneviscerated fish. In the early summer fishing on distant grounds off the North East Scottish ports, however, quite a number of boats now carry wooden boxes (a few, aluminium ones) of about 1/6 cran capacity (30 kg) in which part of the catch — or all of it, if small — is stowed, frequently with some ice. As the net is hauled in, the herrings fall or are shaken into deck "ponds", bins, from which they fall through bunker holes in the deck into the side pounds of the hold or into the central well under the platform carrying the net. Chutes are frequently used to direct the fish as desired.

On arrival at port, fish stowed in boxes are landed and sold in them. The boxes, however, are returnable and repacking for transport is necessary. The "bulked" catch is landed in quarter-cran baskets (45 kg), the fish then being tipped into other receptacles, boxes, "swills" or kits. The boxes used are often those employed in further transport, packing and icing if applied, being done on the fish market. In other cases this is done in the buyer's own premises.

From discussions:

van Dijk, Netherlands, reported that icing of herring at sea is used to a very considerable extent in the Netherlands. Virtually all fresh herring landed in the Netherlands has been iced. The boats are at sea at least 5 to 6 and often up to 12 days. The experience is that the quality for canning, smoking, and marinating is very good. The herring is not used for salting as salting aboard boats is preferred by the Dutch operators.

Bramsnæs, Denmark, mentioned that herring in Denmark is always iced immediately after it is brought aboard the boat except in cases where, during the winter months, it is landed the same day.

Ettrup Petersen, Denmark, mentioned that in Denmark small refrigeration plants had been installed in a few fishing vessels of from 35 to 65 tons. The refrigeration system was not used for the actual chilling of the fish, but only to make up for losses through heat leakage, thus preventing the ice from melting on the trip out to sea and back to port with the fish. The holds were insulated with 4 in. (10 cm) of cork. The compressor was driven by an auxiliary diesel engine. The cost of such an installation was about 8 per cent of the total value of the vessel. Ice consumption had been cut to about one third of what was normally required. Both methyl-chloride and ammonia plants had been tested. Ammonia was found to be the most satisfactory.

Davis, United States, mentioned that the California pilchard was generally 12 hours on the way from the fishing ground to the ports. When landed, the fish had to be processed within 4 or 5 hours as it does not keep at all. In most cases no refrigeration was used at all on pilchard boats. Here a brine refrigeration system, which would give at least partial chilling, even if it were not down to as low a temperature as —1°C. (30.2°F.), would certainly be very much in place. The canners felt that if the fish were chilled in brine aboard the boat, one might extend the packing time from 4 hours to, say, 8 to 9, or even 12 hours.

Refrigeration of tuna on tuna clippers in refrigerated brine was entirely satisfactory and had been used in the U. S. A. for many years. The procedure was generally that the holds of the vessel were filled with brine. The temperature of the brine was brought down to 2 or 3°F. (—16 or —17°C.). As soon as the fish is brought aboard the ship it is tossed into these tanks. The tuna was often still alive when it got into the brine. It stayed in the tanks for about 24 hours. When the hatch was full and the fish was frozen down, the brine was drawn off and the hatch closed. From then on refrigeration is maintained by air. The temperature was brought down to as low as —5°F. (—21°C.). The reason for drawing the brine off the hatches and maintaining the refrigeration by air cooled by refrigeration coils on the walls of the hold was the need of avoiding brine penetration. Fish had been delivered in perfect condition to ports in California, U. S. A., 4 or 5 months after capture, although some flavor had been lost. Experiments were now being carried out in California with the aim of using a similar procedure with the California pilchard. One vessel operating out of San Pedro attempted to use circulating brine to chill pilchards. It appeared that the problem of getting the process applied to sardines was more psychological than technological, as it was difficult to convince the fishermen of the benefits of chilling pilchards. However, these installations are very expensive, and only considerable improvements in the quality of the final product would justify such expenses.

A reason for chilling the fish aboard was that one sometimes has considerable oil losses, as much as 10 to 15 per cent of the total amount of oil in the catch due to separation of the oil from the fish in the holds of the vessel. This was the so-called cold-pressed oil, which is lost with the bilge water. It is caused by the weight of fish on the lower layers. Saponification and emulsification also occured due to the pressure and the temperature in the holds. This gave a raw material which was rather difficult to handle.

Jul, FAO, stressed that ice really was a much better refrigerant than often realized. Firstly, it was always 0°C. (32°F.) and, therefore, there was no need for any measures of control. Secondly, it had a very large cooling capacity. If one suddenly had a large amount of fish, one would just use a large amount of ice from the store of the holds. It would cool the fish very quickly. With mechanical refrigeration, this would not be possible without an excessively large capacity. It was mainly where there was a very constant need for refrigeration that it was easier to use mechanical refrigeration. For instance, experiments have been made in Denmark with tanks for chilling fish fillets. It seemed very tempting to use tanks chilled with refrigerating coils. However, it proved to be very impractical, because the tank had to be filled with water. Then the refrigeration was turned on two or three hours or so before the new clean water was cooled. If instead, ice was used, one only needed to renew the water and add a sufficient amount of ice which would chill the water very quickly. For that reason, such cooling tanks with refrigeration coils were given up entirely. Similarily, the refrigeration equipment which was installed on many fishing boats, both in the United States of America and Europe, was used mainly to preserve the ice which the boat also carried. The mechanical refrigeration offset heat-transmission losses and preserved the ice. The very large consumption of refrigeration needed for the chilling of the catch itself was still provided by the ice which the fishing boats carried. This matter was sometimes overlooked when the use of mechanical refrigeration was discussed.

Davis, United States, reported some similar experiences from the United States with regard to the storing of sardines in tanks. Here one maintained through mechanical refrigeration a large amount of water at approximately 0°C. There was a system of coils in the water tank. The water was circulated through these coils and from there on to the fish-storage tank. It entered this at the bottom, floated through the fish, drained off at the top and was returned to the refrigerated tank. A special difficulty was to avoid hot zones in the tanks which might develop due to insufficient circulation. Therefore, considerable effort had to be made in placing the water inlets *etc.* The water used was generally a 6 per cent salt brine which floated the fish better than plain water, thereby giving a more even circulation of cold brine throughout the tank.

Van den Broek, the Netherlands, mentioned that autumn herrings, frozen after being iced on board, were found to be inferior, when salt had been added to the ice. Even when the concentration of the salt was no more than 2 per cent of the total amount of the herring, the addition gave rise to a considerable increase in fat oxidation.

Inland Distribution

From *Reay and Shewan's* paper:

Taking the case of a Scottish mainland port, for instance, Mallaig or Fraserburgh, a "freshing" journey inland might be as follows: Fish caught 3 a.m.; landed 8 a.m.; packed with ice and sent off by rail; reached London usually in good time for next morning's wholesale market; reaches the fishmonger somewhere in London by, say, 10 or 11 a.m., *i.e.,* 32 hours after catching. Redistribution from London to a retailer in the immediately neighbouring country makes sale possible later on the same day, say 40 hours after catching. Further transport than this means sale on the following day, 56 to 64 hours after catching. Road transport, being much cheaper, is sometimes used, even for long distances. In this case the journey to London would take roughly 24 hours, still in time for a fairly early wholesale market. Redistribution by road to country areas any considerable distance from London would again postpone final sale to the consumer till the third day. A fair quantity of fish is consigned direct from port to retailers. Fresh herrings are not normally sent to English (or even Scottish) markets from the outer-island ports, such as Lerwick and Stornoway. Another day at least would usually be required as compared with the programme just described. From Lerwick, however, fresh herrings — in ice with some added salt — are exported ("klondyked") mainly to Germany, where they arrive some 2½ to 3 days at best after catching. From East Anglia, where "klondyking" is also carried out, the time is shorter, *e.g.,* 2 days. An additional day or two is sometimes necessary in which to obtain a full cargo. These exported fish are not eaten "fresh" as in Britain, but converted into "marinaden" and "bücklinge" — both types of cure that to some extent mask incipient decomposition.

In 1939 a typical package for the long rail journey from Scotland to London was a nonreturnable wooden box holding 3½ stone (22 kg) of fish and ¾ stone (5 kg) of ice, *i.e.,* a ratio of fish to ice of about 4.5:1. Little variation in icing appeared to be made in relation to length of journey or to the state of the weather, although in summer a little salt was often sprinkled over the ice. The rail vans used were of the "closed" type, neither cooled nor insulated. On the open motor lorries used, the stack of boxes was in summer treated with extra ice before being covered by tarpaulin.

Since the war, returnable boxes mainly of 3½ and 7 stone (22 and 45 kg) capacity have been used, the fish to ice ratio being anything from 3.5 to 4.5: 1, the ice being placed as a rule mainly on top of the fish with some below and at times amongst the fish. In warm weather, extra ice is sometimes placed round the stack of boxes in the van and, as noted later, there has been some transport of iced herrings in insulated, chilled vans.

At the central wholesale market, reicing and repacking is not carried out unless the fish are to be redistributed over a considerable distance. The fish generally reach the retailer in the large cities without any icing in addition to that effected at the port. Usually the fish is sent to the inland market ungutted and quite frequently is retailed in this condition, although fishmongers frequently gut and even split and bone the fish for sale display. Sometimes, rather infrequently, the fish are machine split and filleted before despatch from the port.

From discussions:

Aglen, United Kingdom, mentioned that the Herring Industry Board, United Kingdom, had been active in coordinating the distribution of herring when it has to be shipped inland over longer distances for consumption as fresh herring. He felt that considerable improvement had been brought about. Proper coordination of transport and proper icing during transport had improved the ultimate quality very considerably. One private company which owns several fishing boats has organized its own distribution of fresh herring. The herrings are shipped in insulated motorvehicles to certain inland distribution centers. That also had brought about considerable improvement of the fresh herring.

Notevarp, Norway, said that in his opinion it was more important to have well-insulated trucks than trucks with refrigeration for land transportation of fish. The insulation served the purpose of preventing the ice from melting and was more useful than mechanical refrigeration, especially on shorter trips. Before the war, insulated vans were used by Norway for fish transports going as far as Italy. Dry ice was also used. It reduced the melting of ice and increased the storage capacity for fish, because 1 kg dry ice absorbs more heat than 1 kg ordinary ice.

Reay, United Kingdom, reported that in United Kingdom it is a practice now to use dry ice in the summer time at least for shipments of herring from more remote ports.

He also mentioned that if one tried to keep as high a standard as the one used in the Torry Research Station experiments, mentioned below, it would be impossible to distribute fresh herring from, for instance, the Shetland Islands to the main land of United Kingdom. The only possibility remaining would be to freeze the herring. The fish could be frozen in blocks and shipped; it would probably thaw during the shipment, but arrive at the destination in practically the same condition, as far as quality is concerned, as when they left the cold store. (See chapter "Freezing of Herring", pp. 190—216).

Cleaning Practice

From *Reay and Shewan's* paper:

On board the drifter the fish hold is as a rule thoroughly cleaned and painted once a year. During the season the wood becomes coated with blood, slime, faeces, scales, *etc.,* despite hosing and brushing down with water after each trip. Boxes and baskets are used over and over again, being periodically hosed with water, brushed and dried in the sun. Some boxes on shore are returnable and are used several times, being cleaned by washing, brushing and drying. Many are light nonreturnable boxes. Some nowadays are of aluminium. Landing baskets are steeped in harbour water, if thought to be clean enough; otherwise they are hosed with seawater on the outward trip.

Torry Research Station Experiments

From *Reay and Shewan's* paper:

In the spring of 1939 the Herring Industry Board requested the Torry Research Station to make observations and carry out experiments on the handling, stowage and distribution of drift-net herrings. This was done and a short account will be given of the results of this, the only work undertaken in United Kingdom on this subject in recent years.

From general practice, as previously described, it was considered that the main factors likely to influence spoilage of the fish during transport from sea to consumer were:

(1) Too high temperatures. (2) Crushing in stowage and much handling. (3) Infection and contamination from contact with dirty surfaces of decks, holds, baskets, boxes, etc. and (4) The presence of viscera (*c.f.*, "white" fish which are gutted at sea on the catching vessel). The experiments carried out in 1939 were designed to obtain a more exact knowledge of the relative importance for the retention of quality of these various adverse factors, taking into account that some one and a half to three days from catching might elapse before the fish reach the consumer.

For the experiments which extended from May to August, 1939, large samples, usually several stones (1 stone = 14 lb. = 6.35 kg), of herrings treated in various ways aboard the drifter and at the port of landing (Fraserburgh or Peterhead) were rapidly sent by motor lorry to Torry Research Station, Aberdeen, where they were treated and examined as required over a period of some days. Sea water, air and fish temperatures were observed.

A sample of herrings from most of the experimental lots was examined by Dr. *H. Wood* of the neighbouring Marine Laboratory of the Fisheries Division of the Scottish Home Department so that account could be taken of the biological condition of the fish, *e.g.*, state of maturation, "feediness", *etc.* The flesh of the fish was also analysed for its content of water and "solids" and fat.

The state of preservation of the fish at various stages was observed in respect of general appearance, firmness, external odour, particularly at the gills, appearance and general condition of the viscera and the belly walls, and palatability after cooking (steaming in casserole). A "points" scale was worked out to record conveniently changes in these various characteristics and to facilitate comparison between different groups of results.

On occasion the trimethylamine content of the juice of the flesh (mg. N per 100 ml. juice) was determined throughout the experiment as affording an objective index of bacterial spoilage.

From discussions:

Bramsnaes, Denmark, mentioned that it was very difficult to evaluate the quality of fresh herrings. He felt that often the most exact method was to freeze the herrings or salt them and store them for a period of one or two months. Then differences in initial quality stood out very clearly, and, in fact, one might discover many differences that were not noticed if the herrings were judged in the fresh state.

Experiments on the Effect of the Temperature Range

From *Reay and Shewan's* paper:

It was expected that temperature would prove to be by far the most influential factor affecting the preservation of quality — that, the condition of the fish would be better in every respect, the lower the temperature, to an extent that would be of real significance for commercial practice. It was known (Hess 1934) that the initial lag phase, during which practically no bacterial growth occurs, extends at 20°C. (68°F.) in the case of certain common seawater bacteria found on fish, to some 24 hours, and to more than 48 hours at temperatures in the range 0° to 5°C. (32° to 41° F.). Experience with white fish had shown that this was broadly true for the general flora [and quite recent sensory and chemical tests have shown that spoilage proceeds about twice as fast at 5°C. (41°F.) as at 0°C. (32°F.)]. The results of the 1939 experiments amply fulfilled expectation regarding the over-riding importance of temperature.

No bacterial counts were made in these experiments, but the observed production of trimethylamine may be taken as an index of the activity of a part of the bacterial flora present, that part able to reduce the precursor, trimethylamine oxide. The amount of trimethylamine in perfectly fresh herrings was found to be small, of the order of 1 mg. N per 100 ml. of juice. In fish kept without ice at ordinary temperatures [which ranged from 10° to 15° C. (50° to 59° F.)] the production of trimethylamine was generally very slow up to about 30 hours after catching, when it suddenly and rapidly accelerated. Thus, during the first day, the trimethylamine figure was generally between 2 and 4 mg. N. By the end of the second day, however, it was generally between 20 and 40 mg. N. In fish kept in plenty of ice from catching, there was only a slight rise in the trimethylamine figure to never more than 2 or 3 mg. N even after 100 hours, the limit of most experiments. In one experiment the figure had risen little higher after 175 hours; in another it had risen to about 7 mg. N in about 160 hours.

These chemical data agree not unreasonably with the order of lag periods assumed for the general bacterial population and with the observation in the case of "white" fish that the general bacterial count has risen considerably before the sharp increase in trimethylamine occurs. Sigurdsson has since (1947) published results of experiments with herrings which closely agree with our own. Thus, at 10°C. (50°F.) a sharp rise in trimethylamine occurs after a day, and after about 4 days at 0°C. (32°F.).

Arguing simply from these chemical data it might be considered that herrings of good fresh quality should be available for almost a day from catching at ordinary temperatures, say 10°C. to 15°C. (50°F. to 59°F.), and for about 4 days at 0°C. (32°F.). The results obtained by sensory examination, however, have to be taken into account. The observers were by no means a highly trained test panel, but although not unacquainted with the general course of spoilage in herrings, are rather to be regarded as having trained themselves during the course of the actual experiments to note closely the various characteristics of changing quality. For this reason, and the inherent difficulties of sensory judgment and of variable biological material, numerical precision in stating experimentally determined periods for the retention of good quality can hardly be very great. Nevertheless, figures were obtained which are a significant guide to practice.

It goes without saying that the judges readily noted the general effect of lowering the temperature upon the rate of spoilage. In considering the implications of the sensory data for the improvement of current practice, it was necessary to select a minimum high standard of quality on the points scale below which it was thought desirable that herrings reaching consumer or processor should not fall. Fish attaining this chosen minimum standard — difficult to describe precisely in words — have lost no more than a little of their fresh "marine" or "seaweedy" quality and have developed only a slight, but still quite sweet, "oiliness" in both odour and flavour. They have still very good, although slightly dimmed, fresh appearance ("bloom") and have not completely lost stiffness (*rigor*), being fairly firm to touch and to split with a knife. In some cases, particularly early summer "feedy" fish, the belly walls might be quite soft or even perforated or have some pink discolouration, for it is well-recognised and was confirmed that, even in ice, digestion of the belly walls can proceed in such fish at a rate out of all proportion to that of the other processes of spoilage.

The sensory experimental data obtained showed that herrings kept at ordinary temperatures [10° to 15° C. (50° to 59°F.)] have passed the minimum standard of quality as described above by about 6 to 12 hours (average 9 hours) from catching. (In the case of early-May herrings, already noted as good "keepers", the time was longer — about 16 hours). Against this, herrings iced at catching so as to chill them rapidly to 0°, to 2°C. (32° to 36°F.) and kept by adequate icing at this low temperature, did not fall below the minimum standard until after 23 to 40 hours (average 32 hours) from catching.

It will be noted that these periods are much shorter than those based upon the sharp increase in trimethylamine content. Indeed, the latter is an index rather of incipient staleness than of still really fresh quality. It seems probable that the very early changes in odour and flavour of the flesh are not bacterial but enzymic in character, such as for example the initial changes in the aroma of the fat, and occur before the bacterial lag phase is over. It is possible, however, that on the surface of the fish, especially at the gills, where there is comparatively heavy infection, some of the early change in external odour may have been brought about by "resting" organisms, *i.e.*, not actively multiplying.

It is also clear from the sensory data that under the atmospheric conditions prevailing in the summer and early autumn herrings carried without ice on the fishing vessel, and taking anything from a few to 12 hours after catching to reach port, must *on the average* arrive there in a condition that is already equivalent to the minimum standard; and as might be expected, experimental data for fish iced only at landing showed that only a slightly better result was produced than with no icing at all in those cases where the quality of the fish at landing had not already reached or passed the minimum standard.

From discussions:

Borgström, Sweden, called attentation to a recent paper by Castell, Canada (1949) in which Castell proved that one could bring about the same improvement in keeping time for fresh fish by reducing the temperature from + 1 to —1°C. (34 to 30°F.), as the whole improvement brought about by reducing the temperature from the surrounding temperature down to +1°C. (34°F.). He understood that similar results had been obtained in Denmark. The problem was how to apply this knowledge — how was one to get the temperature of the fish down to —1°. He felt that even with the use of ice the temperature did not get down to 0°C. (32°F.). In addition, the temperature during the cooling period decreased quite slowly. He anticipated considerable gains from a close study of this problem.

Bramsnæs, Denmark, called attention to the fact that Castell's experiments were carried out with cod, not with herring.

Sigurdsson, Iceland, pointed out that while Castell's experiments had been carried out on cod, the advantage of using a temperature slightly below the freezing point of water was at least as great when the raw material was herring. His own earlier experiments on the storage of herring in refrigerated brine (Sigurdsson 1945) had clearly shown this. Analyses on the herring showed that some of the chemical changes which take place in fish during spoilage above 0°C. (32°F.) were almost completely stopped, when the temperature was held at —2 to —3°C. (28½—26½°F.). This applied, for instance, to the production of trimethylamine and volatile acids. The proteolytic changes were also retarded very considerably, but not as much as the chemical changes brought about primarily by bacteria. Oxidative rancidity was retarded so much that the herring stored in this way resulted in an entirely satisfactory product when used for canning. He pointed out especially that storage in air at just below 0°C. (32°F.) was not nearly as effective as storage in brine at the same temperature. When mechanized brine cooling was used it made very little difference in cost whether the system was operated at +1°C. (34°F.) or —2 to —3°C. (28½ —26½°F.), but of course one had to be careful not to lower the temperature to such an extent that the fish would freeze.

Le Gall, France, mentioned that the freezing point of fish is somewhere between —1 and —2°C. (30.2 and 28.4°F.). It varies between 0.3 and 0.4°C. (0.5 and 0.7°F.), during the year. In the chilling of fish, one has to get as close to the freezing point as possible, but with proper safeguards against freezing, as this would damage the tissue. Therefore, a mixture of salt and ice might be difficult to use, as one did not always have exact control of the salt concentration. Experiments in France with refrigerated brine had demonstrated this difficulty. It was particularly apparent that one had to have very thorough brine circulation. Shipping of fresh sardines in brine and ice have, however, at times been successfully employed in France.

Notevarp, Norway, related that many years ago experiments were carried out in Norway with storage of fish at —1°C. and about +1°C. (30 and 34°F.), both in ice.

The differences obtained were not very pronounced.

Bramsnæs, Denmark, mentioned that Dr. Reay, in his paper, said that when herring was properly iced it did not fall below the minimum-quality standard until after 23 to 40 hours. He felt that either this standard must be a very high one or there must be great differences between the types of herring caught in various countries. For instance, Mr. van Dijk mentioned that in the Netherlands herrings were kept up to 12 days in ice. And in Denmark the Fladen Ground herrings were considered of satisfactory quality for the fresh market if not more than 4 days old in ice, although it was unsuitable for salt curing.

Reay, United Kingdom, said that the standard used in the Torry Research Station experiments was deliberately a very high one as that was the particular purpose of that investigation. The limit chosen was away above any point where bacterial decomposition or staleness or rancidity could be noticed. It was rather a certain loss of sweetness, loss of entirely sea-fresh flavor, which was used as the criterion. If, for instance, the trimethylamine test was used, the fish did not show any sign of spoilage for 5 days at 0°C.

Notevarp, Norway, felt that there must be a great difference between the various types of herring when it came to keeping qualities in the fresh state. For instance, the Norwegian winter herring was entirely free from feed and kept very well in the fresh state for about 10 days. Spoilage will not be noticeable at 0°C. before 12 to 14 days. He was wondering whether the quality of fish could be correlated to the *rigor mortis.* He felt that as long as fish was in *rigor mortis* it might not be absolutely fresh but at least entirely satisfactory.

Reay, United Kingdom, explained that all the herrings referred to in his paper were summer-caught except for one lot of fish which was caught in May. These latter were not feeding heavily, and the fat content was low. The summer ran from the middle of June to the middle of August. The keeping quality of the fish caught in May was considerably higher than that of the summer-caught fish. This lot was the one which got the highest keeping quality score, and which kept about 40 hours in the experiments referred to in the paper. The fish still had a considerable amount of stiffness in them when it was considered that they had reached the limit of fresh quality set in the experiments.

Notevarp, Norway, mentioned that the temperature of the sea is important for the keeping quality of the fish, as fish has about the same temperature as the surrounding water.

Davis, United States, reported that experiments were going on in his country which seemed to indicate that one could use storage at considerably higher temperatures than normally used if one stored in inert gases. He felt that this might well be cheaper than the icing of fish, considering the labor, *etc.* involved in icing.

Reay, United Kingdom, mentioned that the Torry Research Station had done some research on the use of gas storage for fresh, iced fish, but not for herrings.

Consequences for Icing Practice on Board and at Landing

From *Reay and Shewan's* paper:

It was thus shown clearly that in order to supply the inland consumer with herrings of the desired high quality, *i. e.,* no worse than the present average quality at landing, at any rate in the warmest part of the year, adequate icing on the fishing vessel immediately after catching and adequate chilling during subsequent distribution are obligatory. Even so, a sufficiently high level of quality can be maintained only where retail sale is not delayed beyond the day after landing. Herrings landed, as they mostly are at present, without ice, should, however, be satisfactory for kippering, freezing and canning, but should none the less be iced immediately at landing to preserve them during delay in processing, which should be undertaken on the day of landing. Salt curers have a prejudice against using iced herrings, which is partly attributed to undue loss of scales and to difficulty in leaching out blood, if the fish have lain more than, say, two days in ice. The authors have done no experiments in curing iced herrings and know of no published data.

From discussions:

Bramsnæs, Denmark, mentioned that in Denmark experiments were carried out with salting of herrings after icing. The herrings were Fladen Ground herrings caught by trawl. Tests were carried out on fresh herrings, herrings two days old in ice, and also four and five days old in ice. No difference was found between herrings salted fresh and herrings salted after two days in ice.

From *Reay and Shewan's* paper:

Icing can readily be carried out on large vessels such as trawlers. Drifters are much smaller, but as already noted the icing and boxing of herrings at sea has been practised to a small extent since before World War II — even since the late 1920's. Although most of the later-built drifters are smaller on the average than the older steam drifter, the use of internal combustion engines has resulted in little, if any, diminution in the fish hold. It would seem, therefore, a matter of technical urgency to extend icing at sea as far as may be. It may well be impossible to ice all of very large hauls, but such are exceptional. Most of the drifters now carrying ice stay at sea for about three days. There is a danger here; a tendency for fishermen to exaggerate the preservative capacity of an improved new procedure, and a temptation to stay at sea till the ship is full. The latter practice will not in most instances bring about the desired rise in the average quality of the fish landed. Clearly, only the fish hauled on the day of landing will be suitable for high-quality inland distribution, whilst those hauled the previous day should still, if well iced, be satisfactory for local distribution and for local processing on the day of landing. Ideally, therefore, voyages should not extend beyond two nights.

Icing of Herring Prior to Canning

This subject was discussed quite extensively; see Chapter 12, "Herring Canning", pages 313 ff.

Experiments on Chilling in Boxes

From *Reay and Shewan's* paper:

During the 1939 experiments of the Torry Research Station some tests were carried out concerning the requirements of ice for chilling herrings in boxes. Much more work requires to be done under more varied conditions of external temperature, ratio of fish to ice, distribution of fish and ice, size, type and stacking of boxes, etc.; but certain broad conclusions emerged. Icing on board drifters as then practised left room for much improvement. Usually the boxes used carried 1/6 cran of fish (30 kg) the ratio of fish to ice was about 7 to 1, all the ice being put on the top. Only the top layer of fish, it was found, were efficiently cooled, the rest of the fish having temperatures between 4° and 7°C. (39° and 45°F.) after 8 hours [ambient air temperature 12°C. (54°F.)]. It is difficult to ensure uniform chilling of a mass of fish down to about 0°C. (32°F.) without using a very considerable amount of ice properly distributed. Although theoretically a ratio of fish to ice of about 6 to 1 should correspond to cooling of the fish alone from 15° to 0°C. (59° to 32°F.) experiment showed that for summer stowage on a drifter with the air and fish temperature at, say, 15°C. (59°F.) a ratio of fish to ice of 2 to 1 would not be excessive in order to chill the fish well by the time port is reached. (Still lower ratios than this were actually used in the herring quality tests previously discussed). For the most uniform and rapid cooling it was found that ice should be thoroughly distributed amongst the fish and that there should be a gradual increase in the proportion of ice towards the top of the box, since cooling at the bottom tends to be more rapid owing to the percolation of ice water from above.

In 1939 herrings — not iced at sea — were commonly sent from the ports in boxes of a capacity of 4 stone (just over 26 kg), with a ratio of fish to ice of about 4.7 to 1. Some experiments were carried out in similar boxes in which pre-chilled herrings were packed with various proportions of ice and allowed to warm up naturally in air at about 17°C. (63°F.). The boxes were not stacked together, but spread out individually. Although close stacking would obviously affect the average rate of warming of the load, the experiment suggested definitely that for transport in hot weather in a closed, noninsulated rail van, this ratio of *pre-chilled* fish to ice is not sufficiently low to maintain the fish temperatures between 0° and 2°C. (32° and 36°F.) until the retailer in London could be reached on the day after despatch from Scotland. Heavier icing during transport is, therefore, to be recommended. Guessing from the few results obtained, and assuming warm summer weather [average maximum of 20°C. (68°F.)] and stacking of boxes in uninsulated transport, a ratio of at least 2.5 or even 2 to 1 would seem to be required. As already mentioned, extra ice is frequently put over and round stacks of boxes in hot weather — at any rate for week-end transport. This practice might well be much extended and would probably permit a ratio of perhaps 3 to 1 in the actual packages. The use of closed, insulated vans only for such fish traffic would clearly be advantageous. In recent years quite a considerable quantity of iced herrings have been carried from the North Eastern Scottish ports to Southern England in insulated vans chilled with solid carbon dioxide. It is claimed that this has resulted in a significant improvement in the quality of the fish.

Observations Regarding Stowage and Handling

From *Reay and Shewan's* paper:

In the 1939 experiments observations were made of the effect upon quality of pressure in stowage and of the degree of handling. These, although relatively small compared with that of temperature, and smaller than was expected, were nevertheless distinctly apparent. Fish packed into boxes straight from the net and thereafter left undisturbed, were noticeably superior, at any rate during the first day after catching, to fish taken from bulked or boxed shots and packed in shore boxes at landing. The former were superior in general appearance, firmness and usually also in external odour at the gills, but *not* in palatability. In an experiment in which fish were stowed in a pound to a depth of about 7 ft. (215 cm) there was surprisingly little difference between fish taken from the top and from the bottom of the pound, but the result was in favour of those at the top. Greater damage from pressure would probably have resulted if naturally softer, more "feedy" fish than were available at the time had been used. Certainly worse results than were obtained have been observed in commercial practice. Fish packed with ice in boxes on board and re-iced at landing without disturbing the fish were compared with fish boxed and iced at sea and then repacked and re-iced on shore. There was practically no difference between the two lots of fish, even in firmness. No experiment was done in which the fish were bulked with ice in the ship's pounds. Such treatment, however, would almost certainly be bad, involving, as it would, the crushing of the fish in considerable depth against hard, angular pieces of ice and the shovelling of a mixture of fish and ice at landing.

It may be concluded, then, that although the important characteristic of palatability is apparently not affected by pressure and the extent of handling within the limits observed, general appearance and firmness definitely are. For this reason care should be taken to minimise pressure and to reduce the number of handlings as far as possible. The use of boxes on board ship obviously recommends itself. Bulked fish besides being crushed in the pounds if the stowage is deep, have to be shovelled into baskets at landing and then tipped into other receptacles. A further repacking may then be required before despatch. The use of at most two boxes, one on board and one for despatch inland — would ensure better treatment. The practical experience of the Herring Industry Board's officers supports fully the improvement in the condition of the fish to be gained by boxing them at sea. It is considered too that repacking results frequently in an undesirable loss of scales and sometimes in further loss of condition, and should therefore be avoided, if possible.

Experiments on the Effect of Cleanliness

From *Reay and Shewan's* paper:

A number of experiments were also carried out to see how cleanliness in handling and stowage affected quality. The results showed that extreme cleanliness, or even completely sterile handling, showed no significant advantage over reasonable cleanliness such as is observed by careful members of the trade. It does not seem necessary to recommend anything more than thorough washing and brushing — and where possible exposure to the sun — of boxes, baskets, pound boards, pounds, decks, *etc.* Two special experiments showed that contact with grossly dirty surfaces must at all times be avoided to prevent contact with malodorous dirt rather than actual bacterial infection. The latter, which of course is also avoided, exercises fully significant effects only after some considerable time and is, for example, of greater commercial importance in the stowage of white fish, which may be held in ice at sea for as long as three weeks.

In two experiments herrings landed uniced and then iced for a few hours after landing, were eviscerated and split in various ways by hand or machine and compared (after storage with or without ice) with uneviscerated control herrings. The results suggested that evisceration does not bring about any definite improvement in the preservation of fresh flavour. Further investigations, however, require to be made. In particular, the effect of eviscerating, at landing, herrings stowed in ice immediately after catching needs to be examined. The distribution of split, eviscerated and filleted herrings, packed like whitefish fillets in small boxes with ice has been tried on a small scale with apparent satisfaction by some firms. The main advantage would appear to be some saving of space and weight in transport and the provision of an article "ready-to-cook". Against this is the concentrated labour required to do this job, which is generally done by fishmongers.

The experiments made it clear that to preserve the clean, firm belly wall that is desirable in herrings to be used for kippering, evisceration should be carried out as early as possible after catching. Fatty, "feedy" herrings caught at the end of June were split as for kippering, immediately after catching and were stowed in ice. They were compared with uniced fish landed six hours later, iced for a few hours, and then split as for kippering and stowed in ice. The former fish had clean, strong belly walls even two and a half days after catching. In the latter, after one and a half days the belly walls were soft and could easily be broken by finger pressure; whilst after two and a half days the belly walls in half of the fish had perforated and all were very soft with the rib bones coming loose. It was further noted that evisceration on landing effected some small improvement in the condition of the belly walls as against evisceration after storage on land of the ungutted fish in ice. Unfortunately, evisceration and washing at sea is hardly practicable. When caught the fish were feeding heavily and the digestive juices must have been flowing freely. Immediate removal of the gut apparently prevented digestive ferments (and bacteria from the food) from diffusing into the belly walls, which thereafter remained in relatively good condition. When evisceration was delayed some six hours at ordinary temperature until landing, the ferments had had time to attack and penetrate the belly walls, and once absorbed there, continued to digest it and could only be imperfectly removed by evisceration and washing.

Conclusions from the Experiments

From *Reay and Shewan's* paper:

The main conclusion, it may be repeated, from these experiments is that temperature is the over-riding factor in preserving the quality of herrings and that great improvement in the condition of the fish reaching the consumer and the processor would result if thorough chilling with ice were applied all the way along from catching to utilisation. In addition, improvement would result from handling the fish all the time in small quantities as can be done by employing boxes both at sea and on land. Even if such improved methods came more generally into practice, it would still be impossible to send herrings from outer island ports to reach consumers in Southern Britain at the high level of freshness we have been considering. No doubt, however, "klondyked" herrings would reach the Continent in a significantly better state of preservation, if they had been first iced on board the drifter.

Finally, attention may be drawn to the point made by Dr. Banks (see chapter "Freezing of Herring", p. 214, that herrings quick-frozen in blocks on the day of landing — provided they are iced between landing and processing — could successfully travel from any British port to the consumer, even in uninsulated transport, if closely packed. On arrival from even an island port, the fish would be still mostly of a fresh quality notably higher than the consumer is generally accustomed to, and on reception from a mainland port would be quite as good as freshly landed. In this case too, however, a still better result would be achieved if the fish were iced at sea.

Recommendations for Further Investigations

At the end of the meeting, the following conclusions were reached:

1. Further studies should be devoted to the probable importance of the use of temperatures very close to the freezing point of the flesh in the storage of fresh fish.
2. A more extensive exchange of experience was desirable with regard to the handling of fresh fish and the use of insulated transport at sea and on land.

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Chapter 7

EVISCERATING, BONING AND FILLETING MACHINES

This chapter contains information compiled from the papers referred to below and from the discussions at the meeting.

From discussions:

Heen, Norway, mentioned that to produce cheap herring products it would be very important to have eviscerating machines mechanized. He had seen many machines for heading and eviscerating herrings, but none of them could remove all bones. This was perhaps not so important in the canning industry; but for freezing and many other purposes their removal was absolutely necessary. He felt that research should be devoted to this particular aspect.

From *Huntley's* paper "Herring Canning":

With the large herring as packed in the United Kingdom, eviscerating is now normally done by machine and reasonably effective results are obtained at speeds of about 180 fish per minute. It is, however, still necessary to employ a small number of operators to deal by hand with any fish which, for one reason or another, need further treatment. Possibly the major difficulty introduced into the mechanical design of eviscerating machines is the fact that in Europe it is essential to remove only the head and viscera of the fish and to retain as much of the flesh as possible. With the naturally occurring variation in the size of the fish, this complicates the mechanical operations considerably. On the Pacific Coast of the United States, where it is economically practicable to cut all fish to a uniform length, the problem is a simpler one. For small fish, no satisfactory eviscerating machine has yet been produced.

In those packs in which the fish is not just decapitated it is necessary that the viscera should be removed as completely as possible without damaging the fish; although several machines have from time to time been developed, none has found general acceptance. The problem is one, however, which is still occupying the attention of machinery makers, and it may well be solved before long. Apart from this, however, improvements could be effected in the organisation of the hand operations and in the design of tables, troughs, conveyors, *etc.*, for handling the fish and offal, and much has been done in this direction in the European sardine industry.

From *Borgström's* paper "Herring Delicatessen and Marinated Products":

The highly seasonal nature of the herring fisheries makes it extremely desirable for the industry to be able to handle large quantities over short periods. Therefore, high-capacity cleaning and boning machines are of advantage. Such machines have been developed by the "Arenco", Stockholm, Sweden, and by "Nordischer Maschinenbau", Lübeck, Germany.

The German machine is operated by one person and has a capacity of 2,800 herrings per hour. A somewhat experienced worker is required to reach this capacity, as every four seconds three herrings have to be put in a certain position in the rotating feeding table. The herring is automatically headed at the feeding table and at the same time measured for length and thickness. All the tools of the machine are then set according to this measurement, so that there is a minimum amount of waste. After that, the herring is seized by the tail and pulled through the machine which first removes a narrow strip along the belly and the ventral fins. Then a rotating knife opens the belly and a rotating device removes the entrails, including roe and milt. The two latter parts, which in Germany are often used for marinating, are undamaged by this process. A special device removes not only the backbones but also the side ribs. The herring then goes through a cleaning and washing device which removes the black skin on the inside of the belly cavity. The machine has a device which can cut the herring into pieces for use as tidbits. It can also be set for nobbing, a process by which the heads are removed, and the entrails, excluding roe or milt, are pulled out.

The Swedish "Arenco" machines carry out the same functions. They have successfully been used in many countries. They have a capacity of about 200 herrings per minute when operated by two women.

Most of the following packing work in the manufacture of delicatessen is done by hand although a new development for mechanizing in this particular field is starting. Special efforts have been made to construct cutting machinery for this purpose.

From discussions:

Le Gall, France, explained how the experiences in his country had been that the cutting machines ordinarily developed for herring and herring-like fish could not be used for the French sardines. The reason was that they did not gut the fish completely. Any part of the guts which remained in the fish changed its flavor considerably.

Sarraz Bournet, France, also mentioned that experiments had been carried out in France with the use of machines for the cleaning and gutting of sardines and herrings. Experience had shown that these machines did not work too well for sardines, while they gave good results for herrings, this applying especially to a machine of Swedish design.

Copeman, United Kingdom, said that the Swedish gutting machine "Arenco" was quite satisfactory for large and medium-size herrings. By using this machine some of the larger factories were able to carry out the degutting operation by 18 or 20 persons instead of about 125 to 150 workers, who would be required for cleaning by hand.

Bramsnæs, Denmark, discussed the problem of using machines for eviscerating smaller herring-like fishes. It was not only difficult to obtain complete removal of all the viscera, it was also a problem to feed the machines efficiently and quickly. Therein lay a serious limitation of the efficiency of the present machines when used for small fish. It was almost as quick to clean the fish by hand as to feed the machine.

Reay, United Kingdom, felt that it would be possible to devise a machine which would remove the little thin bones from the back of the herring. He felt that the main defect of the boning machines so far manufactured was that they used a cutting device. The principle which is used by the ordinary housewife might be much better. In this, the herring is slit open down to the vent. It is then pressed downwards and one runs the thumb down the backbone, ripping the bone out. No cutting is used at all. The Torry Research Station had made some experiments during the war to devise a simple tool which the housewife could use for this purpose. He felt that a nail, meatscewer or similar instrument could be used. It should be introduced at the front end of the fish close to the backbone and pushed down the fish with a rolling action which would push the flesh off the bones on both sides of the backbone. It might be, however, that that sort of equipment would be difficult to use where the fish were extremely fresh, still in *rigor mortis,* or very soft.

Huntley, United Kingdom: Experiments were being made to design automatic feeders for cleaning machines for small fish. Referring to the problem brought up by Mr. Le Gall, he also felt that the viscera should be removed completely from the fish. Otherwise, whatever parts remained in the fish would impair its flavor. The canning-machinery companies were studying this problem very carefully. He felt it likely that a satisfactory machine would soon be available.

Heen, Norway, stressed the importance of the fact that most countries have great surpluses of herring. It seemed that it would not be necessary to get the highest yield with a boning machine, as a large part of the catch at any rate would be used for herring-reduction processes. This was an important fact to keep in mind for the mechanical engineers devising boning machines; it made their job much easier.

Recommendations for Future Investigations

While no particular recommendations were made, the following was the general opinion expressed at the meeting:

Future developments in the herring industries will benefit greatly from the continuous improvements of boning and eviscerating machines, especially such which remove all bones from the fish and also such, which are able to handle small-sized fish efficiently.

Chapter 8

FREEZING OF HERRING

This chapter is based on and includes:

FREEZING OF HERRING, a paper prepared for the meeting by *Eirik Heen* and *Olaf Karlsen,* Norwegian Directorate of Fisheries' Chemical-Technical Research Institute (Fiskeridirektoratets Kjemisk-Tekniske Forskningsinstitutt), Bergen, Norway;

FREEZING AND COLD STORAGE OF HERRINGS[1], a special contribution for the meeting by *A. Banks,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland;

and information from the discussions at the meeting itself.

Development of Freezing

From *Heen and Karlsen's* paper:

Freezing, as a method of preservation of herrings for bait, was used by fishermen in Norway before the introduction of mechanical refrigeration. The herrings were placed in metal containers and frozen in ice-salt mixtures. To some extent the frozen herrings were also cooled in the fishing vessel by means of the same refrigerant.

In Norway, the first freezing plant was built about 1920. Here the herrings were frozen in wooden boxes by circulating brine; this system, with modifications, is still predominant. The majority of the frozen herrings were used for bait, but from 1930 on an increasing amount was exported to European markets for human consumption. In 1930 the output of frozen herrings from the freezing plants in Norway was about 5 000 tons; it reached 31 000 tons in 1948.

In 1949 there was a marked drop in the quantity of herring frozen and interest in this article seemed to be decreasing in 1950.

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Department of Scientific and Industrial Research, Paper for Publication No. T. 50/22. Also published in "Modern Refrigeration" (Banks 1951). British Crown Copyright Reserved.

From *Banks's* paper:

Because there is a strong consumer preference in the United Kingdom for fresh or lightly smoked herrings, freezing and cold storage appears to be the only way in which seasonal supplies can be made available all the year round, and the utilisation of the herring catch thereby improved. Herrings are very susceptible to changes in flavour through the development of oxidative rancidity in the fat, and this characteristic presents special problems in preservation. There is little doubt that fresh herrings are not as acceptable as they might be in the United Kingdom, in part at least, because of the development of slight rancid flavours during transit from port to consumer. Moreover, commercial attempt to preserve herrings by brine freezing in the early 1930's were unsuccessful partly because the frozen herrings became rancid very quickly during cold storage.

From discussions:

Reay, United Kingdom: There is some evidence that the adverse effect of brine freezing is not as pronounced on fatty herring as on lean herring.

Freezing Methods

Brine Freezing versus Dry Freezing

From *Heen and Karlsen's* paper:

It has been demonstrated in several laboratories that the quality of herrings frozen in brine will be inferior after a comparatively short time of storage. The freezing of herrings without the use of salt will result in a product definitely more resistant during storage which will develop rancidity to a lesser degree than the brine-frozen herrings.

In our opinion it is necessary to develop an improved method for freezing, packaging, and possibly pre-treatment of herrings to obtain products of higher quality than those which are obtained with the present methods in use in Norway.

The reason why "brine-frozen" herring develops rancidity faster than "dry-frozen" herrings is that the salt which the herrings absorb from the brine during the refrigeration, even in minute quantities, accelerates the processes which lead to rancidity. Many investigations have confirmed this; for instance, experiments, with dry-frozen and brine-frozen winter herring stored at —18°C. (—½°F.) for about 4 weeks showed a difference in rancidity as stated in *Table 1.*

Table 1. *Rancidity in dry-frozen and brine-frozen herring after 4 weeks at —18° C.*

	Organoleptic score of rancidity	Peroxide value	Kreis number	Free fatty acid
Dry-frozen herring	2.0	1.1	3.6	2.0
Brine-frozen herring	3.0	8.7	16.0	1.8

Both samples were prepared from the same raw material. The dry-frozen herrings were frozen in air blast between finned plates, the brine-frozen by the usual spraying with brine at a temperature of about —17°C. (+ 1½°F.). The small quantity of salt absorbed by the herrings already had, as the table shows, a pronounced effect on rancidity 4 weeks after freezing.

Other experiments with freezing of fresh and smoked fillets, previously dipped in solutions of salt of different purity to compare with unsalted fillets, showed the same tendency for the brined products to turn rancid during cold storage, while the unsalted fillets showed rancidity somewhat later. Any influence of the degree of purity of the salt on the process of rancidity was not detected.

As to herrings for bait, it has been an open question in Norway how high the demands on quality freezing and treatment ought to be, as it was felt that the difference was not great and it did not influence the fishing ability of the bait much. Some fishermen maintained that dry-frozen herrings, frozen directly in bait boxes, fished better than brine-frozen, but opinions differed. According to investigations carried out in recent years, however, it has been confirmed that the dry-frozen herrings are superior also as bait.

In 1949 fishing experiments were carried out in Lofoten with 500 kg (1100 lb.) dry-frozen and 500 kg brine-frozen winter herrings frozen under controlled conditions in a refrigerating plant near Bergen. The herring was then stored at —18°C. (—½°F.) for 4½ weeks and distributed among the fishermen in such a way that dry-frozen and brine-frozen herrings were tested under identical conditions.

The results showed that dry-frozen herrings in every case fished better than brine-frozen herrings and that the former gave an average yield about 68 per cent higher than the catches with brine-frozen herrings.

The experiments in 1949 were, however, too few to make it possible to draw definite conclusions. The experiments were continued during the Lofoten-fisheries in 1950, this year with 2 000 kg (4 400 lb.) dry-frozen and 2 000 kg brine-frozen winter herrings. The herrings had been stored for about 4 weeks when the experiments started. The bait was distributed among fishermen in ten different fishing places. This year also, reports from all fishermen showed that dry-frozen bait herrings in every case fished better than brine-frozen herrings. The dry-frozen bait herrings fished, according to the different fishing grounds, from 8.9 to 106 per cent better; the average was 35.5 per cent.

Dry-frozen herrings were on both occasions frozen in blocks of about 12 kg (26½ lb.) between finned plates in air blast of high velocity; the brine-frozen herrings in a brine spray at about —17° C. (+1½°F.) brine temperature for 2 hours. Identical temperatures were maintained during the storage.

Thus, also in the freezing of bait herrings it is advantageous to use dry freezing.

Cost Considerations

From *Heen and Karlsen's* paper:

The herring fisheries in southern and western Norway are carried out over very short seasons (February and March). This makes it necessary for the freezing plants to have cheap installations with big capacity.

In this respect the brine-freezing system has certain advantages over the air-blast and multiplate freezing systems.

For instance the existing Norwegian plants are usually equipped with brine refrigerators. Their freezing capacity compared to the space they occupy is much larger than would be required for the usual dry-freezing methods or air-blast freezing in tunnels or chambers.

While dry-freezing of herrings thus may be slightly more expensive than brine-freezing, the quality will be better, rancidity less pronounced, and fishing ability higher. The need for development of freezing methods other than brine freezing has thus become apparent.

The question is then which of the dry-freezing methods is the most feasible.

It is a question whether or not dry freezing of herring and brisling should be carried out according to methods especially designed for these products.

From *Banks's* paper:

Although they can readily be obtained in fresh condition, and are therefore the most suitable of British-caught fish for freezing in shore plant, herrings are not frozen to anything like the same extent as white fish, chiefly because of economic reasons. Herrings are relatively cheap and they are in season at any one area for only a short time each year.

From discussions:

Aglen, United Kingdom, felt that the cost of quick freezing was a deterrent to the wider development of this preservation method. This had certainly been the case in the United Kingdom where very high hopes had been entertained for the use of freezing; they had not been substantiated due to cost considerations. He recommended a continued research into the problem as it was his feeling that much development would take place in this field in the future.

Reay, United Kingdom, stressed the fact that it was very important to get an impression soon, as to whether freezing was going to be a process to be used for luxury products or one that could also be adapted for cheap, inexpensive food products, especially because it, from a pure technical angle, was an almost perfect method of preservation.

Freezing in Blocks

From *Heen and Karlsen's* paper:

At one institute, the freezing of herrings in metal containers lowered into brine is suggested, in order to utilize ice-making plants. A vertical plate freezer that probably can be fitted for block freezing of herrings has also been built. For packaging frozen herrings in such blocks there should be many possibilities in new materials that can give a protective wrapper put on by automatic wrapping machines at a reasonable cost.

From *Banks's* paper:

Limited quantities of herrings are frozen commercially in the United Kingdom by the air-blast process employing air at —30°C. (—22°F.) or lower moving at about 800 ft. per min. (6 m. per sec.) and also by the multi-plate process. For both processes the herrings are weighed in 3.2 kg. (7 lb.) lots for freezing. The air-blast-frozen herrings are glazed and packed in fibre-board cartons for storage. The plate-frozen herrings are frozen in packages and are not glazed. They are also packed into cartons for storage. The frozen herrings are kept at —20°C. (—4°F.) or below and are apparently quite a popular product.

The freezing processes now employed in the United Kingdom require a large labour staff for weighing and packing the fresh fish, and are therefore costly. Investigations are now in progress in order to design simpler freezing plants for herrings, in which the fish will be frozen in large slabs weighing about 13.6 kg. (30 lb.) and which will require much less labour than the existing processes. It is felt that such a freezer will be of a considerable value not only for freezing herrings for long-term storage, but also for transport from the more distant fishing ports.

From discussions:

Notevarp, Norway, felt that the cost of freezing herrings in air or by other non-brine methods would not necessarily be higher than the cost of freezing in brine. For instance, a block-freezing method might be just as inexpensive and would require less expensive packaging. The blocks might be stored in bulk, wrapped in moisture-proof wrappers. The expense involved here would be much less that of the normal wooden boxes. Actually, this method might be cheaper than packaging in the ordinary way as fresh herrings.

Heen, Norway: Freezing herrings in blocks for processors or wholesalers or canners is a very important possibility. The package should be glazed. Packaging such blocks in some of the modern water-vapor-proof films might be especially promising. They were for the moment very expensive, but technical developments might change that. The price of the packaging material was probably not the most important problem but rather that of mechanizing the whole freezing process.

Reay, United Kingdom, referred again to the experiments mentioned by Dr. Banks which were under way in the United Kingdom and which were aimed at devising a method of freezing herrings in large blocks, to be made up with a minimum of labor. This method would save packaging also, and make the product easier to handle and transport. The blocks would not be consumer packs but of a satisfactory size for processing by canners or kippers or for distribution to retail fish dealers. The commercial pack frozen at present in the United Kingdom, was a half-stone (3.2 kg) package which is too small for a kipperer or processor. Much experience had been gained in experiments with larger blocks. One important feature was that the herrings keep much better than in smaller packages. Especially if the space between the herrings was filled up with water, there was very little oxidation. The blocks did not look particularly good because the blood from the fish tended to penetrate the ice between the herrings. This was not important, however, as the pack was primarily designed for use by a middleman or processor. The retailer would generally thaw the blocks out and sell the herrings as fresh herrings.

From *Banks's* paper:

The herring season in the United Kingdom may last for six months or so, but is made up of a number of relatively shorter local seasons at widely separated areas, which may last for only three months at most. Therefore, freezing of herrings will never be wholly satisfactory from the economic aspect until a way is found of transporting the costlier items of freezing equipment easily and cheaply from one fishing port to another. Ship-borne plants may provide the answer to the problem. There is no doubt, however, that the production of a high-speed refrigeration compressor would ease the situation very considerably.

Rancidity and its Prevention

From *Heen and Karlsen's* paper:

In the storage of frozen herring and other fatty fishes, the chief problem is to prevent rancidity.

From *Banks's* paper:

The reasons why herrings become rancid very quickly at chill or lower temperatures are now well known. Lovern (1938) has shown that herring fat contains a high proportion of highly unsaturated fatty acids. On these grounds alone, difficulty in keeping herrings free from rancid flavours might be expected; but in addition Banks (1937) has shown that the flesh of herrings contains a fat-oxidising system that functions even at temperatures as low as —30°C. (—22°F.). Further investigations by Banks (1939) have shown that haematin protein compounds, *e.g.*, haemoglobin cytochrome-c, *etc.*, are present in fairly high concentrations in the lateral band of red muscle of herrings and that they are probably responsible for the observed catalytic effect.

Rancidity depends on chemical reaction between unsaturated fat and gaseous oxygen and is, therefore, affected by temperature, easy access of air, antioxidants, and pro-oxidants.

Low-Temperature Storage

From *Heen and Karlsen's* paper:

The keeping quality during storage of frozen herrings, as with other frozen food products, is greater the lower the storage temperature. For high-grade products the following temperature requirements are made in Norway:

For storage up to 3 months —20°C. (—4°F.) or colder.
For storage up to 5 months —25°C. (—13°F.) or colder.
For storage up to 7 months —28°C. (—18½°F.) or colder.

The keeping time thus decreases rapidly by increasing temperature and is at —20°C. (—4°F.) less than half of that expected at —28°C. (—18½°F.). The demand on low storage temperature is greater for storage of herring than for storage of non-fatty fishes, for instance cod, owing to the fact that in frozen herrings, rancidity of the fat is the main factor limiting the keeping time. Decrease in quality due to the flesh becoming dry and fibrous, as in frozen cod, only becomes noticeable at a later stage.

From *Banks's* paper:

It is easy to demonstrate the retarding effect of low temperatures on the development of rancidity in frozen herrings, but investigations have shown that storage at low temperature is not in itself sufficient to prevent undesirable changes in flavour. For instance, with North East Scottish summer herrings, which may contain up to 20 per cent or more of highly unsaturated fat, appreciable rancidity may be detected after 4 months' storage at as low a temperature as —28°C. (—18½°F.). For a satisfactory spread-over of seasonal supplies it is necessary to provide for a period of storage of at least six months in excellent condition and it is clear, therefore, that something more than merely storage at low temperatures is required.

From discussions:

Heen, Norway: The cost of cold-storage temperatures of for instance —30°C. (—22°F.) would not be prohibitive if proper construction arrangements were made. Storage temperature would, of course, always be a compromise between what is economically possible and what is needed technically.

Combined Freezer and Gas Storage

From *Banks's* paper:

Tarr (1948) in Canada has demonstrated the efficacy of gas storage. The development of rancidity in frozen herrings can be reduced to a very low level by storage in an inert gas such as nitrogen or carbon dioxide for long periods at —10°C. (14°F.). Tarr has found, however, that the replacing gas must be pure, and in particular must be free from oxygen. Commercial grades of carbon dioxide were observed to be effective in retarding oxidation of the fat, but were found to impart unpleasant flavours to the frozen herrings because of impurities. Tarr, however, condemns gas storage for frozen fatty fish as impracticable because the allowable concentration of oxygen in the gas phase is too low for satisfactory operation on a commercial scale.

Gas storage, which has proved so valuable in other fields, does not appear, therefore, to have much future in the treatment of frozen herrings.

From discussions:

Reay, United Kingdom: The problem involved in the storage of frozen fish is not solely that of rancidity prevention, but includes that of avoiding the considerable change in texture, denaturation of proteins, *etc.,* which normally occurs during frezer storage. Even if gas could be added to prevent oxidation, storage at —10°C. (+14°F.) would not be suitable as it would not prevent these other changes.

Glazing

From *Banks's* paper:

It has been found (Banks 1938) that thin films of ice are almost completely impervious to oxygen at low temperatures and that, therefore, glazing will protect herrings from rancidity during cold storage. It is possible to extend the storage life of Scottish summer herrings at —28° to —30° C. (—18½° to 22° F.) from 4 to about 6 or 8 months by adequate glazing.

The effectiveness of an ice glaze will depend very much on the extent of desiccation occuring during cold storage. It has been observed that the glazed herrings retain their ice glaze for 4 to 5 months during storage at about —25°C. (—13°F.) under commercial conditions.

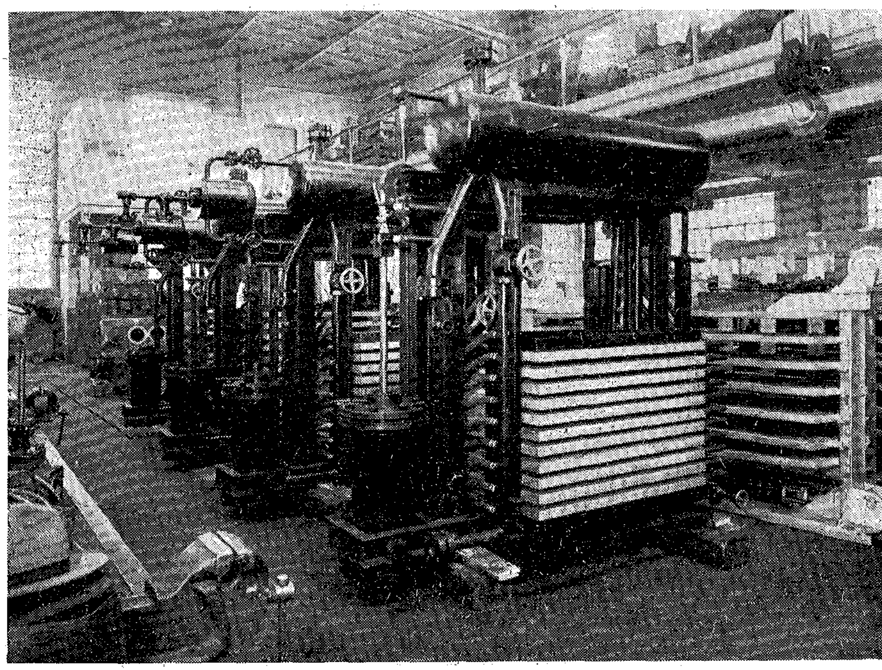


Fig. 1. *Plate freezers for direct evaporation. Capacity, 8 tons per 24 hours (Kværner Brük, Norway).*

Effect of Antioxidants

From *Banks's* paper:

The effect of antioxidants on fats is well-known, but there has been little worthwhile development of antioxidants for inhibiting fat oxidation, particularly in foods. It is true there has been some development of the use of antioxidants for certain food preparations containing fat, *e.g.*, bakery products, *etc.*, but effective prevention of the oxidation of fatty foodstuffs is a different matter. Here the problem is one of discovering a suitable substance which will protect not pure dry fat, but fat containing phosphatides and other complexes and which may be orientated in some way with an aqueous phase, and of discovering a way of adding the substance to the foodstuff so that it functions with maximal efficiency. In addition the substance must be resistant to any enzymes, oxidising or otherwise, that might be present in close proximity to the fat. Herrings present a good example of the difficulties. They may contain up to 20 per cent or so of fat which exists partly in an ill-defined adipose tissue adhering to the skin and partly as globules in between the muscle fibres of the lateral band of red muscle. Whilst it is true that most of the fatty material consists of glycerides, some will be present as phosphatides and more complex substances, probably not associated physically with the fat as a whole. In addition the fat depôt is closely associated with muscle containing the cytochrome-oxidase system, one of the most powerful oxidising systems known and one which is particularly effective in oxidising polyphenols, the type of substance found to be most effective in inhibiting fat oxidation.

From discussions:

Borgström, Sweden: The effect of antioxidants is mainly a surface action. For instance, where ascorbic acid is used, the mechanism was that it absorbed the oxygen at the surface before it was absorbed by the fats. This was for instance the principle used in glazing with solutions containing antioxidants. He felt that the differing results obtained by different research workers might be due to these circumstances. It might well be that ascorbic acid prevented rancidity without being a fat antioxidant.

Reay, United Kingdom: In the experiments carried out in the United Kingdom a thickening agent was not used. He felt that Banks certainly agreed with the theory that the surface distribution of any antioxidant was of great importance for the final result. The differences in physical contacts between the antioxidants and the material itself might well be the main cause for the contradictory results obtained by different research workers or even by the same research worker on different occasions.

Use of Antioxidants

From *Heen and Karlsen's* paper:

Treatment of herring with antioxidants has been suggested in order to reduce or prevent rancidity during storage. To determine the importance of different methods of treatment the Norwegian Directorate of Fisheries' Chemical-Technical Research Institute in recent years has carried out comparatively comprehensive investigations with freezing herring, treated and frozen in different ways. Among others the use of ascorbic acid, NDGA, gallates and hydroquinone in different concentrations had been tried. The herrings were dipped in a solution of the material before packing and freezing, and some samples were glazed with a corresponding solution after freezing. The series of storage tests

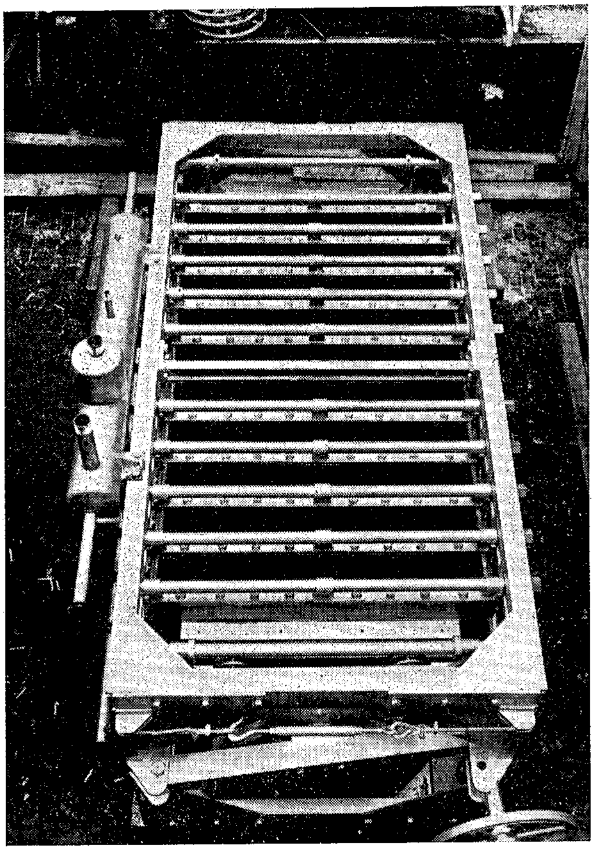


Fig. 2. *Freezer with vertical plates for freezing in blocks. Capacity 7 tons per 24 hours* (*Kværner Bruk, Norway*).

were carried out at —10°C. and at —18°C. (+14 and —½°F.), and the progress of rancidity was followed by chemical analyses (peroxide value and Kreis number) and by organoleptic tests.

An attempt to illustrate some of the results with herring fillets is made in the following representation *(Table 1)*, to which *Fig. 3* also refer. In some other investigations, both with fresh and smoked fillets, similar results were obtained.

Experiments have also been carried out with some other chemicals, such as nitrite and sulfite, but without favorable results. A disagreeable flavour developed with the concentrations used.

All these investigations were carried out with winter herrings. For other herrings results will presumably correspond to them, except that

Table 1. *Results from Norwegian experiments on treatment of herring fillets with antioxidants.*

Listing according to quality	Code on graphs Fig. 3	Treatment before freezing
No. 1	D	2 min. in 2 % ascorbic acid
no. 2	F	dipped in 1 % ascorbic acid + 0.5 % Gelatan
no. 3	C	2 min. in 1 % ascorbic acid
no. 4	E	dipped in 0.5 ascorbic acid + 0.5 % Gelatan
no. 5	B	dipped in 0.5 % Gelatan
no. 6	A	untreated control
nos. 7, 8, 9 disagreeable flavor	G	2 min. in 0.5 % hydroquinone
	H	2 min. in 0.1 % N.D.G.A.
	I	2 min. in 0.5 % ethylgallate
nos. 10, 11, 12 most rancid samples	K	10 min. in saturated solution of impure salt (Trapani)
	L	10 min. in saturated solution of pure salt
	M	10 min. in saturated solution of pure salt + 1 % ascorbic acid

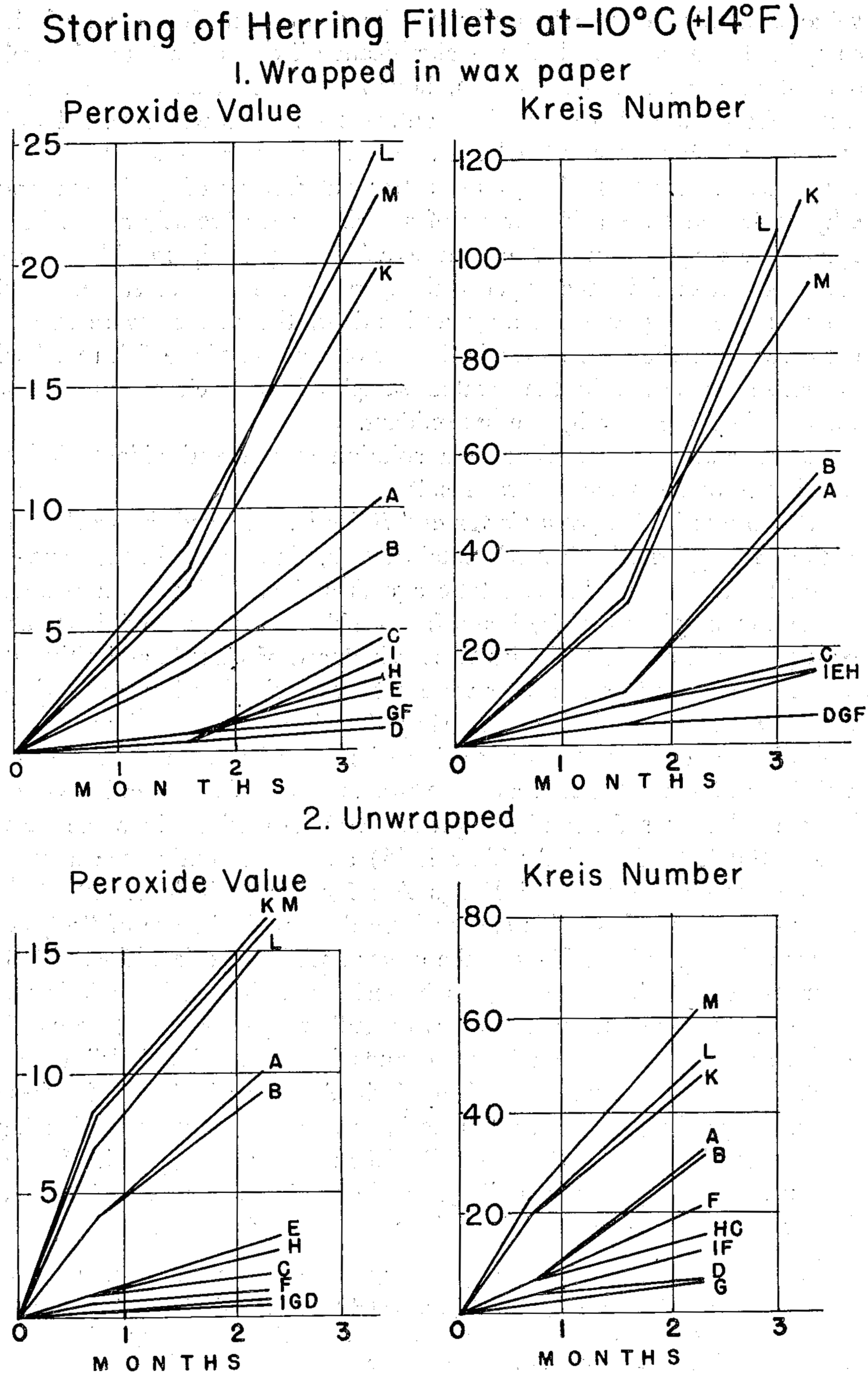
the keeping quality of fat herrings will perhaps be more limited than that of lean ones.

From *Banks's* paper:

Reports have been received from North America (Tarr 1947, Bauernfeind *et al.* 1948, Stoloff *et al.* 1948) from time to time which indicate that simple substances such as ascorbic acid, gallic acid and its various esters can effectively inhibit the development of rancidity in cold-stored fatty fish. It is reported that ascorbic acid is uked on an ever-increasing scale in North America and in some Western European countries for this purpose.

Extensive trials in the United Kingdom using ascorbic acid, gallic acid, ethyl gallate and catechol at the recommended concentrations with whole and filleted herrings do not agree with these reports. All these substances have a slightly inhibitory effect but not one of any real significance. No induction period, characteristic of systems containing antioxidants, could be observed; oxidation, as shown by peroxide values, began immediately the experiments were set up and carried on right throughout at a slightly reduced rate as compared with the controls. There was apparently some difference in the effect of the various substances — ascorbic acid seemed to be the weakest inhibitor but the differences were so slight as to have little significance.

Simple tasting tests were made in conjunction with the peroxide-



Storing of Herring Fillets at -10°C (+14°F)
1. Wrapped in wax paper
Peroxide Value
25
20
15
10
5
0
1
2
3
MONTHS
L
M
K
A
B
C
I
H
E
GF
D
Kreis Number
120
100
80
60
40
20
0
1
2
3
MONTHS
K
L
M
B
A
C
IEH
DGF
2. Unwrapped
Peroxide Value
15
10
5
0
1
2
3
MONTHS
KM
L
A
B
E
H
C
F
IGD
Kreis Number
80
60
40
20
0
1
2
3
MONTHS
M
L
K
A
B
F
HC
IF
D
G

Fig. 3.

value determinations and confirmed the conclusion that none of the compounds investigated had any significant effect on the rate of development of rancidity. In addition, however, tasters expressed a strong dislike for the added flavour of the antioxidant. This was expected with catechol, which was only tried out as a kind of reference substance, but it was surprising to find how the astringent flavour of gallic acid and ethyl gallate and the acid flavour of ascorbic acid adversely affected the specific herring flavour. When, on occasion, very slight rancid flavours could be detected in the superficial layers of the control samples and none in the samples containing antioxidant, the former were always preferred since the sweet, specific flavour of the rest of the fish remained unchanged, whereas in the treated samples it was either masked or changed in some way by the antioxidant.

Tests with fillets, soaked in a solution of the antioxidants before freezing gave the same general result.

A communication from Carter and Bailey[1] mentioned the work done at the Pacific Fisheries Experimental Station, Vancouver, B. C., Canada, regarding the use of bacteriostatic agents and antioxidants in relation to the keeping quality of fresh and frozen fish. Many investigations have been published by the Fisheries Research Board of Canada and although the investigations in some cases were not made with herring, many of the results would be applicable to herring. Specific examples of such work deal with the development and testing of sodium benzoate (Tarr, Bailey 1939), sodium nitrite, *etc.*, as bacteriostats (Tarr, Sunderland 1940 B; Tarr 1948 A); sodium nitrite proved very efficacious in some cases (Tarr, Sunderland 1940 A; Tarr 1945) and has recently been allowed by the Canadian Food and Drugs Act for use with fresh fish flesh. Later publications from this station have dealt with the use of "sulpha" compounds (Tarr 1946 B) and the newer antibiotics (Tarr, Deas 1948; Tarr, Southcott, Bissett 1950) as bacteriostats. Researches relating to antioxidants have involved tests with gallates (Tarr 1945), ascorbic acid (Tarr 1946 C), organic compounds known as "enediols" (Tarr, Cooke 1949), and inert gases (Tarr 1946 A) as antioxidants for fresh and more particularly frozen fish flesh, including in some cases herring flesh (Tarr 1946 A, 1947, 1948 B; Khan 1948; Tarr, Cooke 1949). The nature of the "lipoxidase" system in the brown muscle of herring flesh as giving rise to rancidity effects was studied (Khan 1950).

[1] "A Review of the Technology of British Columbia Herring Products Investigated at the Pacific Fisheries Experimental Station of the Fisheries Research Board of Canada" by Neal M. Carter, Director, and Basil E. Bailey, Biochemist, Pacific Fisheries Experimental Station, Vancouver, B. C., Canada.

From discussions:

Notevarp, Norway, had found the effect of ascorbic acid on Norwegian winter herring fillets very pronounced. He once served a company of 20 men from the fish industry with untreated and treated herring fillets. The treated fillets were found entirely palatable, the untreated ones were considered definitely inferior. The fillets had been stored for four months at —20°C. (—4°F.). Other antioxidants tested at the same time were gallic acid; ethylgallate; hydroquinone and N. D. G. A.; they all gave the fillets a very pronounced off-flavor.

Reay, United Kingdom, had not found any particular advantage in the use of antioxidants. He felt that it might be that the fatty British summer herring will not absorb aqueous water solution of antioxidant as readily as, for instance, the lean Norwegian winter herring. Against this theory, however, went the fact that the British fish did absorb enough of the antioxidant to get a rather distinct off-flavor.

Bramsnæs, Denmark, referred to experiments where the peroxide value had been measured together with the reduction-oxidation index. He had found that the reduction-oxidation index, in general, rose with the peroxide value but there seemed to be no close correlation. It might be that one of the problems would be to keep the reduction-oxidation potential down. In Danish experiments it had been tried by adding cystein to the herring to keep this reduction-oxidation potential down, but it had no effect on rancidity.

Crowther, United States: Some rather large-scale tests with mackerel fillets were carried out in Boston, Massachusetts, United States, some years ago, through cooperation between private industry and government research institutions. Thirteen different antioxidants were used and tested over a period of one year. Results were checked by taste panels. The results were that ascorbic acid was the superior antioxidant for the specific product which was tested then. Later on the best antioxidants in this experiment were tried on salmon fillets on the west coast of the U. S. A. They were applied as a protective coating, that is, added to the water in which the fillets were glazed. There was no significant improvement when 1 per cent ascorbic acid was added to a water glaze. The use of antioxidant dips gave variable results. In some cases the keeping quality of the fillets was definitely extended by the dips while in others the antioxidant appeared to have little effect. In our experiments salmon fillets which were water-glazed, packed in polyethylene bags and stored at — 20° F. (— 29° C.) consistently received higher palatability scores than fillets dipped in 2 per cent ascorbic acid, glazed with 1 per cent ascorbic acid solution, packed in polyethylene bags and stored at 0°F. (—18°C.).

Borgström, Sweden: In no experiments with antioxidants had he found any off-taste whatsoever, when the fish had been boiled before tasting.

Reay, United Kingdom: In the British experiments to which Dr. Banks referred, the taste testing had been carried out by three or four people. The fish was steamed in a casserole before it was tasted. No water was added to the fish. The darker flesh was generally tasted separately from the white flesh.

Lundborg, Sweden, suggested that one tried to treat the fresh herring before freezing with chlorinated sea water. It had given good results in the manufacture of delicatessen and might do so also as an anti-oxidative treatment before freezing.

Ascorbic Acid as an Antioxidant.

From *Heen and Karlsen's* paper:

The results of the above-mentioned Norwegian instigations which comprised a comparatively large amount of material, showed that treatment with ascorbic acid reduced or prevented rancidity to a considerable degree; it seeemed to be the best of the antioxidants tested. Also, glazing with ascorbic acid or ascorbate solution had a great influence and reduced the rancidity both of dry-frozen and brine-frozen herring.

In Norway, more extensive investigations as to the treatment with ascorbic acid on a commercial scale have also been carried out with dry-frozen and brine-frozen herring, as well as with dry-frozen fresh and smoked herring fillets and head- and tail-cut fresh herring. These investigations also showed that dry-freezing and treatment with ascorbic acid or ascorbate gave the best product. The investigations showed that it is possible to store products of high quality of fresh and smoked herring and herring fillets over half a year and more by freezing and treatment as mentioned above in suitable forms, tight packaging and storage at proper low temperatures, for instance —25° to —30°C. (—13 to —22°F.).

(See also pp. 200—05: Ascorbic acid compared with other antioxidants).

From discussions:

Reay, United Kingdom: Ascorbic acid had not been found to be effective on the oxidation of fatty acids in the presence of hematin.

Heen, Norway: The results he referred to in his paper with regard to the effect of ascorbic acid were obtained from experiments on Norwegian lean winter herring. He also felt that there was considerable difference betweeen the results obtained from various fish and fish in various stages of maturity, fat content, *etc.* He said that Mr. Johansen, Bodø, Norway, had described results with other types of fish, for instance catfish or blowfish. These experiments sometimes showed absolutely no effect of ascorbic acid. Some specimens of these fish developed very little rancidity even without the use of any antioxidant, while other specimens similarly treated developed rancidity very quickly. It was, therefore, necessary to study this field much more closely before definite conclusion were drawn.

Reay, United Kingdom, felt that ascorbic acid was likely to be the least effective of the antioxidants because it itself oxidizes so easily.

Notevarp, Norway, had found a great advantage in the use of ascorbic acid as an antioxidant for frozen Norwegian winter herring.

Bramsnæs, Denmark, agreed that experience so far seemed to indicate that ascorbic acid was the only antioxidant which did not give any appreciable off-flavor. It was, therefore, discouraging to hear that Dr. Reay had also found off-flavors with the use of ascorbic acid. He mentioned that he on a visit to Seattle, Washington, United States, had heard about experiments on salmon where ascorbic acid had had no effect, while Dr. Harvey in Astoria, Oregon, United States, felt that the use of ascorbic acid for rock fish was very promising. He also referred to some recent Danish experiments which were not yet finished. They were carried out on Fladen Ground herring so treated that they contained 0.025 per cent ascorbic acid; considerable effects were found.

Ascorbic Acid plus Thickening Agent

From *Heen and Karlsen's* paper:

Gelatan has been used together with ascorbic acid to make the solutions more viscous, the result of which is that the fluid adheres better to the fish, the glaze becomes thicker and the effect of the treatment better.

From discussions:

Borgström, Sweden: When good results with ascorbic acid were obtained in the United States, it might well be due to the fact that it was recommended that one should use a thickening agent in the glazing solution together with the ascorbic acid. This was to ensure that the surface of the fish was completely covered with the glazing solution.

Irish moss was recommended but pectins or alginates might also be used. The acceptor action of the ascorbic acid found here was similar to that found in biological chemistry where ascorbic acid definitely absorbs the oxygen and thereby prevents the oxidation of other compounds. In canning the addition of a certain amount of ascorbic acid to some products would prevent oxidation by the air which may be in the can.

Role of Traces of Metal

From discussions:

Ettrup Petersen, Denmark, mentioned that it might be possible that small traces of metals could change the storage qualities of fish considerably. To test this he once had taken some samples of fish and injected them with small traces of copper, manganese, zinc and iron. Then the samples were dehydrated. Small amounts of copper made the fish darken very rapidly. The proteins were also effected, as their ability to reconstitute rapidly decreased during storage. Neither manganese, iron, nor zinc had any effect. It might be that the varying results obtained with ascorbic acid by different workers were due to small traces of copper which had not been sufficiently recognized. Copper not only affects the fish, as just mentioned, it also works as a very efficient catalyst of oxidation.

van den Broek, the Netherlands, mentioned that erroneous results were obtained on one occasion, where a metal vat was used to contain a solution of ascorbic acid for dipping. The metal catalyzed the oxidation of the ascorbic acid to such an extent, that very soon all the antioxidant was lost. Errors of a similar nature may have been the cause of some of the contradictory results found in literature. Surely this factor will have to be considered wherever ascorbic acid is commercially applied as an antioxidant.

Borgström, Sweden, also agreed that amounts of trace elements, *etc.,* might easily catalyze the oxidation of the ascorbic acid to such an extent that it was lost. This might lead to a wrong interpretation of experiments. He mentioned that traces of, for instance, copper in tanks or vessels might catalyze the oxidation of the ascorbic acid sufficiently to destroy it.

Desiccation and Rancidity

From *Banks's* paper:

An increase in the rate of development of rancidity can be expected to coincide with an increase in the amount of desiccation. Removal of ice from the superficial layers of herrings by evaporation will undoubtedly allow an easier access of atmospheric oxygen to the fat. It is worth recording that a qualitative relationship has been found to exist between the amount of drying and the development of rancidity in cold-stored herrings.

The effect of superficial desiccation during cold storage was a significant feature of the above mentioned experiment with antioxidants. The fillets, although well-wrapped in parchment paper, dried very rapidly during storage and, apparently as a result, became rancid much more quickly than the whole herrings which were frozen in 3.2 kg. (7 lb.) slabs with 10 per cent of added water. The packages of fillets had a higher surface-to-volume ratio, but even so, it has been observed qualitatively on previous occasions that herring fillets do not keep in as good a condition as whole herrings in packages of the same size during cold storage.

Impermeable wrappers are usually employed to restrict drying during cold storage but such wrappers will not be suitable for herrings because they are expensive. Possible ways of reducing drying during cold storage have been under consideration in the United Kingdom for some time particularly with regard to the Government-owned cold stores, all of which are air-cooled, and all of which are alleged to have a high drying effect. A simple solution has not yet been found. It is now agreed, however, that an improvement could possibly be achieved in normal commercial stores by reducing the heat in-leak of normal operation. This is largely a managerial problem involving closer supervision of the opening and shutting of cold store doors. At the same time, however, if the normal thermal load of cold stores is increased by using the store as a freezer or by using the store to complete the process of freezing or to bring down the temperature of transported frozen foods, then desiccation of goods already in cold store will be increased. It is clearly desirable, therefore, that cold stores should be used only for storing frozen foods and that goods going into store should be at or below the nominal store temperature.

Freezing Prior to Canning

Sprat, Brislings, Sardines

From *Heen and Karlsen's* paper:

The sprat *(Clupea sprattus)* is very susceptible to mechanical strain, and is especially tender around the belly. Therefore, satisfactory freezing of sprat is very difficult. It would be a great advantage to the canning industry to be able to refrigerate sprat in order to prolong the short season.

For longer storage, of course, the sprat must be frozen, and here, it is chiefly the problem of rancidity that causes difficulties. During recent years this matter has been given special consideration in Norway.

Different methods such as brine freezing in boxes and dry freezing in blocks have been tried. The brine-frozen samples were glazed and the dry-frozen were packed in wax paper; all were stored at —20°C. (—4°F.). After a certain period samples were taken out and transported while frozen to the factory. The thawing was done by placing the sprat blocks directly in water, or by spraying them with water to give a more gentle treatment. In both cases, however, the sprat was slightly damaged, resulting in considerable waste during canning. However, the greatest drawback was that the fish had turned rancid. Besides, some of the samples became too salty during canning; it appeared that the frozen fish absorbed more salt during brining than unfrozen sprat. Thus, the results of the first experiments were not encouraging, as the finished canned product must be characterized as more or less unfit for commercial use.

The experiments have, however, been continued wtih special attention being given to freezing and storage of the sprat in such a way that rancidity is avoided as much as possible and also protecting the sprat during thawing. Last year, freezing of sprat was tried in boxes of tinplate (40 by 50 by 5 cm.; 16 by 20 by 2 in.) and with treatment with ascorbic acid. Other methods were tried, for example, treatment with salt concentrations corresponding to that of the canned article. The salt was expected to make the sprat more rigid and resistant to mechanical strain; the boxes should further protect the sprat during freezing, storage and thawing. These samples were stored at —20°C. (—4°F.), and the first samples were taken out after about 3½ months. The boxes were transported to the factory in frozen condition.

The canned sprat were all better than in the earlier experiment, but were not entirely satisfactory. Especially the samples, where salt was present during freezing, had turned rancid; the others were not perfect either. In further research in 1950, besides treatment with ascorbic acid, great attention has been given to storage at low temperatures. Freezing has been done in boxes of the same size with ascorbic acid and ascorbate added, and the product stored at —35°C. (—31°F.). Samples canned after three weeks at this temperature did not show signs of rancidity, but the salting was probably a little too scanty. One is, therefore, most likely to succeed in freeze-storing the sprat when it is dry-frozen and, at any rate, stored at —30 to — 35°C. (—22 to —31°F.). In freezing and freezer storage of sprat the demands on freezing methods and temperature during storage are thus still greater than in freezing and storage of herring.

A communication from *Bolton,* Canada, called attention to the work carried out by Charnley and Young (1943) related to the effect of freezing on the quality of canned herring.

From discussions:

Reay, United Kingdom: Experiments had been carried out also at the Torry Research Station in Aberdeen regarding the freezing of sprat prior to canning. The sprat were stored at —10, —20, and —30°C. (+14, —4 and —22°F.). The fish which had been stored at —10°C. for some months had become very rancid. When packed, it produced a product with an absolutely abominable bitter or tannic flavor. When the can was opened, the color of the oil in which the product was packed, was very dark.

Bramsnæs, Denmark: Experiments had been carried out in Denmark with the canning of frozen, lean sprats. They showed a definite change in texture from the frozen product in the way that the flesh was found considerably drier than in products made from fresh sprat.

Notevarp, Norway: In Bergen some experiments had been carried out with fat summer-caught sprat. The fats of fish are highly unsaturated. The first experiments showed that this sprat turned rancid very quickly. Some few thousand cans were packed but with very discouraging results. The oil, for instance, was very dark, and this darkness was found to be connected with the degree of rancidity of the oil in the fish itself. Later experiments in which lower temperatures and better exclusion of air were applied, had given better, but not satisfactory results.

Le Gall, France: French experiments had been carried out with canning of frozen sardines. The results were very variable. In some cases the product was entirely satisfactory, in other cases it had an undesirable taste. The feeling was that the reason for these unsatisfactory results lay either in the freezing process itself or in unsatisfactory cold storage after freezing.

Herring

From discussions:

Copeman, United Kingdom: One of the problems facing the British canners was the difficulty of handling herrings quickly enough to use them while still in a good condition. He, therefore, recommended that efforts should be made to find a method according to which a part of the raw material could be frozen, giving more flexibility to the manufacturing operation. The canners in United Kingdom had carried out experiments where the herring had been frozen and stored for periods of six to nine months and subsequently canned. Excellent results were obtained from a canning point of view. There was no noticeable rancidity and the product was much firmer than the normal pack. One point was, of course, that the cost of freezing added tremendously to the cost of the final product.

Sarraz Bournet, France, reported excellent results with canning of frozen herring. The fish was of good quality and there was no off-flavor whatever. The flesh was not quite as white as it would have been if fresh fish had been used. The results were very similar to those obtained in the canning of fish which had been kept in cold storage at temperatures above freezing for a few days before canning. This also gave a slightly yellowish color of the flesh. In that case, it was often even more pronounced than where frozen fish was used.

Flavor Improvement in Canned, Frozen Sprats and Herring

From discussions:

Reay, United Kingdom, referred to some experiments in United Kingdom where some herring had been brine-frozen and afterwards stored according to methods which probably had not been quite satisfactory. The resulting product had not been good. Some of this herring had been canned, resulting in a pack with a very unpleasant flavor. However, after storage of the canned product for a few months, the undesirable flavor had disappeared and another flavor had developed which was extremely palatable. Tests for rancidity products were negative. A similar result was obtained in the case of the above mentioned sprats frozen experimentally at the Torry Research Station. Shortly after packing the canned product had a very unpleasant flavor, but after several months' storage of the canned product, this off-flavor had disappeared completely and had been replaced by a rather palatable meaty or gamey flavor. This illustrated how the knowledge of what was going on in a product after it was canned was very limited, especially, of course, when special types of raw materials, for instance, frozen, were used.

Notevarp, Norway: In the above mentioned Norwegian experiments with fat summer-caught sprat there have been a slight improvement after several years of storage, but the product was still inferior and storage had not improved the quality of the product appreciably.

Economic Limitations

From discussions:

Sigurdsson, Iceland, felt that the discussion as to whether or not freezing could be used as a method of preservation before canning might be a rather academic one. It was possible that the higher cost could be born when more expensive products, such as sardines, were canned; but he did not feel that there was any possibility of meeting that extra cost in the canning of herrings.

van Dijk, the Netherlands, was inclined to agree that the question of whether or not one could freeze herrings prior to canning was mainly an academic one. However, there were certain periods when herrings came in very large quantities and had to be preserved. Therefore, it would be a matter of careful calculation whether the advantage for the factories of getting a longer production period could outweigh the disadvantage of the added cost.

Thawing

From discussions:

Morel, Belgium, called attention to the fact that while experiments generally had dealt with small quantities of frozen herring for use as raw material for canning, one would have to deal with very large quantities if this process were put into commercial practice. He felt that this might introduce additional problems in connection with defrosting.

From *Heen and Karlsen's* paper:

In the rather big Norwegian experiments, where sprats were frozen in tinplate boxes, the sprat was thawed by water outside the boxes. This way of thawing seemed to be a very good one, protecting the fish and considerably reducing the percentage of waste.

From discussions:

Reay, United Kingdom: The Torry smoking kiln could be used for the thawing of frozen fish on a large scale.

Notevarp, Norway, thought that thawing should best be carried out in cold water. If thawing were carried out in warm air, the surface might be heated too much, before the interior of the fish had been thawed.

Transportation

From *Banks's* paper:

Obviously one of the most important factors in the freezing of herring is the provision of suitable transport for frozen foods. This problem is an extremely urgent one in the United Kingdom since the lack of satisfactory transport between the fishing ports and the large Government cold stores, which were built during the war in "safe" areas some distance inland, has caused endless trouble during the past 4 or 5 years.

Transport of herrings in ice from the Moray Firth to London is not wholly satisfactory from the preservation point of view and transport to other more distant areas, *e.g.,* the south and west coast of Britain is even less so. Experiments have indicated that herrings frozen in large slabs could stand a journey lasting as much as 3 days in the ordinary type of van used for transporting iced fish.

From discussions:

Ettrup Petersen, Denmark, gave information on the question of what it costs to transport frozen herring from Denmark to India. He mentioned that by freezing herring in metal trays in air-blast freezers, each tray holding about 4 pounds (1.8 kg.) the cost of freezing was around 6 öre per kilogram. Transport in a reefer boat at —30°C. (—22°F.) in the holds would cost approximately 200 Danish kr. (about U. S. $ 30) per ton for a month. The trip from Scandinavia to India might easily take one month and a half, thus the cost of transportation would be 30 Danish öre per kilogram, insurance would be around 4 Danish öre per kilogram. The storage period in India before sale might be about one month. Such storage cost in Denmark 6 öre per kilogram per month. It would presumably be higher in India but even assuming the same cost one arrived at a cost of 46 öre per kilogram (3 U. S. cents per lb.). Wholesalers and retailers profits would easily add 50 per cent to this cost. Thus, the cost of transportation and cold storage would therefore, when reaching the consumer, amount to about 69 Danish öre, or about 9 pence per kilogram (4½ U. S. cents per lb.). This seemed to bring frozen products beyond the reach of the majority of the consumers in the Far East.

Recommendations for Future Investigations

It appeared from the papers presented at the meeting and from the discussion that further research was particularly desirable on the following problems:

1. The need to simplify the freezing process to reduce its cost and so permit wider application, both for distribution of fresh herring and as a means of storing herrings prior to canning or smoking. As an example may be mentioned that freezing of herring in large blocks is being studied in the United Kingdom.
2. The prevention of rancidity during freezer storage. For this purpose, the efficiency of good glazing is generally recognized. As to the use of antioxidants, experiments in several countries led to good results, especially with ascorbic acid, but these had not been confirmed in the United Kingdom experiments. In practice, there seems to exist some diversity of opinion as to the usefulness of antioxidants. Research on both the fundamental biochemistry of fat oxidation and its prevention and on the methods of application of antioxidants to fish, with or without the aid of thickening agents, is urgently required.

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Chapter 9

SALTED AND SPICED HERRING

This chapter is based on and includes:

SALTED AND SPICED HERRING, a paper presented by Dr. *D. J. van Dijk*, Chairman of the Marketing Board for Fishery Products, The Dutch Ministry of Agriculture, Fisheries and Food (Bedrijfschap voor Visserijproducten, Ministerie van Landbouw, Visserij en Voedselvoorziening), The Hague, Netherlands;

Part of DRY SALTING AND CANNING OF HERRING IN BRITISH COLUMBIA, a special contribution for the meeting by *P. A. Sunderland*, British Columbia Packers Limited, Vancouver, British Columbia, Canada;

and information from the discussions at the meeting.

Introduction.

From *van Dijk's* paper:

For over 100 years the herring fisheries have been playing a very important role in the countries of Western Europe. The influence of the herring trade on the economic development of this area can hardly be overemphasized. In many countries the fishing industry was the cradle of navigatnon, and the trade the pillars of prosperity.

The possibility for achieving an extensive international trade in herring was opened up, when it was discovered that the quick deterioration, to which fish is exposed, can be prevented by gutting and salting.

From *Sunderland's* paper:

In British Columbia, Canada, government reports published prior to 1900 used the terms "super-abundance" and "knee-deep" when describing the quantity of herring, but a local demand for herring in such a world of plenty, as far as fish was concerned, did not exist at that time.

No mention was made of salted herring until the seventies and eighties, when export of salted herring commenced, the quantities increasing during the last two decades of the century.

From *van Dijk's* paper:

With respect to salted herring, difficulties of such a severe character and to such a wide extent have been arising during the last thirty years, that it becomes urgent to find an escape out of this unsatisfactory situation.

Therefore, it is necessary to review some details of the multitude of problems of an economic character arising in connection herewith. Of course, only a few sides of this question can be mentioned, so that this statement does not have any pretention of giving a fully detailed survey of the situation. If it might convince technologists of the necessity to join hands and if it might arouse their willingness to cooperate wholeheartedly in tackling these problems, it may, however, be a good contribution to the solution of the existing problems of the herring industry.

Present Production of Salted Herring

From *van Dijk's* paper:

In the nineteen twenties Europe no doubt still was the most important herring producer. After 1930 a change in this situation took place, however, because Japan, Canada and the United States of America, became important herring producers, even to such an extent, that in 1949 Japan could gain the first place among the producers of salted herring and allied species.

Production of herring and allied species is still increasing. Although exact figures are not available, the total catch for all countries can be estimated at about 3.3 million metric tons, whereas, as far as known, total landings of all sorts of fish in the world amount to over 12 million metric tons. The production of salted herring reached about 500 000 metric tons in 1949, 300 000 of which were produced in Europe.

The following countries take an active part in the production of salted herrings: Norway, United Kingdom, Netherlands, France, Sweden, Iceland, Belgium, Finland, Denmark, Japan, Canada including Newfoundland, and the United States of America.

If we leave Japan out as an important producer of salted herring and pilchards, it can be stated that Western Europe is the greatest supplier of this product. In Norway, one of the leading countries in this area, the production of salted herring increased considerably during the years after the last war and reached a total of 115 000 metric tons in 1949.

The United Kingdom can be regarded as the second important producer, although the production has decreased heavily. In 1938, 127 000 metric tons of cured and "red" herring were produced in this country, but this figure fell to 42 000 metric tons annually during the period of 1946—1948.

The Netherlands took the third place in Western Europe in 1949. In this country the fishing industry quickly recovered from the heavy losses it sustained during World War II. The landings are now bigger than in the years before the war. They increased from 64 000 metric tons annually in the period of 1930—1939 to 82 000 metric tons annually in the years 1946—1949.

For further details on the extent of the production of salted herrings in the various countries, see *Table 1*.

From *Sunderland's* paper:

Mention should be made also of the Scotch-cured (brine-salted) herring industry in British Columbia, Canada. During World War I a good market for this product was developed in the United States and Australia. In fact, in 1918 the value of Scotch-cured herring, more than half a million dollars, exceeded that of any other herring product produced in British Columbia. But since then only small quantities of herring have been cured in this way.

The dry salting of herring for the Oriental market commenced in 1904 and the production of this product increased rapidly. The Chinese coolie class offered a good market for the cheap dry-salted herring, which together with rice made a satisfying meal for them. The pack, however, suffered a decline during World War I but even then 50 per cent of the catch was dry-salted. While the market for Scotch-cured herring declined after the war, more dry-salted herring was packed. The quantity of the dry-salted pack increased rapidly from 172 610 cwt. (8 769 metric tons) in 1918 to 1 072 188 cwt. (54 467 metric tons) in 1928. However, since then the British Columbia production of dry-salted herring gradually has decreased. In 1938 it was 149 700 cwt. (7 605 metric tons), in 1949 59 995 cwt. (3 048 metric tons).

Fishing Methods

From *van Dijk's* paper:

Being a most perishable fish, herring must be preserved quickly. As it is also a cheap fish, inexpensive preservation methods are preferable. Salt preservation fits these requirements. But this in turn means that the economy of the herring-salting industry ties up very closely with the

Table 1: *Production of salted herring and allied species.*

	1946	1947	1948	1949
	metric tons			
Belgium	18 647	16 230	12 102	7 087
Canada	18 213	12 316	11 017	12 737
Newfoundland	29 897	15 063[6]	19 564[6]	5 858[6]
Denmark[4]	4 100	4 100	3 700	2 000
Finland	6 500	6 000	4 000	4 000
France[5 6]	13 000	36 500	30 000	25 500
Iceland	20 900	8 359	11 480	12 900
Ireland	254	85	1 430	947
Italy	10 000	10 000[1]	10 000	12 108
Japan	139 100	69 750	44 935	193 358
Netherlands:				
salted	45 000	58 000	74 000	60 000
smoked[1]	17 000	17 000	25 000	13 000
Norway	70 600	94 600	110 000	115 211
Philippines	1 546	3 884	1 608	1 266
Portugal	3 205	1 033	3 092	2 790
Sweden	17 761[9]	7 990[9]	23 819	....
United Kingdom[7]				
salted	34 971	28 795	44 887	20 687
smoked	59 226	66 460	69 599	54 087
United States of America[8]	6 300[1]	6 300	6 300[1]	6 300
Total	516 220	462 465	506 533	(549 836)[10]

[1] Estimated.
[2] Inclusive marinated, dried.
[3] Product weight unless otherwise indicated.
[4] Faroe Islands and Greenland not included.
[5] Continental France and Corsica only.
[6] Smoked herring is or may be included.
[7] England, Wales and Scotland including Isle of Man, 1946—48, England, Wales and Scotland, 1949.
[8] Including Alaska.
[9] Exports.
[10] Sweden not included.

Source: FAO Fisheries Bulletin, Vol. 3, No. 3, p. 47. May-June 1950.

economy of the primary production itself, in other words: the catching methods. A brief discussion of the fishing methods is therefore in order.

In the countries producing salted herring, great differences may be noticed in the methods of fishing. They can be divided into two groups, *viz.*, passive methods and active methods.

Passive Methods

From *van Dijk's* paper:

There is no doubt that the passive way of catching herring is the older one. Here the fisherman relies on experience gained in preceding years. He knows, that the herrings concentrate in certain areas, varying according to the seasons. In these places fishing gear is cast and the herrings get entangled in the nets.

The principle passive method undoubtedly is the herring drift-net fishery, using nets hanging vertically in the sea. This is achieved by fixing corks and buoys to the top and pieces of lead to the bottom of the nets. This method is used especially by the British, Dutch, German and Swedish fishermen. The swimming herrings touch the vertical net and try to worm themselves through the meshes, their gills prevent them fom escaping backwards, while the meshes are so narrow that they cannot get through. It will be clear that, in using this method, everything depends on whether the herrings swim into the nets or not.

From *Sunderland's* paper:

In British Columbia, Canada, drag seines had been used until around the turn of the century, but about 1905 gill nets were used to supply the local market.

Active Methods

From *van Dijk's* paper:

Trawling is the most important example of an active catching method. Here a drag net is towed over the bottom of the sea with the greatest speed that the ship can possibly reach. This method is being used among others by fishermen from the United Kingdom, Belgium, Germany, the Netherlands, Sweden and Denmark.

Another active fishing method is the one that makes use of the purse seine, with which the traced herring shoal is encircled. Its lower edge is then drawn together with a purse string. Icelandic, Norwegian, Swedish, Danish and East German fishermen use the purse seine extensively.

A third active method to be mentioned is that used by Danish fishermen, *viz.*, the so-called "snurrevad", a bag-shaped net, which is towed through the water at a low speed, while the lines are in constant vibration. This vibration is transmitted to the water and drives the fish into the net. However, this method is of no practical importance for catching herring.

From *Sunderland's* paper:

Drag seines and gill nets did not catch sufficient fish to supply the growing export trade in dry-salted herring, so purse seines came into use in British Columbia, Canada, about 1910.

n *van Dijk's* paper:

The adoption of the trawl has been the cause of heavy controversies. ording to some, the trawl fishery is, to a large extent, responsible the diminishing of the fish population of the North Sea. A big part the brood is said to be destroyed by the trawl nets, which plough the bottom of the sea with their foot ropes, often made heavier with chains. It is difficult to determine how far this factor is of importance compared circumstances which influence the density of the fish popula- which should cover a very long period, it should be exists a close relationship between trawl fishing of the fish population and whether the application ny effect or not on the abundance of the herring. his problem might be, it is not the intention to

t influence on the types of vessels ift-net fishery, the lugger is a does not need a powerful motor hauling the nets usually takes lone aboard, it is very important city.

As the name already indicates, the trawler is the most appropriate vessel for the herring-trawl fishery. To carry out this method of fishing ıst be equipped with a of the sea at

hen fishing is adopted when of production ift-net or the

This is one of the reasons why the countries which are compelled to fish far outside their coastal waters find themselves in an unfavorable position as to cost of the vessels they have to employ.

Thus, the nature and location of the fishing areas are of great importance for the whole economy of the industry. They will, among others, decide what fishery technique will be applied, and in turn, what vessels are to be used especially if fishing takes place on the high seas, the distance from the fishing grounds to the ports is very important.

The English, Scots, Norwegians and Icelanders are in this respect in a favorable position. Therefore, in the herring industries of their countries, the herrings are usually gutted and salted ashore, whereas the Germans and the Netherlanders are compelled to do this work at sea.

Small craft can as a rule be built at a low cost. The countries situated a long distance from the fishing grounds have enlarged the boat catching capacity. They have equipped their vessels with more powerful motors, so that the time necessary to reach the fishing grounds have been shortened considerably and more trips per year can be made. Moreover, the ships have been enlarged, so that they may stay longer in the fishing area and carry a bigger load. These factors are apt to lead to bigger landings of herring.

Improvements in Capture Techniques

From *van Dijk's* paper:

In the last few years important inventions have been made, which more and more eliminate the element of luck which has been playing such an important role in fishing operations all through the ages. Publications about so-called catch indicators have appeared in various professional journals. It is clear that it is of great advantage to the skipper, if he can see how much fish is in the net and thus is able to decide which moment is the most profitable to board the net. This instrument may save time and prevent the net from getting overloaded and torn. It is evident that this lowers the operating costs.

Furthermore, experiments are being carried out with the so-called floating trawl, an invention of a Danish netmaker. Up to 1948/49 when this method was introduced the net was towed over the bottom, but with this invention it will be possible to drag the net through the water at any desired level. The net is towed by two vessels steaming side by side at a distance of about 165 yards (151 m.). The depth at which the net must be kept is indicated by an echo-sounder, which shows where the herring shoals are swimming.

The latest news in the field of fishery is that Soviet scientists are experimenting with various methods of fishing without nets. Strong electric currents are helping to attract the fish to pumps, which suck the fish out of the water. It was found that a fish pump on its own, no matter how powerful its suction capacity, only caused the fish to swim away from it.

Trials are also being made to attract the fish by light of different colors. The intention is to catch the fish which are gathering around the lamp by means of a purse seine.

Echo sounders and even accoustic ranging installations are already in use on a large number of vessels; they also contribute to enlarge the catching possibilities. These techniques are especially important because they create the possibility of tracing fish shoals, and in this way diminish the loss of time. Moreover, these methods have made it possible to distinguish the kind of fish that may be found under water.

Technique is still being improved. My summing up most certainly is not complete, but it does indicate that fishing technique is developing very quickly nowadays; so one may conclude that there exists the technical possibility of catching still greater quantities of herring.

Salting and Curing Methods.

Main Methods.

From *van Dijk's* paper:

As regards the curing methods of herring already on board the luggers some differences can be observed.

The fishermen of the United Kingdom, Iceland, Norway and Sweden are, due to the short distances they have to cover between the various fishing grounds and their ports, in most cases able to land the herring in a very fresh condition. The herrings, therefore, can be salted ashore and, if desired, gutted. The Dutch and the German vessels, on the other hand, especially in the beginning of the herring season, have to make rather long trips to reach the fishing areas. To be able to carry out this kind of fishery it became necessary for them to preserve the herring aboard the vessels. For this purpose a considerable quantity of salt is loaded before they leave port. Formerly various qualities of salt were used for the different catching periods. At present most countries outside Scandinavia use home-produced salt, either sea salt gained at their own shores or mined salt.

Sea salt has the advantage that, due to its high content of magnesium sulphate and magnesium chloride, it dissolves quicker and supplies a better brine. On the other hand sea salt has a smaller degree of purity and, moreover, increases the chance of a bitter taste, if the herring has to be stored for a long time.

A part of the herring that is caught by German and Dutch vessels is gutted before being salted. The gutting of herring is a very old method and has the effect of increasing the keeping quality and improving the taste. A short but sharp knife is used. A deep notch is cut into the throat after which, by a turn of the knife, the stomach, the heart, the liver and a part of the entrails are removed by pulling them out of the body cavity. This method has the advantage that the herring quickly loses its blood. It is not advisable to clean the whole abdominal cavity, because then certain enzymes that give the herring such a fine flavour during the ripening process may be removed.

The enzymes cannot do their proper work if the herrings are salted too heavily, so that, especially with the matjes cure, the percentage of salt is kept very low. After the gutting the herrings are mixed with salt in a tub; then they are put into barrels which are closed after salt has been added.

In other countries the herring undergoes the same manipulation ashore. Only very fresh herring can be used for this kind of curing.

There is also a considerable production of ungutted, salted herring. Herring salted in this way is, with the exception of "matjes", not suitable for immediate consumption.

The "matjes", a kind of herring that has not yet attained a state of sexual maturity, is gutted and slightly salted. After a very short time of soaking it can, after being cleaned, be eaten without further processing. If the catches are abundant, the "matjes" have to be placed in cold-storage rooms. A lot of people are held back from consuming this kind of herring, because they are of the opinion that they get raw fish. However, the ripening process mentioned before, brings about such a change of the proteins and fats that not the slightest conformity exists with raw fish, either with regard to flavour or composition. This way of consuming herring has become very popular in the Netherlands and Germany and to a certain extent in Belgium as well.

The full herring is caught just before the spawning takes place. This kind of herring is not always gutted. With the exception of Eastern Europe, full herring is not sold to the consumers before being processed. It is the principal raw material for the smoke and marinating houses. The full herring is, as a rule, subjected to heavy salting which makes it hard and dry. This method makes the herring less suitable for immediate consumption. On the other hand the keeping quality is greatly increased, so that it forms an excellent article. The spent herring is caught just after the spawning process and is, as to quality, inferior to the full herring. Owing to its small percentage of fat and the dryness of the fish flesh it is practically never salted.

Dry Salting in British Columbia.

From *Sunderland's* paper:

Although closely related to the herring of the Atlantic, the Pacific herring differs in its spawning habits. Whereas the Atlantic herring spawns on the gravelly bottom of the sea, usually in many fathoms of water, the Pacific herring deposits its spawn from near high-tide line to only a few feet below low tide, among the eelgrass and the rockweed that grow along the shore, the larvae emerging in about two weeks. The herring may survive for two, three or four years before reaching the market.

From the first days of expansion of the British Columbia salted-herring industry boats or scows were used for transporting the herring to the salteries, where the fish was hoisted by means of brailers into carts which were spilled into large tanks holding from 12 to 15 tons of fish each. These tanks were usually made of heavy 3-in. (7½ cm.) planking and had to be water-tight. Therefore, the cracks between the planks were either caulked or the tanks were often lined with canvas. The conveyors moved the fish up an incline to the plant. They consisted of wooden or metal bars fastened to an endless chain running in a trough. It was customary to have a row of tanks arranged on either side of a horizontal belt conveyor allowing a space of 18 in. (46 cm.) or more between the two rows of tanks. The conveyor running between the two rows of tanks consisted of a 12-in. (30½ cm.) rubber belt and the fish spilled into the tanks from inclined chutes leading from this belt conveyor. While the tanks were being filled coarse-grained salt was added, the quantity depending on the fat content of the fish.

The fat content of the British Columbia herring is at its highest point at the beginning of the "pre-spawning" run, which commences in the autumn, and decreases gradually until the end of the run. By the last two weeks of December the difference in the fat content of the fish becomes quite noticeable.

In the early days of the industry each operator, guided by his own experience, regulated the amount of salt used according to his own opinion and would, for instance, use about 62 bags (a bag contained 125 lb., 56.7 kg.) of salt to 15 tons of fish until the middle or end of December. From then until the end of the season he might continue using 58 bags of salt to 15 tons of fish. Eventually, however, government regulations specified certain conditions which the operator had to follow.

The herring was stirred or trampled the day after salting, and from then on every day while curing in the tanks, to insure that all the fish in the upper layer of the tanks were immersed in the brine which formed as the salt dissolved. It was customary to leave the fish in the tanks for 5 to 6 days until the end of the year, and after the beginning of the year from 4 to 5 days. The length of time allowed for curing also depended on the temperature as well as the fat content. When no blood could be squeezed from the gills of the fish it was considered sufficiently cured. An experienced operator could also judge by splitting the fish with his hands.

At the completion of the cure the fish was removed from the tanks by means of hand brailers and allowed to drain on the plant floor for about 12 to 16 hours before the final packing with additional salt into 400-lb. (181 kg) boxes. While the fish was being shovelled into the boxes, 5 bags of salt for every 15 tons of fish were added, and the contents were pressed or trampled into the boxes before sufficient weight could be attained and the lids could be nailed on. The boxes were then piled up three or four high until the following day when the lids were finally nailed, and the boxes were wired and stored until they could be shipped. However, several mechanical presses were built about 1929 which made the boxing up much simpler. With some of these machines it was possible to nail the lids on more than 60 boxes per hour, and it was also possible to complete the packing operation as soon as the fish had been sufficiently drained.

From discussions:

Needler, Canada, called attention to the fact that the main principle of the preparation of hard-dried, Oriental-cured herring in Canada was that of keeping the brine saturated at all times. In the earlier days this was assured by having a piece of burlap suspended over the top of the salting vats. Salt was placed in this burlap so that there was salt on the top of the vat and not just at the bottom, thus assuring saturation. He emphasized also that it was generally considered that this is the cheapest way of preserving herring so it would keep for a longer period.

From *Sunderland's* paper:

Some of the Canadian government regulations which apply to the dry salting of herring may be of interest:

"1. Any water that may have accumulated amongst the fresh fish in a boat or scow shall be allowed to drain away when the fish are being discharged therefrom and before salting takes place.

"2. (a) The fresh fish shall be thorougly salted into tanks or other water-tight receptacles in such a manner as will permit of each fish coming in contact with the salt. All fish shall be sound and they shall be salted within 24 hours after being taken from the sea. If the tanks or other receptacles stand in the open when filled, they shall be covered and protected from rain and snow.

"(b) The date on which fish have been salted into each tank shall be shown on the tank and in such a manner as will make it easily seen by the inspector.

"(c) When pickle has formed in each tank it shall be maintained at a strength of 90 degrees or more.

"(d) The inspector shall by a salinometer test the strength of the pickle in each tank at each visit to a curing place during the season.

"3. All herring taken from the opening of the fall season, in British Columbia, to the end of November shall remain in salt for not less than 6 days of 24 hours each, and all herring taken from December first to the end of the season shall remain in salt for not less than 5 days of 24 hours each before being boxed for shipment. All herring for shipment shall be sound, thoroughly cured and in good condition.

"4. Boxes for shipment of dry salted herring to the Orient shall be 42 inches long, 24½ inches wide and 14 inches deep, outside measurement (Editor's note: 106.7 by 61.4 by 35.6 cm.). The sides, top and bottom shall consist of good sound boards 1 inch in thickness, and the ends of similar boards 1¼ inch (Editor's note: 25.4 and 26.0 mm.) in thickness. The boxes shall be strongly made and well nailed.

"5. The fish on removal from the tanks shall be drained of pickle for 24 hours and afterwards firmly packed in standard boxes and thoroughly sprinkled with salt. Each box shall be filled to its utmost capacity with fish at the time of shipment. A mark or number shall be plainly marked on each box to indicate the packer of the fish and the date on which the fish were first inspected."

Spicing

From *van Dijk's* paper:

Spicing of herring is another method of preserving herring; it is mainly practised in the Scandinavian countries. The herrings are headed, the entrails are sometimes removed and then the herrings are packed in barrels, a certain amount of spices are added and finally a liquid poured upon the contents. By many different recipes that are followed products are obtained differing widely in taste. After a rather long-lasting ripening process this herring may be used for different purposes, although it is mainly used to produce the so-called "gaffelbitar" (tidbits). The preparation of spiced herring requires great care and must be supervised by experts. In view of the many years of practice in the Scandinavian countries it is clear why they especially succeeded in gaining a market for these products.

One should not exaggerate the importance of this trade. It may be estimated that the international trade in "kryddersaltet sild" amounts to some 5000 metric tons a year. Nevertheless, the sale of this speciality is important to Norway, Sweden and Iceland because of the fact that it means an additional market for herring.

Need of Mechanization

From *van Dijk's* paper:

Up till now the whole salting process was being done by hand. Many efforts have been made to find labour-saving devices in the salting of herring, however, they have met with little success. Notwithstanding the many technical improvements to which the herring industry has been exposed, the actual salting process has apparently not been susceptible to such changes.

In the Commodity Study on Herring and Allied Species the following statement by the Scottish Home Departement rightly appears:

"We cannot but be impressed by the vast field for research that is offered by this ancient industry, in which many of the established practices have been handed down, practically unaltered, from father to son through many generations."

As far as the gutting on board is concerned, there is little chance that some forms of mechanization can be introduced in the near future. The limited working space aboard the luggers probably hampers a development in this field.

Up till now the lack of time and the absence of sufficient labour at times of abundant catches has caused the salting of ungutted herring. This has a bad effect on the quality.

However, a certain part of the catch will usually be salted ungutted, as it can be sold at lower prices.

From discussions:

Aglen, United Kingdom, felt that it should be possible to reduce the cost of producing salted herring. In the United Kingdom this is done through the use of cutting machines of a Swedish make, which he did not think were used elsewhere. They worked quite satisfactorily, but were still being improved upon.

Reay, United Kingdom, gave information about some experiments carried out in Scotland by the Torry Research Station at the request of the Herring Industry Board. In these, herrings were "nobbed" (head and gut removed) by machine as for canning, and were then mixed with salt and shovelled into large vats for curing. After some months the cured fish were graded and packed with brine into small lacquered tin containers or small wooden barrels. At vats, large wooden tubs and large enamelled bath tubs were used; concrete vats could also no doubt be used.

"Gibbed" herrings (gills and gut removed by hand in traditional way, although there are now machines for doing this) were treated in a similar manner. Both "nobbed" and "gibbed" herrings were also packed carefully with salt in wooden barrels and cured therein, all in the traditional manner.

Extensive taste testing of the products were carried out. When tasters saw the headless, "nobbed" herring they rated them inferior to the "gibbed" traditional cure; but when the latter were beheaded immediately before tasting no difference in quality was detected. In fact, there was little difference in quality between any of the various cures.

The experiment proved that it was possible to salt herrings satisfactorily by mechanizing pretreatment and replacing skilled by unskilled labour in packing the fish for salting. It also showed that cure need not be made, as is often held, in containers made of wood.

One of the advantages of the modernized process was that final selection and choice of packaging to suit various types of customer demand could be delayed to the last moment.

The Present Marketing Situation

Increasing Difficulties

From *van Dijk's* paper:

After having found that the possibilities for producing salted herring give reason to expect an increase in supply rather than a decrease, it is interesting to investigate how the sales of this product will develop. One probably has to assume that every year an outlet must be found for at least 500 000 metric tons of salted herring.

Moreover the number of herring-producing countries is still increasing and in the near future it will undoubtedly by enlarged further by measures taken in accordance with "Point Four" of the Truman program and the FAO Expanded Technical Assistance Program, which aim at a quick development by technical assistance to under-developed areas. The new fishing countries, which lack the experience of the European countries, may then be able to start their fisheries with the most modern equipment. When one takes this development into account, it is certainly not to be expected that the landings of herring all over the world will decrease.

If we do not succed in taking the necessary measures, it is to be foreseen that the difficulties which are encountered at present by various producing countries with regard to selling their products will prove to be negligible compared with those, which will have to be surmounted in the future. Thus the problems of the herring fisheries, which are in most pressing need for a solution, are not to be found on the production side, but much more in the field of marketing.

The difficulty experienced in selling salted herring is all the more serious because of the fact that the seasons during which the various countries are catching herring coincide, to a great extent (see *Table 2)*.

Table 2: *Survey of the herring seasons in the various European countries*

Norway (North Sea)	Jan.—May
» (Norwegian Sea)	Aug.—May
» (Finmarken)	Jan.—June
Sweden	Aug.—March
Denmark	June—Oct.; Feb.—Apr.
Iceland	July—Oct.
Germany	March—Apr.; June—Dec.
Netherlands	May—Feb.
Belgium	Dec.—March
England	May—Dec.
Scotland	Jan—March; May—Sept.
France	May—Feb.

Present and Potential Consumption of Salted Herring

From *van Dijk's* paper:

With regard to Western Europe it can be stated that in some of the herring-producing countries the consumption of salted herring most probably cannot be increased considerably. A few countries having a very small population produce quite a lot of salted herring. As a consequence practically the whole production has to be exported.

Norway, for example, has a population of just over 3 million and the per capita consumption of fish is already high. The consumption of salted herring can be estimated at 5 kg. (11 lb.) per head. In view of this high figure it is not very likely that this country offers a substantial additional outlet. Exact figures on the consumption of salted herring in Iceland are not known, but as only 140 000 people live in that country it is negligible as a market. In Denmark and Sweden which also have relatively small populations and where fish consumption is high, an increase in the consumption of salted herring would most probably lead to a repercussion on the consumption of other fishery products.

In Germany, Belgium and the Netherlands the consumption of salted herring showed a considerable increase in the years immediately after World War II. In these densely populated countries salted herring is considered a cheap food so that it will only be marketable at a low price. When, in the beginning, other foodstuffs were very short salted herring met with little competition. Since the middle of 1948 this picture changed fundamentally.

As no figures concerning the consumption of salted herring in these producer countries are available, we shall use figures from the Netherlands as an illustration of the trend in herring consumption during the period of 1946—1949. It is true, that these figures are not representative for Western Europe, but still they may give us some idea as to the decline in this period.

In the nineteen thirties the consumption of salted herring (mainly matjes cure) and "red" herring amounted to 2.5 kg. (5.5 lb.) per year per capita. In 1946 this figure had risen to 4.3 kg. (9.5 lb.) and in 1947 even to 5.8 kg. (12.8 lb.).

During the last two years a falling off in the demand for these products is observed. The consumption amounted to 3.6 kg. (7.9 lb.) in 1948 and 3.1 kg. (6.8 lb.) in 1949.

From discussions:

Bramsnaes, Denmark, mentioned that an old custom in Denmark had been that one meal every day on a farm included salted herring. A barrel of salted herring was in these days bought for the winter's supply; it seemed that the modern consumer reacted against this type of container.

Aglen, United Kingdom, said that the consumption of salted herring in the United Kingdom, as in Denmark, was much smaller now than it used to be. In the old days, most farmers kept a barrel of salted herring for the winter's supply. He felt that the discontinuation of this tradition was due to the housewife's reaction to the salted herring. He felt that there was a considerable potential market for salted herring, matjes herring, *etc.*, in bars, restaurants, *etc.* However, here also a ready-cleaned, easy-to-handle product would be preferred. He recommended work to develop such products. He felt that when boning by machines was not used so much in the Netherlands, it was because most salting was done aboard.

Export Situation

From *van Dijk's* paper:

It is known to all of us, that the world trade in salted herring has taken a turn for the worse. From the preceeding information it has appeared that this decline in trade has not been caused by a decreasing production of salted herring.

We only realize how very difficult the situation is, if we consider the figures shown in *Table 3*. There we find that the average export per year decreased from 393 mill. kg. (882 mill. lb.) in the years 1930—1934 to 290 mill. kg. (639 mill. lb.) in the period 1935—1939. Just after World War II the total export of salted herring could not reach a higher average than 260 mill. kg. (564 mill. lb.). This means that the international turnovers fell back by one third since the thirties.

At present no exact figures are available for the period 1920—1930, but we may safely assume that the international trade in salted herring was even brisker than in 1930—1934, in which period the serious economic depression started and badly affected world trade. However, not all the exporting countries had to bear an equally heavy burden of the decline in trade, which has continued since 1930.

The export from the United Kingdom dropped very severely. In the years 1946—1948 the average annual export amounted to only 25 per cent of the average of the years 1930—1934 and also in this period, owing to the economic depression, this level lay well below that of the twenties. In the period 1925—1929 the annual export averaged about 270 mill. kg. (595 mill. lb.).

For the Netherlands, up till and including 1947, the exports are stated in gross quantities, whilst since 1948 export figures represent

Table 3: *Total exports of salted herring and allied species*[1]

Countries	1930—1934[2]	1935—1939[2]	1946	1947	1948
	million kg				
Total	393.2	289.7	255.9	234.7	288.1
United Kingdom	177.2	122.9	43.4	38,2	49,8
Netherlands	69.5	64,1	14,9	48.8	48.8
Norway	74.1	44.3	105,7	92.9[3]	112.6
Iceland	20,7	24.2	15.2	6.6	11.0
Sweden	2,4	3,8	18.8	8.0	24.2
Canada	33.9	17.5	21.9	17.4	16.4
New Foundland	4.0	3.3	30.0	15.0	17.1
Other countries	6.3	4.1	4.8	5.3	6.3

[1] Smoked and spiced herring included.

[2] Annual average during that period.

[3] Smoked and spiced herring not included.

Source: Commodity Study on Herring and Allied Species 1920—1948, published in May 1949 by FAO.

net totals. This implies that the gross export in 1948 equals that of the years 1930—1934. In 1949 this quantity was increased to a level 5 per cent higher than that in 1948.

The export of Norway shows a very favourable picture, though in the mineteen thirties the quantity exported decreased by 40 per cent. In the years 1946—1948 the average exported quantity was 40 per cent higher than the average of the period 1930—1934. For this country 1922 and 1923 were the peak years with totals of 159 and 151 mill. kg. (351 and 333 mill lb.), respectively.

For Iceland the nineteen thirties were favourable years. However, in the years 1946—1948 the average export reached 50 per cent of the total exported on an average in the years 1930—1934. For this country such a development may create a difficult situation as a large part of the economy depends on the outcome of the fisheries industry, and, in particular, on the export results.

Before the outbreak of World War II Sweden did not hold an important place among the salted-herring-exporting countries. In the years 1946—1948, however, this country exported 17 mill. kg. (37.5 mill. lb.) per year on an average. This means a very important increase.

If we consider the exports of Canada, including Newfoundland, it appears that the serious setbacks which were experienced in the nineteen thirties (about 50 per cent) could be made good in the postwar years.

Present Importing Countries

From *van Dijk's* paper:

For a proper valuation of the sales possibilities it is necessary that we consider the more important importing countries of salted herring.

Starting with the United States we see that the imports of salted herring showed the following development:

1930—1934 average 15.9 mill. kg. (35.1 mill. lb.).
1935—1939 average 15.2 mill. kg. (33.5 mill. lb.).
1946—1948 average 13.2 mill. kg. (29.1 mill. lb.).

The total consumption lies about 17 per cent below the level reached in the nineteen thirties. The decrease in total consumption, however, is much more serious than this percentage indicates. The population in that vast country increased from 123 million in 1930 to 151 million in 1950, *i.e.*, by more than 20 per cent. If the consumption per capita had remained the same, at this moment an import of a much bigger size could have existed. The cause of this sharp decline must, most probably, be sought in a change in the consumption habits during World War II. During these years all contacts between the Western Europe supplies and their clients in the United States had of course to be broken off.

With the help of good information services and an intensive propaganda it may be perhaps possible that a part of the lost ground can be regained. Yet, however important this area may be as it supplies us with the badly needed hard currency, it takes only 5 per cent of the world exports of salted herring.

With regard to markets for salted herring, the prospects in Germany are less favourable. In the year 1930 this country still imported 115 674 metric tons. Owing to the economic depression, this quantity fell to 95 690 metric tons in 1932, and it fluctuated around 60 000 metric tons annually in the period 1932—1938. During the first year after the war demand for fishery products was very brisk in consequence of the lack of other foods. The German fishing fleet, which had shrunk heavily as a result of the war losses, was not able sufficiently to supply the country, which in the meantime had been divided into two parts, so that in the years 1946—1948 still 69 391 metric tons, were imported. In 1949 imports amounted to 65 713 metric tons, while during the current year the imported and still to be imported quantities will most probably be well below this figure. Germany's own fleet has been expanded considerably during the last few years, whereas the per capita consumption shows a continuing decrease. We have to reckon with the fact that this former importer, which in 1930 still absorbed 20 per cent of the world exports, will sooner or later practically disappear as a buyer of foreign-produced salted herring.

Apart from the United States of America and Germany, the Eastern European countries used to be important buyers. Figures on the imports of these countries are not available, still a conclusion can be drawn. It is namely known, that total imports of salted herring in these countries — especially in Soviet Russia — fell.

World War II, which resulted in a large expansion of Eastern Europe — politically as well as economically — did not change this situation for the better. The cause of the decrease of the quantities imported in these countries is hardly an indication of a change in consumption habits, but rather due to the fact that consumption is decided by the purchasing policy of the governments. An additional difficulty to the trade with these countries is that exporters have to deal with a so-called single buyer. Moreover the small purchasing power of the population in these areas plays an important role in the trade relations so that an increase in exports can only be achieved by means of low prices.

Development of New and Improved Salted Products

From *van Dijk's* paper:

If we study the overall position of the herring industry and the marketing possibilities, it must be noticed, that on one side we meet with the probabillity of increased landings, while on the other, the chance of finding new outlets for herring is declining. There exist important differences in the costs of production between various countries, which causes difficulties in their finding sufficient markets. Therefore, it is necessary to search for new processing methods which may lead to increased sales possibilities for herring and herring products. It is clear, however, that therewith the herring problem has not yet been solved. On the production side we shall have to look for such methods, which may contribute to a further economizing in the fishery itself. In the conclusions of the herring meeting, which was held at the Hague, the Netherlands, 29 August—2 September 1949 under the auspices of FAO, is stated that it would seem useful to call together a special meeting of experts working in this field.

The many factors, which are leading to an unfavourable future of the herring fisheries are no doubt to a great extent to be found in the economic field, but besides these there are certain technical difficulties, the solution of which may contribute to an improvement of the economic situation of the herring industry.

One of the most important conclusions, which the above-mentioned herring meeting reached, was that it would be necessary to call together a meeting of technologists as soon as possible to examine the possibilities of developing new or existing processes, which would lead to an increase in the marketing of herring.

The importance of the cooperation of technologists of different countries is evident. By the close cooperation of the technologists in this field it may be possible to discover new processing methods, which will fulfill the economic needs as well as the requirements of the consumers.

On the other side it is equally necessary to aim at finding methods which in the long run include an improvement of the methods used for the processing of herring. More particularly this applies to the methods which are in use for the transportation of fresh herring. By an improvement of transport, especially with regard to the technique and by increasing the degree of keeping quality of the fresh herring during the transportation it might be possible to have the herring products also in those countries, in which the standard of living is low, but where, on the other hand, labour is so cheap, that it pays to erect factories for the further processing of herring for local consumption.

Owing to the fact that consumption habits only change gradually it will not be possible to enlarge the consumption of herring within a short time so that as far as the marketing is concerned it will be very difficult even to maintain the production at the present level. This is another reason, why it is necessary to search for new processing methods and develop new types of salted products.

In the first place, it should be taken into account that these new products must be in accordance with the tastes of the people living in the countries, where an outlet for herring must be found and, moreover, the products must be in harmony with the special consumption habits of these countries. Further we have to reckon with the fact that the old consumption habits will be abandoned more and more, as far as they are not directed to ready-to-eat products. The important progress in technique which has been taking place during the last decades should make it possible to find new ways in the field of production, packaging and transportation of herring. In addition to the above mentioned requirements, these new methods must be in accordance with the general requirement that they must be economically executable; this means that their costs must be in a correct proportion to the general price level which exists in those countries in which these new products might be introduced.

Practice often has shown that minor improvements in packaging and processing made it possible to reach new consumer groups, or induce those persons who — owing to the old form in which the product was presented — were apt to leave it out of their diets, to continue purchasing it.

In view of the necessity of enlarging the marketing possibilities it is important that experts start investigating as soon as possible whether by application of certain containers and of special means of transport a contribution can be made to open up markets in distant countries.

A good cooperation between technologists and market explorers will further be necessary in the search of curing possibilities which conform as well as possible to the consumption habits of the buyers in these new regions.

How far the application of new curing methods will expand the sale of salted herring is difficult to estimate beforehand. It seems important, however, that the experts give their full attention to the development of processes which furnish products with an added appeal to the consumers. For these new products one may partly start from fresh herring. Nevertheless, ways have to be found to prepare products which can be made from salted herring to unburden countries which land herring in a salted state and those countries which salt herring to prevent them from deterioration.

From discussions:

Jul, FAO, quoted *The Economist* for 17 June 1950 containing an article called "Cambling in Fish", dealing with the situation in the fisheries industries and commenting on the rather dark outlook for the industry at that particular time. The article stressed the great importance of keeping a high quality. "Besides quality", the article read, "novelty is the great essential. It is unfortunate that so many new experiments in marketing fish, in canning, freezing and filleting, should have been launched, not to make dull fish better, but to make fish bearable. These bad starts will also have to be lived down, for modern housewives have proved repeatedly that ready-processed, easily-served food is what they want; corn flakes have ousted porridge, tinned salmon has ousted its weight in fresh fish — even the poorest customers queue up for fried cod and leave cheap herrings on the fishmonger's slab. It should not be beyond the ingenuity of the industry to fillet herrings, to popularise frozen cutlets of absolutely reliable, branded quality, or to rival tinned salmon with a ready-to-serve white fish."

Lighter Cures

From discussions:

Bramsnæs, Denmark, called attention to new developments in lighter salt cures. Such products keep very well, even at normal temperatures. They are thus different from matjes herring, which has to be kept under refrigeration. One example of these products is the Norwegian silver herring (Norwegian: "sølvsild"). Other examples are certain German products.

Sigurdsson, Iceland, asked whether any results have been obtained by combining a light salt cure with antioxidants and preservatives. He mentioned that for instance a German product marketed under the name of "Polarstern" had received quite a bit of publicity and seemed to be a product of this type. It was stated in the literature about the product that very much less salt than that ordinarily used was contained in the product.

Van Dijk, the Netherlands, was convinced that mild-cured salted herring would appeal to more groups of consumers than the usual heavier-salted type. There is, for instance, a good demand in the United States for Dutch matjes herring, but better ways of storing herring aboard should be found, together with methods to improve the keeping quality of the product itself.

Heading and Boning

From discussions:

Notevarp, Norway, related that the tendency in his country was to salt more and more beheaded herring. More than 50 per cent of the Norwegian salted-herring production off Iceland was nowadays salted without heads and was reported to be well received by the trade. For that process fewer barrels and less salt was required so the final cost might well in the long run be lower than the cost of producing the ordinary full-salted herring.

Welin, Sweden, said that in his country formerly all herring salted off Iceland was packed ungutted. Experience showed, however, that the belly content gave difficulties in the keeping quality of the product especially when it was stored during the summer months. It was then tried to market salted-herring fillets, but they seemed to become too hard. Split herring was also tried but was not too well received by the trade. It was then tried to produce salted herring without heads and guts. In the beginning the housewives reacted against them, although the product was sold cheaper than herring with heads. The situation changed, however, in one or two months, and the demand soon exceeded the supply. Sales of headless herring now increased year by year. Nowadays, most of the herring salted off Iceland is without heads and guts and even the herring cured in Sweden, caught on Fladen Ground, is to a large extent treated in the same way.

Bramsnæs, Denmark, called attention to a newly developed boning machine for salted herring which removed not only the backbones but also the rib bones and side bones. One Danish company had begun to sell salted boned herring. In interviews housewives had said that they anticipated buying more salted herring if they were obtainable in this way.

Van Dijk, the Netherlands, agreed that boning of the herring before salting would be an improvement. Too great importance should not be attached to this, however, since in many countries the retailer, and not the housewife, had to do the cleaning and boning. This also relieved the housewife of the inconvenience of having to trouble with herring offals. Therefore, he did not feel that the introduction of boned-herring retail packages would be of too great an importance.

Notevarp, Norway, felt that it would be detrimental to increased herring sales to leave the cleaning and preparation of salted herring to the retailer. Herring should much rather be sold in any grocery store and in such a way that the retailer had no responsibility for and no work with the cleaning or preparation.

Borgström, Sweden, mentioned that several Swedish concerns were packaging beheaded, salted herring, saving 25 per cent of the carrying load during transport. This method introduces, however, the problem of keeping the oil in the flesh. The heading and gutting also means an increased loss of oil. Some oil escapes from the flesh of the filleted herring and gets rancid very quickly. Work on methods to prevent oxidation should consequently be encouraged.

Consumers Packages

From discussions:

Borgström, Sweden, said that the opinion in Sweden was that the market for salted herring could only be maintained through improved methods of presentation. There is a certain trend from salted to fresh products. But there is also a trend towards products, which are easier to handle. So cutting machines and even more improved packaging methods are of the greatest importance. Denmark, Norway, and the

United Kingdom have been experimenting with tin-plate containers for salted herring. This is the case also in Sweden, where several ten thousands of cans with salted herring have been sold. The size of the can is generally 4 kg. (8.8 lb.). Experiments are also being made with tin cans of the size of 10 to 25 kg. (22 to 55 lb.).

Bramsnæs, Denmark, felt that use of smaller tin-plate containers, as used in Norway might be a good improvement. Danish experiments had shown that salted herring kept well in lacquered tin-plate containers, if the tin plate had a minimum of 1½ lb. of tin per base box.

Borgström, Sweden, reported that in Gothenburg and other larger Swedish cities, a completely cleaned and boned salted-herring fillet is being marketed in pliofilm bags. This product is very much favored by the housewife. It cannot be used for prolonged storage. It is a method for distribution rather than for storage. Further developments of such consumer packaging would be highly important. The rancidity problem prohibits longtime keeping of these packages.

Notevarp, Norway, said that experimental packages of herring fillets marketed in Norway had been packed in brine and in closely sealed pliofilm bags to prevent oxidation. The fillets were without side bones, cleancut. The shelf-life of the product was from 2 to 4 weeks. He felt that such packaging would not add too much to the cost of the product as ordinary salted herring had about 60 per cent offal or waste. It should give some savings to remove this waste before salting.

Crowther, United States, mentioned that recently mackerel fillets in saturated brine had been packed in pliofilm bags and put on retail sale in the United States. It gave a very attractive package which was easy to handle for the housewife, and might do away entirely with the old salted-mackerel bucket. The bags are stored in refrigerated display cases in the retail stores, the temperatures being somewhere between freezing point and the room temperature, probably between 55 and 70°F. (13 and 21°C.).

Borgström, Sweden, mentioned that several experiments were going on in Sweden with regard to the packaging of mackerel fillets, herring fillets, *etc.,* in pliofilm and other transparent bags. He also called attention to a method according to whcih herring was packed in cellulose acetate-film bags, together with for instance butter and parsley. The contents could be boiled or fried right in the package. He felt that new processes like this would have great significance for fishery products.

Other Improvements

From discussions:

Van Dijk, the Netherlands, felt that in considering possibilities for finding wider markets for salted-herring surplus, it would be of great value if salted herring could be so improved that it would stand up better under shipment to tropical countries. He mentioned one case where a shipment of salted herring of high quality was sent from the Netherlands to Australia. The shipment was completely decomposed upon arrival due to the high temperatures it had encountered en route. The same would be the case if one attempted to ship normal salted herring to the Far East.

Crowther, United States, in this connection made the proposal that one might consider shipping salted herring to the Far East and there set up processing plants which could process salted herring into products which might be particularly acceptable to the local population. He, therefore, suggested that research should start with the salted product and seek to prepare from that one which would be acceptable in the region.

Lundborg, Sweden, called attention to the problem of slimy salted herring. He felt that sliminess to a great extent could be avoided if the herrings were washed in chlorinated water before they were processed. The water could be chlorinated according to a process that he recently had been experimenting with in Sweden. The finished product was also better in its general quality after such a treatment, and there was no corrosion of the tin can.

Recommendations for Future Research

It was the general feeling at the meeting that the following matter required the closest attention of research workers:

1. The method of presentation to the consumer is a most important factor; therefore, more research is needed, for instance, regarding consumer packs of boneless salt herring, and similar products.
2. Lighter cures being more and more favored by the public, it seemed that more research on the matter would be useful.

Chapter 10

HERRING DELICATESSEN AND MARINATED PRODUCTS

This chapter includes:

HERRING DELICATESSEN AND MARINATED PRODUCTS *(Semisterile Herring Preserves)*, a paper presented by Dr. *Georg Borgström*, Director of the Swedish Institute of Food Preservation Research (Svenska Institutet för Konserveringsforskning), Kallebäck, Gothenburg, Sweden, and information from the discussions at the meeting.

General Considerations

From *Borgström's* paper:

A substantial part of the Swedish canned-food production consists of semisterile products, chiefly made of herrings. Similar products are made in other Scandinavian countries. Slightly different types of herring delicatessen, chiefly more acidified, are produced by the German, Dutch and British fish-canning industries. They are generally called "marinated", As these are quite sizeable industries, there is good reason to make these particular products the subject of a special chapter in this book.

Semisterile herring products are normally not cooked, but the fish is preserved in the raw state. They are not processed by heat but are cured in a salt-sugar brine. This exercises a certain preserving effect. In addition, a small amount of a preservative is added. In some cases special acids, such as citric or lactic acid, are used. These products are put into cans of the general type or in some cases into special packages, for instance, kegs, which was the original method for this type of product. In fact they were produced in Scandinavia prior to the development of canned foods sterilized by the Appert method. By the middle of the seventeenth century fish, especially sprats, were already spiced and preserved with salt and acids and put into wooden kegs. This is the same product as the modern Swedish anchovy, which is now packed in hermetically sealed tin cans, but not heat-processed afterwards. The production of semisterile herring preserves presumably originated in Scandinavia. It was already practiced privately in the 17th century. The first commercial manufacture started in 1841; today a large number of factories manufacture these products.

Germany also produces this type of "anchovy"; here it is made from raw material imported from Belgium or Russia. By the start of this century. Russia already produced what was called "killo" — preserves of sprat — similar to the Scandinavian anchovy.

Keeping Qualities.

From *Borgström's* paper:

In our days most of these products are packed in hermetically sealed containers and in that way protected from oxidization. This means that development of rancidity is retarded. Most of these herring delicatessen are made from various sprats and herrings, *i.e.,* fishes having a high fat content. Very few are put into glass packages as it is generally considered preferable to protect them from light which accelerates the decomposition of fish flesh by enzymes and bacterial processes.

Due to the fact that some bacteria survive in the semisterile media and to the fact that the enzymes have not been destroyed but continue their activities, there are continual changes at various rates in these products. These processes have to take place to give the right taste and the right texture to the flesh. The predominant biochemical process is the breakdown of protein into amino acids, chiefly by enzymes. These processes are not too well studied from a scientific point of view; only the general trend of the process is known. The fish flesh is partly transformed through a ripening process in order to develop a special aroma which is further enhanced by the addition of spices.

This means that the products are semiperishable and cannot be stored for long. This, of course, is a draw-back when considering the possibility of using this type of preserves for the feeding of underdeveloped regions or for world-wide export. Generally, they have a keeping time of about six to twelve months in cold storage; it is appreciably shortened under warm conditions; in ordinary commercial practice in North European climate they will keep at the most two months.

These products depend for preservation on the cure they are given prior to packing and on subsequent storage at low temperatures. The tin or glass container simply serves as a method of packing superior to the types of containers previously used. Their use has very little or no preservative effect. It is not possible to heat process spiced and cured herring. They get tough and fibrous in texture, unpleasant in flavour and discoloured through the heat treatment.

From discussions:

Copeman, United Kingdom, mentioned that British canners had been experimenting with marinated and similarly treated products packed in cans, but the British public, not used to this type of product, was confused by the flipping or blown cans which sometimes occurred. The canners, therefore, felt that it would not be advisable to introduce such products in the United Kingdom.

Borgström, Sweden, replied that according to Scandinavian experience this was entirely a question of consumer education. The Swedish public was well acquainted with the fundamental difference between semi-preserved and wholly sterilized products in cans.

Huntley, United Kingdom, said that the distribution of lightly salted or marinated products packed in small containers for the retail trade, which were presumably all hermetically sealed containers, and would have a limited shelf life, posed some important questions. These were, firstly, whether the countries in which these products were sold had a system for controlling the age of the stocks in the retail stores and, secondly, what was the attitude of the public-health officials towards such products which might deteriorate and produce apparently spoiled cans merely by being left too long in stock.

Use of Preservatives and Antioxidants

From *Borgström's* paper:

Preservatives are generally added. Earlier boric acid was used and this is still the case in Germany and some places in Sweden. Most commonly benzoates are applied — chiefly sodium benzoates or benzoic acid. More effective is the dual effect attained when the benzoate is combined with hexamethylene tetramine. 0.2 per cent is the quantity of preservative mostly used. The esters of paraoxybenzoic acid may be good substitutes for sodium benzoate.

The salt exercises an additional preserving effect. The salt content is generally 8—12 per cent depending on the type of delicatessen. The pH is supposed to be at the neutral point and at the start it generally is; but it may, due to the progressing proteolysis, change to the acid side and reach pH 5.5.

From discussions:

Bramsnæs, Denmark, reported that in Denmark a long range of chemical preservative had ben tested, *i.e.,* gallates, salicylic acid esters, several halogenated acetic acid esters, various antibiotics, sulfanilamide, hydroxylamine, nitrite, vanillates, *etc.* No exciting results were found. One of the more interesting was that benzoic acid, which is very widely used, proved to be a pro-oxidant, accelerating the development of rancidity. One might, therefore, consider using a mixture of that preservative with an antioxidant. The best preservatives found during two years of rather thorough investigation was a mixture of benzoic acid and minute quantities of hexamethylene tetramine. It was found that the esters of paraoxybenzoic acid were perhaps a little better than the benzoic acid itself but hardly enough to justify its use as long as the price is about 10 times as high.

Notevarp, Norway, mentioned that it might be possible to add preservatives which would stop the autolytic decomposition. The addition of ascorbic acid as an antioxidant was not very expensive, probably a few Norwegian öre, half a U. S. cent, per kg. product, which does not seem too high to justify its use.

Bramsnæs, Denmark, referred to a Danish experiment carried out with herring tidbits about two years ago using a German preservative called "Foromycen". The product has been marketed under various names, but no information was then obtainable on the composition of the product. As it was thus impossible to say whether the product was safe to use, the experiments were discontinued. The results with regard to the keeping quality obtained were not very encouraging. Bramsnæs felt that one should continue and probably even increase the efforts to find new and better chemical preservatives, but at the same time look into the possibilities of better hygiene in the plant.

Lundborg, Sweden, mentioned that according to his experiments a mixture of benzoic acid and hexamethylene tetramine was the best preservative for herring delicatessen.

Boning and Eviscerating Machines

See chapter "Eviscerating, Boning and Filleting Machines", p. 186.

Delicatessen

Scandinavian Anchovy

From *Borgström's* paper:

When semisterile herring delicatessen are made, both fresh fish and salted fish may be used as raw material. In some cases the raw product is smoked or treated with acids. First is discussed a product, which in Sweden is called anchovy, the Swedish anchovy. As mentioned this was already made in Sweden in the 17th century in families of the upper classes. It became an industry only in the latter part of the 19th century. As far as is known, the first Scandinavian factory of this type began its activity in 1841 in Norway. In 1872 Sweden exhibited this product in Philadelphia in the United States. Since the beginning of this century there has been a sizeable export of this product from Sweden and Norway. For more detailed information reference is made to the author's (Borgström 1950) survey of the development of the Scandinavian anchovy industry.

Swedish anchovy is prepared from sprats; the best product is one obtained when the product is spiced directly in the cans. The fresh sprat is put *direct* into the consumers' can, then a mixture of dry sugar, salt and spices together with powdered sandalwood or some similar spice is added. This particular mixture is used in order to give the fish an appetizing reddish color. There are about fifteen different ingredients used in the Swedish anchovy to give a pleasant flavor. They are all added in the dry stage, and in various layers in the can. The can is closed in the same way as a completely sterilized one. After a few days the sugar and the salt become dissolved in the liquid separating osmotically from the fish. The use of a prepared brine is sometimes practical.

Besides this method, where the fish product is put directly into the can, anchovy is sometimes repacked. The anchovy is first packed in barrels, where the raw material is treated with sugar and salt and the ripening starts. Later the can is filled with this half-ready-made product, a special mixture of spices or some type of sauce is added, and the final ripening takes place in the can.

There is also a special type of anchovy where the *columella,* the back bone, and the skin are removed. This is called the skinned and boneless anchovy. It consists of sprat fillets or sometimes small herring fillets.

Tidbits

From *Borgström's* paper:

Another type of product is "gaffelbitar", generally called "tidbits", a common denomination for a lot of different herring delicatessen where the herring is cut in pieces of convenient size. This type of product appears in the market under various names. The raw material generally consists of herring caught off Iceland, but you also find products made of other herring such as the Fladen Ground herring and the fat coastal autumn herring. The factories which make these products generally consider the Iceland herring as qualitatively superior as raw material for this type of delicatessen, because the fat is more uniformly distributed in the flesh. This opinion has not yet been scientifically verified.

In the production of tidbits, spiced herring, prepared in the following way, is generally used. The herring is beheaded and eviscerated, then packed with spices, sugar, and salt in a barrel in which it is stored to undergo the ripening process. This curing takes place in a salt concentration of 10—12 per cent and in a cool place.

After the herring is ripened it is filleted and later skinned and the side bones removed. This procedure generally takes place at room temperature. The entire product is allowed to warm up before handling, as, experience claims, the amount of oil extracted from the flesh becomes less in this way. The fillets are cut in cross-way pieces or obliquely in thin slices. Various types of spiced sauces such as dill, tomato, or imitations of oyster, roe, wine, *etc.* are added. These products are then stored preferably at +2°C. (35½°F.) until shipment.

From discussions:

Lundborg, Sweden, had tried treatment of spiced Iceland herring in chlorinated sea water. The product was then manufactured into tidbits. It proved to keep much better and, peculiarly enough, the corrosion of the can was also much less than usual. Dr. Lundborg explained that the apparatus used for the chlorination of sea water consisted of an iron cylinder with a graphite rod in the centre. The sea water flowed through this cylinder which was the minus electrode while the graphite was the positive electrode. The equipment was run on the ordinary electric current.

Matjes Herring

From *Borgström's* paper:

Sugar-salted or spiced herring, often called "matjessill", matjes herring, is another type of herring fillets used in Scandinavia. This is really the young herring not yet sexually fertile. It is now generally used in many places to indicate lightly salted fat herring without gonades. It is usually packed in whole fillets in packages of various sizes; very common is a long hermetically sealed can which contains two pieces of big fillets.

Matjes herring is generally prepared in the Scottish way. The fish is first drawn, then treated with very fine salt. The amount of salt is only 12 to 16 per cent or slightly higher. It is more sensitive to the attack of bacteria and has to be stored more carefully, preferably at temperatures just above 0°C. (32°F.).

From *Borgström's* paper:

The predominant trouble of semisterile preserves of herring is their restricted shelf life. Preservation only lasts for limited periods.

Proteolysis

From *Borgström's* paper:

In spite of the use of preservatives, fermentation proceeds slowly and becomes evident only after some months, especially after storage under warm conditions. Proteolysis is accelerated and the fish flesh becomes more and more soluble until finally the entire content becomes fluid. This is, however, a long-range effect, but the keeping time may be sharply reduced by unfavorable conditions of storage and handling.

This constant formation of amino acids, which are dissolved, constitutes a big difficulty in establishing a true net weight. Even the normal ripening process means a loss of weight. The catching season and the age of the fish determine, to a certain degree, the rapidity of these biochemical transformations.

In many cases a whitish coating is formed on the surface of the fish. It also appears in the bottom of the can but not between the fillets, which lie close together. It occurs wherever the brine is in contact with the fish surface. This white coating consists of crystallized tyrosin formed when the protein decomposes. A similar precipitate sometimes appears on bacon or marinades. The conditions under which tyrosin is found are not scientifically established. It seems to occur very much by chance.

From discussions:

Bramnæs. Denmark, pointed out that the breakdown of proteins in herring delicatessen had practically not been studied at all. He felt that such a study might well lead to better knowledge of the whole process and thereby to methods which would give better keeping qualities. At the moment, herring delicatessen products kept 2 to 3 months on the shelf at ordinary temperature. Still this was not enough, as this limited keeping time considerably inconvenienced the trade. In Denmark attempts were made to find chemical or bacteriological methods for judging the quality to be used in connection with organoleptic testing. It seems that tyrosin content can give some indication of the ripening of herring tidbits. However, while preservatives may retard bacterial decomposition, they do not affect the formation of tyrosin.

Sliminess

From *Borgström's* paper:

In some cases a sliminess of the brine develops prior to the formation of tyrosin. Studies on the causes of this transformation of the sauce are in progress at the Gothenburg Institute. It is caused mainly by certain non sporulating bacteria, *e.g.*, some species of *Pseudomonas* and *Alkaligenes*. *Leuconostoc* organisms are rare. More important are, however, some spore-forming aerobic bacilli of the *subtilis* and *mesentericus* group. The cause of the slime production apparently is a polymerization of various carbohydrates. Most remarkable is the fact that some of these slime-producing bacteria develop even in very strong brine, *i.e.*, 20 per cent; obviously they have a strong halophilic character. Contamination presumably takes place during processing.

In this connection one should emphasize the detrimental influence which some ingredients may have. If contaminated through spices, which sometimes might be the case, the brine might introduce undesirable bacteria: Onions often carry *aerogenes* bacteria, which develop in an acid media. This makes it necessary to boil the onion prior to use in preparing delicatessen.

The chief difficulty of delicatessen preserves is to establish the amount and type of bacteria, which should be permissible with regard to public health and product quality. Fact-finding research on a broad scale is needed. So far, however, no cases of poisoning have been reported but it is most likely that this load of bacteria plays an important role in the quality of the products. In this respect the situation is similar to that of frozen products.

Production of Herring Delicatessen

Denmark

From *Borgström's* paper:

Year	Danish anchovy and bone-free herring		Tidbits ,herring fillets, etc.	
	Quantity	Value	Quantity	Value
	1000 kg.	1000 D. kroner	1000 kg.	1000 D. kroner
1939	538	955	643	1226
40	471	973	543	1303
41	454	1074	378	1318
42	423	1445	284	1334
43	489	1792	248	1346
44	767	2348	321	1470
45	599	2051	555	2105
46	445	1776	729	3514

Norway

From *Borgström's* paper:

Year	Norwegian anchovy in cans		Norwegian anchovy in barrels		Tidbits in sauce	
	Quantity	Value	Quantity	Value	Quantity	Value
	1000 kg.	1000 N.kr.	1000 kg.	1000 N.kr.	1000 kg.	1000 N.kr.
1927	749	797	98	114	388	594
28	610	858	49	71	388	658
29	786	861	75	73	400	679
1930	736	726	93	90	388	628
31	548	580	31	56	331	533
32	610	630	52	52	475	633
33	620	663	36	42	430	591
34	497	572	52	48	534	776
35	663	774	134	64	639	998
36	635	663	104	51	683	1052
37	...	...	159	71	899	1472
38	620	733	72	35	1025	1757
39	713	872	225	81	997	1861
1940	457	670	141	69	515	1247
41	...	...	72	85	550	1791
42	357	842	313	805	135	179
43	228	502	284	325	595	1787
44	396	883	135	179	595	1787
45	393	929	82	107	527	1715
46	416	1200	116	199	1240	4436
47	1093	2942	294	528	1943	7498

Sweden

From *Borgström's* paper:

Year	Swedish anchovy		Tidbits and herring fillets	
	Quantity	Value	Quantity	Value
	1000 kg.	1000 Sw. kronor	1000 kg.	1000 Sw. kronor
1909	...	1628	...	...
10	...	1703	...	...
11	...	1604	...	...
12	...	1747	...	...
13	...	1585	...	...
14	...	1644	...	...
15	...	1870	...	...
16	...	2954	...	...

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(Table concluded.)

Year	Swedish anchovy		Tidbits and herring fillets	
	Quantity	Value	Quantity	Value
	1000 kg.	1000 Sw. kronor	1000 kg.	1000 Sw. kronor
17	...	2034	...	...
18	...	3758	...	...
19	...	3460	...	...
1920	...	4775	...	...
21	...	4740	.....	...
22	...	3619	...	...
23	...	3589	...	...
24	...	3425	...	...
25	...	3765	...	...
26	...	3546	...	...
27	4260	4054	...	...
28	4025	3765	...	...
29	4214	4029	...	...
1930	4236	3900	...	...
31	3394	2963	4741	4690
32	3473	2846	4719	4385
33	3046	2698	4213	4163
34	3516	2906	4766	4821
35	4051	3726	5056	5525
36	4237	3833	5011	5363
37	3939	3461	5463	5935
38	3988	3699	5470	6236
39	4382	4427	6495	7505
1940	3819	4607	4687	6949
41	5345	6720	3876	8405
42	5486	9043	1709	5328
43	6774	13982	843	2816
44	5461	10362	2287	7353
45	6149	12054	3009	9515
46	4645	8576	4480	13527
47	5499	9480	6293	18163
48	5211	9347	6894	20025

Marinated Products

From *Borgström's* paper:

In earlier times marinades (German: "Marinaden") were often manufactured from salted herring. This is no longer practiced to the same extent as previously. There is a marked tendency towards marinades from fresh fillets. The raw herring is bleached through treatment with hydrogen peroxide and later preserved in acetic-acid brine (5—6 per cent acetic acid or vinegar, 6—8 per cent salt). In order to avoid fermentation saccharin (0.01 per cent) or similar chemicals are used as sweetening agents instead of sugar.

Thus, marinating of herring is a particular type of acid-curing performed by salt, vinegar, sugar, and spices. The latter include onion, cucumber, laurel leaves and spices. A special sauce is made from herring milts. Sometimes marinades are prepared in two stages: the preliminary cure is made at the coast, where the product is packed into barrels, later it is repacked into final packages, cans or bottles, spiced sauces and onions being added.

In order to attain a reasonable shelf life of marinades, salt and acids may be added in excess. Before using the products they are water-treated. Cold storage is practiced to an increasing degree. Preservatives are sometimes used, especially hexamethylene tetramine at a concentration of 0.1 per cent. As the final concentration of salt in the fish is not high (about 2 per cent) this product will not keep more than 4 to 6 weeks at ordinary temperatures, so they are in addition kept at temperatures below 10°C. (50°F.). There are large German factories annually producing more than 5 000 tons of marinades.

From the technological point of view four different types of marinated products are distinguished:

1. Cold marinades, *e.g.*, Bismarck herring, rollmops, "Kron" sardines, marinated herring, *etc.*
2. Cooked marinades (German: "Kochmarinaden"), *e.g.*, jelly herring (German: "Gelee-Heeringe"), Aspik herring, *etc.*
3. Fried marinades (German: "Bratmarinaden"), *e.g.*, fried herring, fried rollmops.
4. Special marinades (German: "Fein-Marinaden"), *e.g.*, herring fillets, Bismarck herring and rollmops, mayonnaise dressing.

Fried Marinades

From *Borgström's* paper:

The fresh fish are washed, beheaded, cleaned and rolled in dry seasoned flour. After frying in oil at 180°C. (356°F.) for 4—8 minutes (small) or 12—20 minutes (large), which is done in a special machine, the herrings are packed in cans, generally 8 liters, (2.1 U. S. gall.) and covered with vinegar. Sometimes they are placed in vegetable oils, such as soybean and cottonseed oil.

Rollmops

From *Borgström's* paper:

A special type of marinated product is the so-called "rollmops", preserved in an acidified salt solution. It is manufactured chiefly in Germany, Norway, and Denmark, and very little in Sweden. The fish, generally herring, is drawn and washed thoroughly with a salt solution after which it is treated with acid for some days, usually with an 8 per cent citric acid. The fillets, when sufficiently ripened, are rolled around a small piece of dill pickle or bit of onion or cucumbers and fastened with wooden tooth picks.

Herring Salad

From *Borgström's* paper:

A by-product of the marinade production is herring salad. After treatment for the requisite time in the pickling vats, the fish are finally sorted. Broken fish and trimmings from this sorting are packed into cans, jars or wooden kits with vegetables and sauce. Chopped onion, cabbage and cucumbers are mixed with 20 per cent of fish, and a sauce made from salted-herring milts and vinegar is poured over it.

Scientific Problems of Marinades

From *Borgström's* paper:

Scientific studies in Germany have revealed that during the curing in the pickle salt enters the herring flesh through diffusion and consequently is directly proportional to the concentration and time of treatment. When equilibrium is attained, about 40 per cent of the original salt in the brine has entered the fish. The acetic acid on the other hand seems to gain some protein compound and become bound in the flesh. The amount of acetic acid absorbed is linked to the salt concentration and influenced by it. When 2 per cent acetic acid is used, insignificant amounts are absorbed at all salt concentrations; at 4 per cent acetic acid the salt concentration is decisive. Absorption takes place only at salt concentrations between 6 and 10 per cent. When 6—8 per cent acetic acid is used, the pickling proceeds completely independent of the salt concentration.

Consequently, when difficulties arise, it is no use treating the raw products for a prolonged period. Curing or pickling are impossible to accomplish if the right concentrations have not been observed.

A special problem is the softening of the cold marinades in the warm season. This is quite a natural process and generally not due to deficiencies in the manufacture. At a temperature of + 30°C. (86°F.) a similar proteolysis takes place as in the delicatessen. Amino acids are formed indirectly through the proteolytic enzymes produced by bacteria.

Transport should only take place at temperatures below + 20°C. (68°F.) and storage should preferably be as near 0°C. (32°F.) as possible. Freezing spoils the product.

During the curing proteolysis takes place and an average weight loss of 2 per cent is due to breakdown of protein into amino acids which are dissolved in the brine. In addition 13—14 per cent of water is lost in the diffusion process. Some fat and other components are also lost to the brines so the total average loss according to Biegler's calculations amounts to 22—25 per cent.

Another trouble with marinades is the yellow coloring of the onion in rollmops and Bismarck-herring. This is a chemical-catalytic process due to the formation of special color substances with metal impurities dissolved from the tin can — presumably small quantities of iron sulfides. When cans have been kept at a high temperature the oil separates and collects at the top of the brine.

Conclusions

From *Borgström's* paper:

Most of the herring delicatessen and marinated herring products, because of their particular processing, become specialities and consequently attain a higher price value. It has also been stressed that they have a restricted shelf life and do not keep for any longer time under warm conditions. As products for the feeding of the human population they are best adapted to the temperate regions. Future developments in their processing might, of course, create means for obtaining sterile or almost sterile herring delicatessen with the raw condition retained, *i.e.,* without cooking. The increased use of refrigeration in storage and during transport may give these semisterile products new chances.

On the other hand, in order to get as many different products as possible — in order to counteract monotony of the diet — it might be worth while to develop methods for large-scale production of certain herring delicatessen. It should be stated, however, that the general trend in Sweden in this field is the contrary one. Efforts are made to manufacture products more and more specialized and of a superior quality.

From discussions:

Jul, FAO, mentioned that the meeting should consider all aspects of herring utilization. The problem of sending herring products to Asian and African population is a very important one. Nevertheless, it is only one part of the questions put to the meeting. All possible outlets for herring products should be considered, including the advanced products for sale in the more developed countries. As an example one might consider the very considerable trade that one sees in the United States where salted, pickled cucumbers were packed in hermetically sealed bags of pliofilm or similar material, and sold in retail stores. They were put in stacks on shelves, *etc.*, and handled without any special care. Nevertheless, there never seem to be any problems with regard to leakage or breakage of the bag.

Recommendations for Future Research

The meeting concluded that:

1. A cooperative research program regarding chemical preservatives would be appropriate.
2. The bacterial and enzymatic processes involved in the preparation and ripening of herring delicatessen have received little investigation, and research in that field should be encouraged.

Chapter 11

SMOKING, DRYING AND DEHYDRATION OF HERRNG

This chapter includes:

PRESERVATION OF HERRING BY SMOKING AND DRYING,[1] a paper presented by *C. L. Cutting,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland;

HOT SMOKING OF HERRING, a special contribution to the meeting by *F. Bramsnæs* and *Halvor Petersen,* Technological Laboratory of the Danish Ministry of Fisheries (Fiskeriministeriets Forsøgslaboratorium), Copenhagen, Denmark;

and information from the discussions at the meeting.

Introduction

From *Cutting's* paper:

Smoked fish generally keeps in palatable condition for a longer period than fish that has not been smoked. The enhanced resistance to bacterial and mould attack depends in varying measure upon (1) the pretreatment, such as splitting, trimming, cleaning, and the degree of salting prior to smoking; (2) the extent of drying that occurs; (3) the quantity of various bactericidal and fungicidal smoke constituents absorbed; and (4) the temperature to which the fish is exposed during the smoking process (Cutting 1945, 1951 B; Shewan 1945 A).

Herrings have been smoked at least since the Middle Ages. In 1230 it is recorded that the Abbé of Fécamp used to give trees to the parish for the smoking of herrings (Le Gall 1938). Smoke-houses and a "blackhouse" (used for making "black herrings") are mentioned in an

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Department of Scientific and Industrial Research. Paper for Publication No. T. 50/25. Published in part in "Fishing News" (Cutting 1951 A). British Crown Copyright Reserved.

Table 1. *Description of the chie*

Product	Pre-treatment		Salting		Sm	
	Description	% wt. loss on trimming	Description	% wt. loss	Description	T
						Old Kiln
"Reds"	Whole, ungutted	0	Dry salted in vats	20	Cold smoked intermittently	1 week
"Silvers"	do.	0	do.		Cold smoked over billets of wood (heat rather than smoke)	1 night
Bloaters	do.	0	do. 1 night	6	do.	do.
Kippers	Split along back, gills and viscera removed and washed	12—24 (depend. on roe content)	Brined for 20—25 mins., usually with dye	0	Cold smoked over sawdust fire	6—18 hou
Kippers for canning (mild cure)	do.	do.	Do. but no dye	0	Do. till slightest develops colour	4—10 hou
Kipper fillets	Headed, boned, belly walls cut away	45—55	Brined 10 mins., us. with dye	0	do.	4—8 hou
"Buckling"	Whole, ungutted usually	0	Dry salted overnight	6	Hot smoked in a dense smoke	3—4 hou

English will dated 1349. The Statute of Herrings in 1357 amongst other things fixed the maximum wholesale price at Great Yarmouth of "red" herrings, which are of great historical and commercial interest (Samuel 1918). In 1599, a famous Elizabethan poet set out to write a play eulogising them (Nashe 1599). The author of "Robinson Crusoe" in 1724 says that Yarmouth could smoke cure 40 000 barrels (probably about 8,000 metric tons) in a season (Defoe 1727). Just before the French Revolution, more than three times as many red herrings as white (*i.e.*, fresh) herrings were being eaten in Britain. A book written in France at that time (Du Hamel du Monceau 1769) depicts the process of making them which is exactly the same as that still prevailing.

Since the advent of railways in Great Britain in the 1840s, speeding up transport of fish, it has been possible to distribute fresh fish to the manufacturing towns in the interior; and in consequence the taste and demand for salt fish and red herrings has declined.

At the same time, smoked products were developed which, although

·pes of smoke cured herring.

ıg		Yield of smoked product (% of landed weight)	Approx. composition			Approximate storage	Life in good condition
e ʼorry Kiln	% wt. loss by drying on trimmed t.		Water	Fat	Salt	Ordinary temp. (16° C. (61°F.))	Chill temperature (0° C (32° F.))
—4 days	20—25	65—70	40—45	15—20	14	Several months	Many months
—8 hours	5	75—80	45	15—20	15	A few months	Several months
3 hours	6	85—90	55	15—20	2—3	A day or so	A few days
—6 hours	15—20	65	55	15—20	2—3	Several days	A week or so
?—3 hours	12—14	67½	55	15—20	2—3	A few days	Several days
?—3 hours	10—12	40	55	15—20	2—3	A few days	Several days
?—3 hours	20—25	75—80	55	15—20	2—3	A day or so	A few days

less salty, dry and smoky than heretofore, kept long enough to be distributed without chilling by means of icing through the British railway network, *i.e.,* a week at the very outside.

In this way arose the "kippered" herring (invented, after several less-successfull attempts, in 1843) and also probably the much more perishable Yarmouth bloater (about 1935), both of which are "cold-smoked" products, and the "buckling" or "hot-smoked" herring, actually cooked in the smoke, which is so popular in North Western Europe. The attractive flavour of these soon led to the older cures being ousted from the diet.

Britain is probably the largest smoked-fish consuming country in the world. At least as many herrings are eaten as kippers as are eaten in the fresh state, each outlet accounting for about 1/4 of the catch in 1948 and 1949 (see *Table 2)*.

In the following, lightly smoked, mild-flavoured "cures" preferred by industrialised countries will first be considered; then the traditional and primitive "cures", which are usually very dry and often very salty, and the possibility of improvements; and, finally, the potentialities of the artificial "dehydration" of fish, in some form or other, using up-to-date mechanical equipment.

These cures are briefly described in *Table 1,* pp. 258—59.

Table 2. — *Allocation of British-caught herrings, 1949*
(nearest 1,000 tons)

Use	Home	Export
Fresh	48	—
"Klondyked"	—	12
Kippers	47	4
"Reds"	—	10
Canned	13	5
Quick-frozen	5	—
Salt cured	1	35
Marinated	1	—
Meal and oil	22	—
	137	66

MILD SMOKING OF HERRING FOR EUROPEAN CONSUMPTION

Cold Smoking

Kippers

From *Cutting's* paper:

Kippers are made by splitting fresh herring along the back by means of a knife or a special machine, so that the backbone is on the left hand side when looking at the cut surface. Most of the blood is washed away in copious-running fresh water. The heads are not removed, but all material, including the roes, gills and guts, likely to favour decomposition, is more thoroughly removed in this cure than in any other. The reduction in weight as a result of cleaning varies from 12 to over 20 per cent, depending on the maturity of the fish, *i.e.,* the state of development of the milt or roe.

The split fish are brined for from 20 to 30 minutes in 70 to 95 per cent saturated salt solution, which results in the fish absorbing about 2½ to 3 per cent of salt. More than about 3½ per cent is generally regarded as unpalatable. Oversaltiness is a common fault, particularly in the thin side of the kipper, which takes up salt more quickly than the side containing the bone.

The brined fish are suspended by the napes from tender hooks arranged in pairs on both sides of sticks, or tenters, which are then normally hung up in tall kilns, usually overnight over lines of fires of lighted wood chips almost smothered with sawdust, preferably of oak, so as to produce a dense, cool smoke.

Properly smoked and cured kippers should have lost about 15 to 20 per cent of their weight in the kiln, and should feel quite dry (*i.e.*, not sticky) to the touch and fairly rigid, *e.g.*, they should not sag when held horizontally by the tail. They should be free from dust, dirt and ashes, and the cut surface and skin should be quite oily if made from really fatty herring containing 15 to 20 per cent of fat. "Spent" fish or lean fish (with say 5 per cent or less of fat) cannot produce a first-rate kipper. The belly walls should not be torn, since this often betokens self-digestion owing to too great a delay between catching and splitting, nor should there be any black discoloration or remnants of gut, gills or swim bladder. The skin should not burst away at the sides, nor should the backbone crack when pressed. These are both signs of partial cooking due to heating beyond the maximum-permitted smoke temperature of about 29°C. (84°F.) in the kiln. Such fish do not pack well into boxes for transport.

The fish should not taste noticeably oily or rancid in any way, particularly in the brown lateral streak of flesh just underneath the skin and the texture should not be too tough.

If the fish are fresh before smoking as they should be, properly cured kippers should keep in first-class condition for several days at ordinary temperatures of about 16°C. (61° F.) and still be palatable after a week; at chill temperatures, 0°C. (32°F.), they should keep well for a week and remain palatable for 2—3 weeks.

A really good kipper properly cooked is a delicacy that can compete in its own right with any other breakfast dish in any nation's diet. It should not be impossible to increase the British home consumption of kippers above the present figure of about 400 million, which is only about 8 per head per year. Any child more than a year old can, with very little encouragement, be persuaded to eat them, often with evident enjoyment, once the skin and backbone are removed. There are several reasons militating against an increased consumption, and in fact the British home consumption of kippers is decreasing with that of other fish foods.

In the first place there has been a general decline in the standards of kippering which set in well before World War II, and was associated with the introduction of the practice of artificially colouring smoked fish. This tendency was accentuated by a further decline in standards of quality during the war period and immediately after, partly as a result of the shortages of other foods which forced the consuming public to be temporarily less discriminating.

Dyeing kippers before smoking, now almost universal in Great Britain, permits the production of an attractively coloured article which, however, is not smoked so thoroughly as undyed fish, and is, therefore, not dried as much, with the result that the yield is greater, *i.e.*, more water is sold along with the kipper. Consumers have probably grown accustomed now to the moister, less smoky and, of course, more brightly coloured article, and might not greatly relish an abrupt reversion to the product made prior to World War I. However, the dyed fish does not, generally speaking, keep as well as the old-fashioned product, with the result that many people have grown to regard the kipper with a certain amount of suspicion.

In addition, dye permits the kippering of herring of a poorer quality than would have been cured before dye was introduced into the industry. Good-quality, fatty herrings cannot be obtained all the year round, and the kippering of herring low in fat content was only made possible by the camouflaging effect of dye. Only the large-scale application of icing herrings at sea and of the freezing and cold storage from one season to the next, described in other chapters, can enable good-quality kippers to be marketed all the year round.

Undyed, lightly cured kippers are canned on a fair scale. Machine-cut boneless fillets are also smoked, usually with dye.

Attempts at by-passing the smoking process altogether, *e.g.*, by dipping the fish in smoke liquors (often related to "pyroligneous acid" which is not permitted by certain "Foods and Drugs" administrations) have not met with success since the natural flavour is not produced. Moreover, the fish still need to be dried in order to cure and keep properly. This remark also applies to the recent development of electrostatic smoke precipitation (Hamm, Rust 1947).

From *Carter and Bailey's* communication[1]:

At the Pacific Fisheries Experimental Station, Vancouver, B. C., Canada, it was found in a comparison of various British Columbia soft-woods for smoking herring that a satisfactory grade of kippers can be produced using as a source of smoke some of the soft-woods native to this province; the kinds of wood most suitable are balsam, spruce, and hemlock, while neither red cedar and fir were as satisfactory (Sidaway 1944).

Mechanical Kilns for the Kippering Industry

From *Cutting's* paper:

The most important development in the British kippering industry in recent years is the increasing adoption of mechanical kilns to provide control and uniformity of the smoking process. The usual upright brick kilns which are substantially the same as those used in the Middle Ages have a number of disadvantages. They smoke unevenly, are difficult to control and waste time and labour. The fish often pick up soot and ashes and sometimes drop off the hooks onto the fires. In the kiln referred to (Hardy, Cutting 1942; Cutting 1942, 1950), it is possible to control the speed, temperature, humidity and density of the smoke, with the result that the product can be evenly coloured, flavoured, dried and preserved with less trouble and labour in a shorter time. A good dyed kipper can be obtained in about 4 hours, compared with a range of say 8 to 18 hours in existing kilns. Fully cured undyed kippers take 6 hours and a canning cure about 2½ hours. All the forms of cold-smoked herring mentioned in this chapter can be smoked satisfactorily in this kiln.

From *Carter and Bailey's* communication:

Although the average smoking time for kippers in a commercial smoke-house is 12 to 15 hours, only 4 to 6 hours smoking are required in an air-conditioned smoke-house developed at the Pacific Fisheries Experimental Station (Sideway 1945 B). The construction of a commercial vertical-type smoke kiln, in which the fish travel on a vertical conveyor system under automatically controlled temperature and humidity conditions, is described by Lantz (1949).

[1] "A Review of the Technology of British Columbia Herring Products Investigated at the Pacific Fisheries Experimental Station of the Fisheries Research Board of Canada" by Neal M. Carter, Director, and Basil E. Bailey, Biochemist, Pac. Fish. Exp. Station, Vancouver, B. C., Canada.

From discussions:

Reay, United Kingdom, stressed that in the mechanized smoking process the type of smoke generator was very important. In Aberdeen, Scotland, a rather crude system was first tested, using biscuit tins with gauze bottoms, air being blown up through the burning sawdust. It was found that this produced a type of smoke which was quite different from that obtained from the usual overblown fire in an ordinary smoking kiln and resulted in products with a rather unusual flavor. Some preferred it to the usual flavor, others did not. Chemical analyses of the smoke produced according to these various methods showed some quite significant differences (Pettet, Lane 1940). Therefore, the methold was finally discontinued, and a system much similar to the ordinary old-fashioned hearth was now used. It was arranged as a battery of hearths, four on each side, eight altogether, and connected with pipes, *etc.,* but nevertheless the flavor which was obtained with that kind of smoke generator was very similar to the traditional one.

Heen, Norway, mentioned the possibility of electrostatic smoking. He, also, felt that this process did not correspond to the smoking in air and smoke even under conditions where temperature, humidity and amount of smoke were controlled. It would be very important, however, to devise a completely mechanical method for smoking herring, especially lean herring and small herring.

Le Gall, France, found it was worth noting that equipment for mechanical smoking had been developed in Eastern Canada in 1937.

Bramsnæs, Denmark, related that in Norway the first mechanical smoking kilns were constructed in the late 1920's and the beginning of the 1930's.

Bloaters

From *Cutting's* paper:

The name bloater has been current since Elizabethan times, and seems originally to have referred to a pale-smoked "red", something like the "silver cure" (see p. 276). For the more recently developed Yarmouth bloater, fresh herrings are dry-salted in the whole, ungutted condition overnight (losing about 6 per cent by weight) and are then hung on "speats" passing through the gill opening and mouth, and mildly smoked for about 10 hours over fires made of hard-wood billets which provide flames and heat rather than dense smoke. The fish are not coloured by smoke although about another 6 per cent is lost by evaporation. In the

Torry kiln, bloaters can be made in about 3 hours, half of which consists of drying without smoke. Yarmouth bloaters are restricted in distribution owing to their perishability. Only a few thousand metric tons are produced annually, although there is probably a good deal of "back-shop bloatering" and wind drying of herring which is not recorded.

From *Carter and Bailey's* communication:

The preparation of bloater paste is discussed by Sidaway (1945 A) and of a speciality product ("smoked spiced niblets") by Lantz (1947).

Hot Smoking

From *Bramsnæs' and Petersen's* paper:

This section is concerned with the preservation of herrings by smoking at sufficiently high temperatures to coagulate the herring flesh. This procedure is usually called "hot smoking" contrary to "cold smoking" by which latter method the fish flesh is not coagulated, and remains somewhat transparent.

Bucklings

From *Cutting's* paper:

Bucklings are herrings which, after dry salting or brining for two or three hours, are threaded by speats through the eyes and hung in a hot dense smoke in a special kiln sometimes containing gas heaters, usually with some provision for introducing moisture so that the fish are not dried excessively. There are normally two stages in the smoking process, first drying at a fairly low temperature, and secondly cooking at a smoke temperature which rises to over 96° C. (205° F.) while the temperature of the fish reaches 60° C. (140° F.). The product should be golden in colour with a satin-like skin. In Germany, where this cure is very popular, various special mechanised kilns are used, as described in a recent paper (Myles, Reay, Farrer 1946). Bucklings are as yet scarcely eaten at all in Britain, although at least one firm has been producing them on a fair scale in Yarmouth for the past two or three years. Rapid transport is again essential if a cure retaining the viscera is to reach the consumer in first-class condition. Chilled transport and buffer storage would do much to increase the area of penetration of these cures.

Hot Smoking in Denmark

From *Bramsnæs' and Petersen's* paper:

Apart from cold smoking of salmon, hot smoking is practically the only smoking method used in Denmark. It is for either whole or gutted and cleaned herring, the latter being the most common practise. The herrings are eviscerated and washed in fresh water. The loss due to the gutting and cleaning operation is about 30 per cent. The herrings are either smoked unsalted and then lightly sprinkled with salt while being packed — this procedure is generally used on the island of Bornholm in the Baltic — or the herrings are brined for about half an hour in a 10—12 per cent salt solution before smoking.

In the kilns used on Bornholm the herrings are hung up two by two on wooden sticks, triangular in section, the head of one herring being put in below the gill cover and out through the mouth of another herring.

In the so-called German kilns, where round iron spits are used, the spit is either pushed through both eyes of the herring or entered below the gill cover and pushed out through the mouth of the fish.

After being suspended the herrings are dried. On Bornholm the drying takes place, weather permitting, in the open air, where the sticks are hung on wooden frames. In case of rain the herrings have to be dried in the smoke kiln. The temperature of the herring during this part of the process must not exceed 30—40° C. (86—104° F.). If the drying temperature is too high the percentage of fish falling down during this period will be considerable. The drying is done in order to make the head and the skin of the herring so strong that the herring does not fall down during the smoking period, where as a rule a temperature of about 60° C. (140° F.) is used to bring about a coagulation of the proteins of the fish meat.

Types of Danish Smoke Kilns and Smoking Procedures

From *Bramsnæs' and Petersen's* paper:

There are two main types of smoke kilns in Denmark, the one used on Bornholm and the so-called German kiln. The former will be mentioned first, as it seems to be directly inspired by the ancient custom of smoking fish in the chimney above the open fireplace.

The *smoke kilns used on Bornholm* are built of bricks and have somewhat varying dimensions, but they generally have a cross section of about 3 by 3 m. (about 10 by 10 ft.) at the bottom. The bottom of the kiln is covered with firebricks and raised about half a meter (20 in.) above the floor of the smoke-house; from the bottom and upwards, the front of the kiln has a large uncovered opening, which is about 1½ m. (about 5 ft.) high. Above this the kiln is narrower, the walls sloping inwards and forming a truncated pyramid, which finally opens into the chimney.

In the old kilns a fire is built on the kiln bottom itself and is pushed backwards and forwards with a poker. In the new kilns the fire is placed

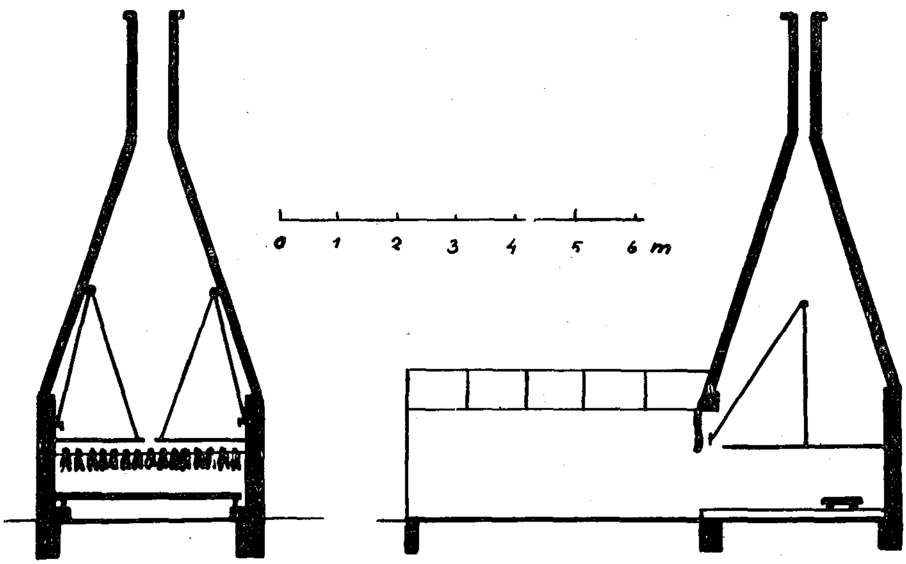

Fig. 1. *Hot-smoking kiln of the type in use for herring on Bornholm, Denmark. The fire is placed on a flat trolley which is mounted on wheels.* (*Fiskeriministeriets Forsøgslaboratorium, Copenhagen, Denmark*).

on a flat trolley which can be pushed backwards and forwards in the kiln.

The sticks with the herrings to be smoked are placed about 60 cm. (2 ft.) above the bottom of the kiln, which usually holds about 200 kg. (about 440 lb.) of fresh herrings.

Above the herrings there are two big wooden dampers turning on hinges placed in the two side walls. During the drying these dampers are opened to allow the hot air to pass freely through the herrings and into the chimney. As soon as the herring can stand further heating without falling down, the drying period is ended and the dampers are lowered so that the lower part of the chimney is almost closed, leaving only a little vent in front of the kiln for the smoke to get out through the chimney. In their lowered position the dampers are just above the herrings which are usually hung in one layer only.

The drying is started with dampers open and with the burning wood in a strip on the front of the kiln bottom. As the drying and the following smoking proceed the fire is pushed backwards and forwards until a uniform product has been obtained.

The wood used is hardwood, preferably alder wood. Coniferous wood is not used, as it may give a bitter taste. If the wood gives too many flames, the flame is subdued by sprinkling water from a swab.

The drying time in the kiln depends upon the amount of drying which

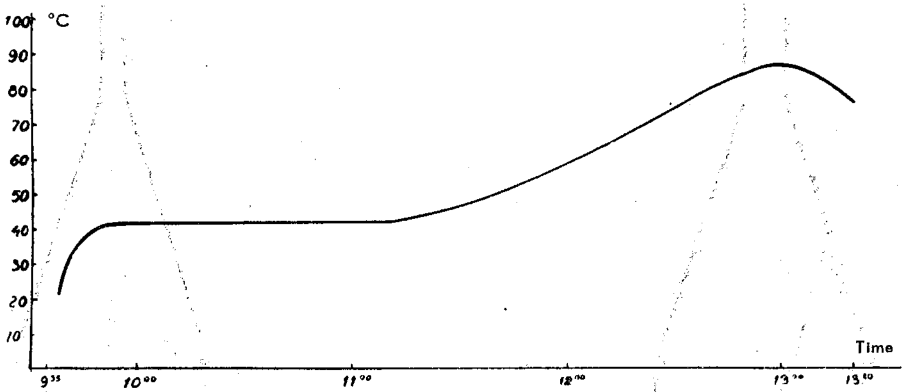

Fig. 2. *Temperature in a Bornholm-type hot-smoking kiln. The herring is first dried at a fairly low temperature, then smoking starts with a gradual increase in temperature. (Fiskeriministeriets Forsøgslaboratorium, Copenhagen, Denmark).*

has already taken place, if the herrings have been placed in the open air, a drying method which is preferred and always used when the weather permits. If this drying has been sufficient, the smoking can start at once. If the drying is done in the kiln, it usually takes about half an hour at a temperature of 30—40° C. (86—104° F.).

The smoking which should give a golden colour, the proper smoke flavour, and the cooked consistency to the herrings is started by lowering the dampers and the fire is subdued by sprinkling water from the swab. The hot air and the vapour produced when the fire is subdued will then gather around the herrings with the surplus escaping under the frontal edge of the dampers and passing into the chimney. The smoking with the dampers down generally lasts 1½ to 2 hours. During this period as constant a temperature as possible is kept in the kiln. When the smoking is finished the dampers are opened, and the fire is allowed to burn more freely so that the temperature is increased for a short while to about 80—100° C. (176—212° F.), and the herrings are dried well on the surface. Then the fire is extinguished, and the herrings cooled outside the kiln.

100 kg. of fresh herrings usually give a yield of 55—60 kg. of smoked herrings.

The so-called *German kiln* is the most common type outside of Bornholm. It is usually built as a brick chamber about 2 m. (6½ ft.) high and about 1 by 1 m. (3¼ by 3¼ ft.) in section. The lower part of the side walls and of the back wall and the bottom itself are made of firebricks. In front the kiln is closed with an iron door, which can

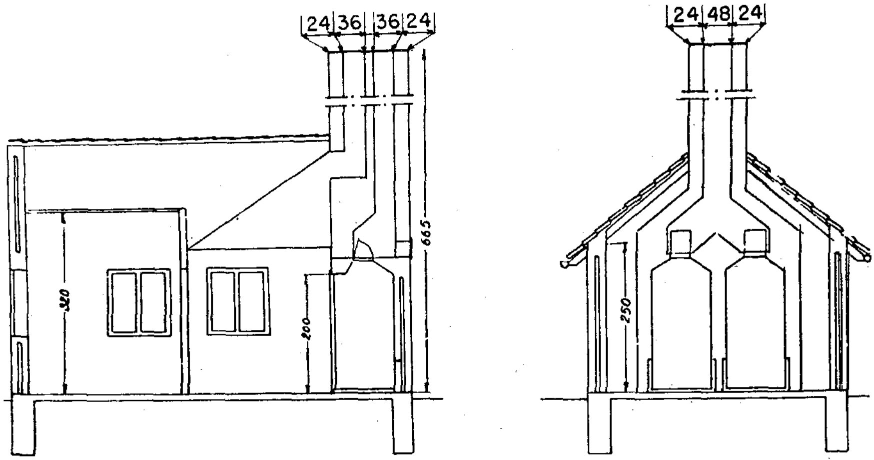

Fig. 3. *Danish hot-smoking kiln of the so-called German type* (*Fiskeriministeriets Forsøgslaboratorium, Copenhagen, Denmark*).

be divided into three parts, a lower part through which the fire is tended, a central part through which the smoking frames with the herrings are placed, and an upper part which may be omitted and which, at any rate, only serves to regulate the smoke. The kiln is connected to the chimney by a short duct, 25 by 25 cm. (10 by 10 in.) in section. It is generally considered important that each smoke kiln have an independent outlet to the chimney. This outlet leads obliquely upwards to the chimney. The draught in the kiln is regulated by means of a damper in the duct.

About 80 cm. (2⅔ ft.) above the kiln bottom, angle irons are placed in the side walls with about 25 cm. (10 in.) between the irons. The wooden smoking frames carrying the spits with fish are placed on these irons. As a rule 2—3 frames with herrings are smoked at the same time.

The drying in this kiln is carried out with half-open doors and with open damper. While in the kiln used on Bornholm a uniform treatment of the herring is obtained by moving the fire, this uniformity is obtained in the German kiln by turning the frames around once or twice during the smoking and at the same time reversing the order of the frames so that the upper frame gets nearest to the fire. After about three quarters of an hour the temperature is raised, and now — before the final smoking — the herrings are cooked over a bright fire.

The final smoking takes place with partly closed damper, the fire ng subdued with sawdust and possibly with water. A dense smoke hich the herrings obtain the desired flavour and colour, is now iced. This part of the process generally lasts about one hour.

discussions:

Bramsnæs, Denmark, added that when using the German-type smoking kiln it was generally difficult to avoid getting too much smoke ng room. One had to use a special fan arrangement to oom was kept fairly free from smoke. There was ween the product produced in the so-called Born- called German kiln, although the public seemed epared in the former. This might, however, very ces in raw material.

ked, in relation to hot smoking, whether it would efore drying or whether it was necessary rdinarily done.

ered that it is ordinarily necessary to imply because if it were left to coagulate be so soft that it would break

r it would be possible to do and only dry and smoke the in it.

at this seemed to be essentially the cold-smoking process, where the coagulation of the fish is avoided entirely.

cked in boxes hment paper. rings. If the herrings (about 4½ oz. per 10 lb.) is used. The boxes are dispatched and sold upside down. This results in a plesant appearance of the fish when the box is opened later in the shop. The salt imparts a bright, shiny surface to the herrings.

Smoked herrings from Bornholm are generally packed in the way they leave the smoke oven, attached to one another by the gill cover.

Research in Denmark.

From *Bramsnæs' and Petersen's* paper:

Hot-smoked herrings with about 12 per cent fat contain 50 per cent water and 2—3 per cent salt. The *keeping quality* of this product is 4—5 days at 18—20° C. (64—68° F.). After this period growth of mould appears on the skin of the herring. Under the storage temperatures mentioned above, mould appears before the fish meat is appreciably infected by bacteria, *i.e,* before the fish is tainted.

The above mentioned *keeping quality* of 4—5 days has so far been considered sufficient for normal retail distribution. During recent years, however, producers and dealers have felt that the trade would involve less inconvenience if the keeping quality could be prolonged by a couple of days.

When the herring is packed in boxes lined with parchment paper the mould seems to start on the wood and then spreads to the paper which is partly dissolved.

It has often been discussed whether *brining the herrings* before smoking would be better than sprinkling them with salt in the boxes after the smoking. Laboratory experiments seem to indicate that the salt content of the smoked product in both cases will be only 2—3 per cent calculated on the basis of the total content of salt and water and that the keeping quality in either case will be approximately the same. One might think that the salt would concentrate in the skin, especially when the salt is sprinkled in the boxes. Analyses of the skin have, however, shown only the same 2—3 per cent. Not only the method of salting, but also salting on the whole seems to be of minor importance to the keeping quality. Salting is done, first of all, to improve the flavour as experiments indicate that the smoke flavour will be reduced if salting is omitted.

Knowledge of the *temperature in German kilns* is somewhat limited; it is known that the drying temperature is about 30° C. (86° F.) and maximum temperatures of 100—120° C. (212—248° F.) have been measured. *In the kilns on Bornholm* the temperature of the smoke around the fish has been measured in detail. The drying is done at a temperature of about 35—40° C. (95—104° F.), the smoking at about 60° C. (140° F.) the temperature gradually rising towards the end of the treatment. Just before finishing, the dampers are opened again and the smoker lets the temperature rise to about 90° C.

No doubt, some day one ought to look into what could be obtained in the form of better keeping quality by extending the last quite brief part of the process, where the temperature is about 90° C. (194° F.).

It is the impression at the Technological Laboratory of the Danish Ministry of Fisheries that an effective *cooling* of smoked herring *before packing* is of great importance to its keeping quality. Experiments are, therefore, going on to find an inexpensive method of cooling in air with a low count of microorganisms.

Treatments with *chemical preservatives* have been tried by

1) salting the unsmoked herring in a brine to which the preservative has been added,
2) dipping the smoked, still hot herring, for a few seconds in a solution of the preservative, and
3) powdering the smoked herring with the preservative or in the case of unbrined herring, sprinkling with salt to which the preservative has been added.

So far sodium nitrite, benzoic acid, acetylsalicyllic acid and some antibiotics have been used as preservatives. Some improvements have been noticed but not enough to justify, from an economical point of view, the use of any of the examined chemicals. Nitrite, perhaps, constitutes an exception, but further experiments are necessary.

On Bornholm *packing materials* other than the porous wooden boxes with an inside liner of grease-proof parchment paper have been tried, for instance cellophane bags, but apparently so far without obtaining a better keeping quality. A single experiment with packing of smoked herring in cellophane showed curiously enough that the packing material became mouldy on the outside after 4—5 days' storage at about 20° C. (68° F.). Further experiments are necessary.

The laboratory has tried disinfection of the box wood by dipping it in a 3 per cent solution of sodium hypochloride. After 3 days' storage of the smoked herring no mould was observed on either dipped or undipped wood, but the paper in the boxes where the wood had not been dipped was apparently somewhat dissolved. After 2 days' further storage there was a heavy mould formation on wood, paper and fish in the undipped boxes, while in the dipped boxes only a faint mould was noticed on the fish and nothing on the paper and the wood.

Lowering of the *storage temperature* of course enhances the keeping quality of smoked herrings. At about 5° C. (41° F.) they will keep for 1—2 weeks. However, there are two disadvantages in this procedure. One is that humidity is formed on the herrings when they are taken out of the chill-oom, thus giving ample possibilities for mould formation, and the second is that there is a marked loss of flavour during storage.

Lately experiments with *freezing* of hot-smoked herrings have been taken up. The quality of the product survives the freezing itself better than could be expected, although some loss in flavour has been noticed. The influence of storage still has to be determined. It is, of course, necessary here to change the type of packaging from wood to some moisture-vapour-proof material.

Mechanical Kilns for Hot-Smoked Products

From *Bramsnæs' and Petersen's* paper:

In Denmark one type of mechanical smoke kiln has been tried experimentally in order to lower the cost of production and to secure a more uniform product. A great deal of effort was put into these experiments. So far the results have not been satisfactory. A reasonable quality of hot-smoked herrings can be produced in the type of kiln used, but the herrings so far cannot compete in flavour and texture with the smoked product made in the traditional manner.

From *Cutting's* paper:

Although in United Kingdom there has been less experience with hot-smoked fish than with cold-smoked, at least one factory has been using the Torry Smoking Kiln for smoking sprats prior to canning. There seems no obvious reason why it should not prove equally successful for bucklings and similar products.

Possibilities from Using Newer Types of Kilns

From *Cutting's* paper:

The types of smoked fish product that have been developed have been dictated by the type of kiln employed. With the adoption of the newer horizontal-flow controlled type of kiln, new and improved products might become possible. Thus, in a traditional kiln with a vertical updraught, fish have to hang vertically on sticks or hooks. The flesh, therefore, has to support the whole weight of the fish and usually head or bones are left on the fish to provide strength. Thus, fillets suspended from hooks or rods sometimes tear the flesh and fall off. They are, therefore, often laid flat over pairs of sticks or rods. They cannot then be smoked evenly, because of the damp patches where the fish touches the stick and because the smoke does not deposit as quickly on the uppermost surface of the fish as on the underneath. This is perhaps why smoked fillets are usually dyed, to give a superficial uniformity of colour.

Hot-smoked fish would tear even more easily since cooking softens the flesh. Thus, headed and cleaned white fish, in which the vertebral column is stronger than in the case of herring, can be tied together by the tail and laid over a stick. Buckling on the other hand cannot be smoked with the heads off or gutted and washed.

With smoke flowing horizontally, however, fish can be smoked lying on trays as long as the smoke is not prevented from getting at the underside. The trays should be constructed so that mesh marking is minimised, but the pattern left would be no more unsightly than the holes left by tenters and speats. Tentering, too, is about the only step in the smoking chain that still requires individual handling of the fish. Placing fish on trays for smoking, which is quite common procedure in America, should be more amenable to mechanisation than tentering or speating. By this means it is quite possible that new cures could be developed which would overcome some of the disadvantages of the older ones, in the same way that, for example, completely boneless kipper fillets might displace kippers, even although it deprives one of the particularly succulent part under the bone. Thus, for example, it is possible that gibbed or gutted and cleaned and headed fish, or boned fillets might yield palatable cold- or hot-smoked cures while at the same time overcoming the disadvantages of messy viscera or troublesome bones.

Marketing Possibilities for European-type Products

From *Cutting's* paper:

A fair quantity of kippers are exported from United Kingdom to various parts of the British Commonwealth. These are usually frozen in wooden boxes, although a proportion is now quick-frozen. They have to be cold-stored on the ship where cold-storage teperatures are often as high as —10° C. (14° F.), which causes noticeable deterioration owing to rancidity, desiccation, *etc.*, during normal voyages to, say, South

Africa and Australia. Better quality, and perhaps consequently greater consumption, would result from a general lowering of cold-storage temperatures aboard ship and at depots at each end.

This product can, however, only penetrate relatively expensive markets, owing largely to cold-storage charges.

From discussions:

Bramsnæs, Denmark, felt that the marketing possibilities for hot-smoked herring were limited and probably could not be extended much beyond the areas where these products were already in use, namely, Denmark, Northern Germany, Sweden, *etc.* Hot-smoked products should be eaten within a few hours after smoking to be at their very best. However, they may keep for some days. The prospects for wider use of smoked products were much better when it came to cold-smoked products, as these kept far better than hot-smoked.

Heen, Norway, felt that there were further possibilities for marketing smoked products in the frozen state.

Promotion of Sales

From *Bramsnæs' and Petersen's* paper:

The Technological Laboratory of the Danish Ministry of Fisheries has prepared a recipe for smoked-herring paste. The herring can be used directly after being skinned and boned because it has already been cooked in the kiln.

In the laboratory's test kitchen the possibilities for using smoked herring in the household have been gone through. The resulting recipes have not only been published in print, but have also been the subject of a short moving picture.

SMOKING, DRYING AND DEHYDRATION OF HERRING FOR TROPICAL CONSUMPTION

"Hard" Smoking

"Red" Herrings

From *Cutting's* paper:

The British output of "reds" in recent years has been of the order of 10 000 metric tons, almost all of which has been exported.

The Netherlands and Norway also enter into the export market.

Manufacture of "Red" and "Silver-Cured" Herrings

From *Cutting's* paper:

For the manufacturing of "red" herrings ungutted herrings are laid in vats with dry salt, which extracts fluid from the fish, forming a brine pickle. When sufficient salt has been absorbed they can be taken out and smoked. In one experiment, the salt content of the whole fish containing about 10—12 per cent of fat after 1½, 3½ and 5 days' salting respectively, was 6.3, 11.0 and 13.1 per cent, that of the flesh being somewhat less. If left in the vats, the flesh ultimately becomes permeated with a saturated salt solution provided that sufficient salt is present. At this stage they can be kept covered with pickle for several months. Such "vatted" fish, however, have to be desalted prior to smoking by soaking in water, otherwise the drying would result in salt crystallising in the form of a white powder on the outside of the fish. The salt contents in one instance after 0, 5, 11 and 17 hours soaking were 18.3, 13.5, 10.6 and 9.3 per cent. They are then hung up on rods in kilns and smoked in cool smoke for several weeks in the case of a full cure, which is hard, shrivelled and dark brown in colour. Too rapid drying results in "casehardening". A softer, more golden-coloured product is now mainly exported to the Mediterranean region. The average accumulative percentage losses of weight for nine successive days' smoking in one commercial test were: 8.0, 10.5, 12.5, 14, 16, 17, 18.5 and 20 per cent. Fish that are too fatty do not make good "reds". The East Anglian autumn herring (with 10 to 15 per cent of oil) are ideal, but the North East Scottish fish at the beginning of the season when they contain 20 per cent or more are too oily (Lovern, Wood 1937).

"Silver-cured" herring (not, of course, to be confused with the much more recently patented "sølvsild") which have a more restricted, although growing market, are only smoked for a much shorter period and are therefore dried up less than "reds", giving a bigger yield, and take on practically no colour. They have consequently to be salted for a somewhat longer minimum period than is the case with "reds". They have to be washed to remove the brown scum and dirt before smoking.

The proximate composition of both "reds" and "silvers" is in the region of 40 to 45 per cent of water, 15 per cent of salt and 15 to 20 per cent of fat (see also Shewan 1944, 1949 A).

Problems of Expanding the Market for "Reds"

From *Cutting's* paper:

It ought to be technically feasible for the relatively limited market for red herrings to be extended both in depth, so as to penetrate wider sections of the community in the present importing countries, and also in breadth, so as to embrace other countries with the storage problems associated with warm climates and poor communications, *e.g.*, South America and tropical Africa. They are already being sold in West Africa and East Africa. As always, prices must be commensurate with incomes.

Packaging in the tropics must be adequate to resist average summer temperatures in the region of 35° C. (95° F.) and relative humidities of 85 to 95 per cent of saturation (Centre Nat. d'Inf. Econ. 1948; Cutting 1949), and also the inroads of insects such as protein-eating beetles, mites and ants. The only type of container which is certain to fulfill these requirements is the open-topped can with seamed-on lid, but more research is required on the behaviour of less-expensive forms of packaging at high temperatures and humidities.

Samples of ordinary commercial red herrings when stored for nearly a month in air in sealed cans at a temperature of 45° C. (113° F.) are still quite palatable, and they would probably keep for several months without serious deterioration, although the product is slowly cooked at this excessive heat and a quantity of brine collects in the can. Packing in carbon dioxide would be expected to increase the storage life and inhibit mould growth; trials of this are at present underway.

It is interesting to note that in a similar preliminary trial with the dried salt cod of commerce, which has much the same salt and water content (20 per cent and 35 to 40 per cent, respectively) although, of course, it contains practically no fat, keeping quality at an elevated temperature was considerably worse in a sealed can than in the open. This appears to be due to the fact that unless the product is dried to well below the commercial average water content, say down to 20 per cent, the high equilibrium relative humidity (probably about 85 per cent) maintained in a closed space encourages mould growth ("dun"). After a month's storage at 37° C. (98° F.) there was considerable darkening in colour, breakdown in texture and development of "off" odour and flavour which was far less noticeable in samples stored in a waxed paper wrapper which prevented appreciable further drying from occurring.

From discussions:

Hanson, United Kingdom, felt that the results from this experiment was surprising considering the fact that some countries, for instance, Norway, export salted cod in sealed tin-can containers. The water content of this product is generally around 33 per cent and the salt content more or less the same as in the products mentioned by Dr. Cutting.

A participant from Norway said that it was correct that such shipments of salted cod packed in tin-lined containers generally arrived in a satisfactory condition in, for instance, the Argentine. It did, however, occur that some decomposition took place due to the high temperature during transit and the humidity in the container itself.

From *Cutting's* paper:

Although "reds" can be eaten raw occasionally and in smallish amounts, for such salty and highly flavoured commodities to form an important part of the diet, they would often, presumably, have to be desalted, *e.g.*, by soaking or boiling in water, or else incorporated into dishes where the overall salt content is not thereby rendered excessive.

Improvement of "Red" Herrings

From *Cutting's* paper:

There are only two British home outlets for "red" herrings. They are made into "bloater pastes", on account of their potent flavour, and as "delicatessen" they figure in minute total quantities in hors d'oevres, *etc.*

A milder cure of red herrings can result in a product which is not too salty when eaten raw and is not vastly dissimilar to smoked salmon. If suitably developed and not too expensive such a process might help to engender the taste for this type of product amongst broader sections of the community. Whereas dry salting extracts fluids from the tissues of the fish, and thus commences the curing, before brine begins to flow back from the pickle produced, salting in concentrated brine, which is a quicker and more uniform method, does not normally result in any change in weight. The fish is somewhat plumper and heavier in consequence, although if the brine is kept up to strength, saturated salt solution as in dry salting finally penetrates all the tissues.

If the fish are smoked in a mechanical kiln, such as that developed at Torry Research Station (Hardy, Cutting 1942; Cutting 1942, 1950), the relative amounts of smoking and drying can be subjected to a measure of independent control.

There is a field here for the study of the physics and engineering aspects of the preparation and of the keeping quality and acceptability of this type of product.

In preliminary experiments to develop a satisfactory mild cure, the following analyses and observations were made. Dry salting of round herrings with a fat content of 15 to 20 per cent for 16 hours, resulted, according to size, in a loss of weight of 4 to 7.5 per cent, and an uptake of about 3.5 per cent of salt; after 48 hours, the loss was 12 to 19 per cent and the uptake was 5.5 to 8 per cent of salt. Brining for 1½ and 2 hours in a 20 per cent salt solution (about 70 per cent of saturation) resulted in no loss of weight and 2.3 and 2.9 per cent of salt respectively. The fish were then smoked for 6 to 8 hour periods during the days only in the kiln at a temperature of about 20° C. (68° F.) and at an air speed of about 3 ft. per sec. (0.9 m. per sec.) with a fairly low, uncontrolled relative humidity. The 16 hours' dry-salted and brined fish lost by weight in evaporation, respectively, after 1 day, 15 and 10 per cent; 2 days, 20 and 17 per cent; 3 days, 24 and 20 per cent; 5 days, 29 and 25 per cent; 6 days, 30 and 27 per cent. Obviously the rate of drying falls off very rapidly. The final salt content of the smoked fish was 4.25 per cent for the dry-salted and 2.5 per cent for the brined fish These products, although quite attractive to eat, were probably too "green" and not cured enough to keep for more than a few days. Dry salting for 48 hours, followed by 5 days' smoking resulted in a loss of 30 per cent by weight and a salt content of 6.5 per cent, and the product was a much more likely cure.

These times could probably be reduced by smoking for 24 hours per day, or if the product benefited by intermittent smoking and hanging, two or more batches could be smoked and hung alternately, thus increasing plant output.

Such milder cures might require chilled storage if they are to be widely distributed, particularly in warm countries. Storage tests at controlled temperatures and humidities would, therefore, be required, and once again packing in cans in carbon dioxide might be investigated as a means of extending storage life.

Experiments might also be made to produce a red-herring cure from herrings filleted before salting and smoking, in which the absence of guts and bone might be an improvement. However, laying bare the flesh may accelerate the development of rancidity in the fat, and the guts may themselves contribute something essential to the characteristic flavour of red herrings.

Various Combination Methods

Smoking of Salt Herrings

From *Cutting's* paper:

Salt herrings, a cured product of as venerable a lineage as "reds" could, of course, be taken from the pickle, desalted to the necessary extent and then speated through the eyes and smoked. This is not usually done, however, perhaps partly owing to the difficulty of speating a "gibbed" herring and also to its uglier apperance. The fish may also go rancid at any break in the flesh when exposed to air.

Pickled herrings can, of course, be desalted to a salt content at which they are tolerable to ordinary palates (about 3 to 4 per cent in the case of a cooked product, somewhat more if eaten raw), but this takes several days even in running water. Large numbers of tanks are thus required for desalting on a commercial scale. Moreover, the characteristic bitter flavour is never completely washed out, and the protein is denatured by the long exposure to salt. The flavour and appearance of the product is not, therefore, such as to recommend itself to people accustomed only to fresh fish. Nevertheless, desalted herrings have been canned experimentally and during World War II numbers of commercial attempts were made to split and smoke them in the kipper fashion.

There was no need, of course, to brine the fish after splitting and absolutely no glossy cut surface could be obtained. Moreover, it was difficult working with fair-sized batches to desalt the fish uniformly to a tolerable level without some of the fish going "off". The commercial tendency was, therefore, to produce too salty an article. The result was generally speaking in any case unsuitable to British palates, although some such product might well be acceptable in many parts of the world. It should thus be possible to transport the fish in the salted condition in barrels and to desalt and smoke on the spot as required.

Drying of Salt Herrings Without Smoke

From *Cutting's* paper:

It is understood that small quantities of herrings are dried without the use of smoke or salt in Iceland at certain time of the year by the combined action of wind and sun. Such a product would be expected to be extremely rancid. Salted herrings exported from Canada and Newfoundland to Hong Kong and the West Indies are reported to have been dried (but see also Chapter 9, pp. 226—228). Samples of those reshipped from Hong-Kong to Britain in ordinary and refrigerated storage, when analysed contained respectively 40 and 42 per cent of water (indicating perhaps that the former had dried out during reshipment); 21 and 17 per cent of salt; and 15.5 and 18 per cent of fat. There is little evidence in these figures to substantiate the statement that the fish are dried at all. The sample shipped in refrigerated storage was by far the better, and even if it had not suffered much deterioration since it left Hong-Kong, it must be quite a palatable cure. This product is sold very cheaply, so that only slight processing costs could be borne in any process intended to imitate or improve it.

Information on the types of local product accepted by native populations is also of interest in considering whether suitable products could be made from herrings.

Samples were obtained from Aden of sun-dried whole anchovies *(Stolephorus indicus)* and of split, salted, sun-dried mackerel (which appeared from their shape to have been horse mackerel). When soaked in water for 24 hours, a whole fish only picked up about 1.2 and 0.7 g. water per g. of fish, respectively. When steamed for 30 minutes, the anchovies tasted very rancid and rather tough, as well as sandy, and were generally unpalatable. The mackerel was not quite so disagreeable, but was tough and had no fishy characteristics. The water contents for an anchovy and mackerel, respectively, were 15 and 22 per cent; salt, 2.4 and 18.1 per cent; oil, 2.9 and 4.7 per cent. The mackerel oil had a high peroxide value of 23. These samples nevertheless seemed to be acceptable in South West Asia and East Africa.

The British Herring Industry Board has been making commercial experiments, with a view to developing the export of cheaply "dry-cured" herrings to colonial markets (Herr. Ind. B. 1948). Ordinary dry-salted herrings used for making "reds" could probably be dried satisfactorily enough for an export product of this type in the usual kilns to produce something like a "silver cure" by using fires which give little or no smoke, *e.g.,* coke braziers. There would be the usual difficulties in obtaining uniformity of drying which could be overcome by using a special dryer. The best air speed, temperature and relative humidity for maintaining the most satisfactory conditions for evaporation and avoiding "casehardening" would need investigation.

Smoking and Drying of Herrings Without Salt

From *Cutting's* paper:

Without the use of salt, natural drying in the sun and wind is bound, even in suitable climates, to be so slow that noticeable spoilage is liable to occur before the water content throughout the fish is sufficiently low for bacterial action to be retarded (about 20 to 30 per cent) (Shewan 1949 B). Exposure to air and sunlight, too, would be expected to result in the development of considerable oxidative rancidity in the fat. Artificial dryers might speed up the process sufficiently to prevent advanced decomposition during drying. Nevertheless, a good deal of native-caught fish is consumed in this form.

In British West Africa, salt fish is apparently not relished. Norwegian produced "stockfish", i.e., sun- and wind-dried, unsplit cod, is much preferred, about 30 000 metric tons annually being imported at one time.

The British West African natives themselves smoke ungutted, unsalted fish, cut into pieces if too large, for upwards of a week in a mud oven or an iron drum or over an open fire, resmoking from time to time whenever the onset of putrefaction demands it until the product is perhaps months old.

A sample of "bonga" from West Africa was examined at Torry Research Station. This appears to be a horse mackerel, with an intermediate oil content, hot-smoked, it is believed, at a very high temperature, with the head on, round and ungutted. The sample examined may perhaps have deteriorated, or dried up or oxidised further during transport to this country. It was dark brown and very hard, almost like wood, and although the fish was not at all oily in appearance or feel, there was a decidedly "off" oily odour. The flavour, although unpleasant and not at all fishy, was not repulsive. The reconstitution properties were very poor, only 0.8 g. of water being picked up per g. of fish when soaked overnight. One sample contained 14.4 per cent of fat (corresponding to perhaps about 4 per cent in the fresh fish); 12.4 per cent of water (which is below the level at which moulds will grow, *viz.*, 16—18 per cent on a fat-free basis) (Shewan 1949 B); and only 1.3 per cent of sodium chloride, showing that the fish had not been salted. The peroxide value of the fat (expressed in ml. 0.002N $Na_2S_2O_3$ per g. fat) was 11.0, indicating that considerable oxidation had taken place, although it is doubtful whether the peroxide value necessarily gives a true measure of fat oxidation in cases of advanced oxidation, when the peroxides themselves might have broken down into further products of oxidation.

Another sample of bonga obtained through another channel from the same source, had a similar fat content (13.0) but the water content was very much lower, only 0.75 per cent, possibly as a result of storage in dry conditions. Or alternatively, the moister sample might have picked up water vapour from the atmosphere.

It should not be difficult to produce a product at least as palatable as this from herrings. However, they would have to be rather lean, "spent", or "off season" fish with a fat content of not much more than 5 per cent if they were to be at all comparable with bonga. In addition, the higher the fat content, the longer the drying would take, and the greater the danger of fat oxidation rendering the resulting product, revoltingly "painty". It is perhaps worth remembering that, although natives may

Table 3. *Drying of whole round herrings*

Temperature (° C.)	Net drying time (days)	Sample analyses			
		% H_2O		% Fat	
55—63	1	56		8.9	
»	2	53		9.4	
		Hard	Soft	Hard	Soft
30	4	36	50	6.4	12.2
»	$4^1/_3$	39		10.5	
»	5	26	41	10.1	11.2
102	6	5.4	29	17.1	13.1
»	7	1.8	7	16.1	—
»	$7^1/_3$	0.5	4.5	15.9	18.5

acquire some peculiar tastes, they will not necessarily tolerate advanced fat oxidation, which is peculiarly unpleasant.

Some lean herrings were obtained in the middle of February, 1949, speated through the eyes without splitting or gutting, and hot-smoked for 6 hours at a temperature of about 55—63° C. (131—145° F.), which was considered to have conferred sufficient smoky flavour and colour. Drying without smoke was then continued in the kiln for several days at the same temperature with an air speed of 7 ft. per sec. (2.1 m. per sec.), and a low relative humidity of only about 5 to 10 per cent owing to the small load of fish in the kiln. The fish then were still far from dry and, owing to evident "casehardening", it was felt that nothing further was to be gained by continuing at such a high temperature. The temperature was, therefore, reduced to 30° C. (86° F.) and the fan kept on for five days to sweep away moisture as it diffused through the fish to the surface. The fish was left to stand overnight on the last three days in order to equilibrate. The moisture content was thus reduced to between 25 and 40 per cent. The drying was then finished in an air oven at 102° C. (216° F.) for a further two days, during which a sample of harder fish lost a further 28 per cent and of softer ones 41 per cent before evaporation ceased. The progress of drying can be followed from *Table 3*.

The product, whilst not very attractive, and rather fattier than the bonga, would probably be quite acceptable. The time required for the thorough drying of round herrings is a major problem, but it might be possible by experiment to reduce the time to 2—3 days. Fillets would be much quicker to dry than whole fish, and the product would be superior even if dearer.

Experiments in Warm Climates

From *Cutting's* paper:

Several experimental attempts have been made in warm climates to improve upon native cures. These are of interest because they have had to contend with difficulties of storage as well as of preserving the fish satisfactorily in the first place. United States experiments on the salting and smoking of fish in Puerto Rico (Jarvis 1932) and the Virgin Islands (Fiedler, Jarvis 1932), applying the experience previously obtained in preserving river herrings in warm climates on the mainland (Tressler 1920; Taylor 1921, 1922), worked out the best smoking procedure for fish up to about 1 lb. (0.45 kg.) in weight. Great importance was attached to extremely careful washing to remove all traces of blood and membranes, which spoil at a lower temperature and taint the rest of the fish. This point may require consideration in developing a relatively lightly salted and smoked product for storage under tropical conditions. The fish were first gibbed (*i.e.,* their throats were cut and the intestines removed through the incision, as for salt curing of herring), dry-salted for two hours, rinsed, air-dried for two hours, followed by smoking in a dense smoke (whether hot or cold is not clear) for 9 hours. 35 per cent by weight was lost, and the product kept in good condition for 4 days without refrigeration. Dry salting for 2 hours followed by cold smoking for 18 hours resulted in a loss of 53 per cent and the product kept for 6 days at ordinary temperatures and was unspoiled after a month at —2° C. (28° F.). It is not kown how fatty these fish were, but obviously something similar to these products of a relatively high grade, much superior to bonga according to western palates, could be produced from Atlantic herrings, although chill-storage might be required for transportation and buffer depots.

In the Gold Coast during World War II, a satisfactory process was worked out for sun drying and then hot smoking fairly heavily salted fish (Johnson 1941, 1943, 1947). The most satisfactory final composition of the cured fish was 9 per cent of salt and 25 per cent of water. *Sardinella* species (similar to herring) were first split, gutted and washed thoroughly without scaling; left for about 18 hours in a 15 per cent-by-weight salt solution; rinsed quickly in water and sun-dried for 3 days; and finally smoked for one day at about 60° C. (140° F.). The fish kept in fairly good condition for 2 or 3 months, after which spoilage began to be evident, due not so much to bacterial putrefaction as to pink halophilic bacteria, moulds, smut fungi, and to insects, particularly mites.

"Herring" layered with half their weight of salt in tanks and kept covered with saturated brine could be held for as long as 16 months. When soaked in water overnight to remove excess of salt, sun-dried for 3 days and smoked for one, as before, they still gave products with a satisfactory flavour even if they were rather brittle.

In Aden where the climate is hot and dry, an improvement on the ordinary sand-dried "sardine" (see earlier) which is rancid, sandy and infested with beetles, has been made by salting with one third by volume of salt, and keeping under the blood pickle for 48 hours, followed by washing in clean sea water and shade drying for 4 days until hard. After 2 weeks the fish exuded a film of oil and developed a distinct rancid taste.

Gas Storage of Dried, Smoked, Slightly Salted Herring Fillets

From *Cutting's* paper:

As has been stated, it is a slow and difficult process to reduce the water content of whole fish below about 30 per cent, and although fillets are thinner and therefore dry more quickly, the time consumed is still excessive. Although a moisture content of 30 per cent is not low enough to prevent mould growth and other types of deterioration, it is quite a normal figure for the products on sale, for example, in the Indian markets. An experiment was, therefore, carried out with the object of determining whether fish could be preserved at this water content by packing in sealed cans filled with carbon dioxide without the presence of a high concentration of salt.

Herring fillets (containing 22 per cent fat) were taken because the surface area is about double that of whole fish, and because water can diffuse to the surface more readily in the case of a thin slice, so that drying is quicker. The fillets were given a 5 to 10 minute dip in strong brine, in which they would take up about 2—3 per cent of salt, more to add a condiment than to assist preservation. The fish were then hot-smoked at a temperature of 70° C. (158° F.) above which it is known from experience with dehydrated fish (see later) that fish begin to scorch.

The moisture content was reduced to between 25 and 30 per cent (at which, of course, it was very tough and never reconstituted properly) in about 8 hours, which is probably a reasonably economic length of time from the point of view of output from a given capital expenditure on dryers. It would almost certainly have taken more than twice as long to reduce the water content to the safe level of less than 15 per cent. When stored in ordinary boxes, the product became mouldy, inedibly tough and bad-flavoured owing principally to atmospheric oxidation of the fat within a few weeks at ordinary temperatures. In cans containing

100 per cent carbon dioxide, they were still edible and much superior to native cures such as bonga, even although not very palatable according to our tastes after 6 months' storage at 32 to 38° C. (90 to 100° F.) which covers average tropical summer temperatures. The bacteriological aspect, particularly the possibility of anaerobic growth, in this type of process would require investigation and control. It should not be difficult by cleanliness, hygiene and reasonable care to ensure a safer product than many native cures at present marketed. Obviously, there is quite a field for exploration here.

Possibility of Mild Cures for Marketing in Warm Climates

From *Cutting's* paper:

An experiment was carried out to see whether products little more dried or smoked than our mild smoke cures could be stored in cans in carbon dioxide for at sufficient period to permit exports to the tropics without refrigeration. Such products would perhaps be more attractive than the fillets dried to 25—30 per cent described previously which were tough and unreconstitutable.

Split and "gibbed" herrings containing 14 per cent of fat and 65 per cent of water were brined in saturated salt solution for three hours and then smoked for 10 hours at about 35° C. (95° F.) at a low relative humidity of about 25 per cent. They lost, respectively, about 30 and 13 per cent by weight. The final salt contents of samples of the products were 7.5 and 5.8 per cent; the water contents 42 per cent and 60 per cent; and the fat contents 19 and 13 per cent. When stored in cans with carbon dioxide, they were still quite passable in flavour and texture, although much too salty for British tastes, after two weeks at 37° C (98° F.), four weeks at 19° C. (65° F.) and 14 weeks at 0° C. (32° F.).

Dehydration

From *Cutting's* paper:

Dehydration as practised during wartime, presents a cooked minced flesh, which can include head and bones if softened by cooking. This product, although not likely to be much esteemed in Western Europe except in an emergency, seems eminently suitable for undeveloped countries, and preliminary tests on acceptance have been promising.

The problem was to prepare for emergency-feeding purposes a dried

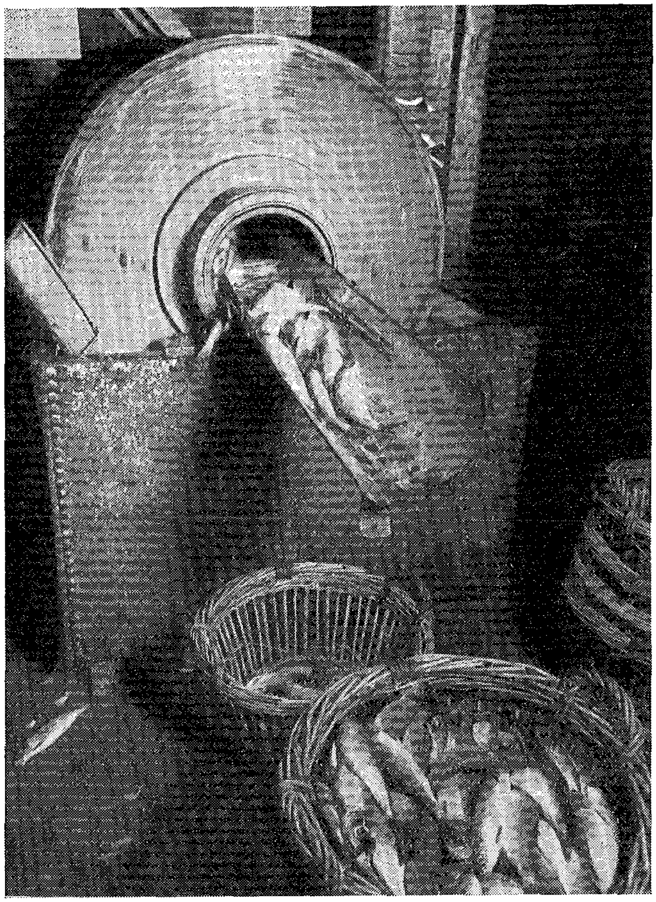

Fig. 4. *Fish emerging from rotary washer in herring dehydration plant.* (*U.K. Ministry of Food, Crown Copyright*).

product that kept well and was compact, and could be quickly made into a dish which tasted tolerably similar to fresh fish, and at least had no cured or "off" flavours. As already pointed out, raw whole fish or fillets take far too long to dry satisfactorily by normal processes. Only by cooking and mincing could an open-structured material be obtained that could be spread uniformly on wire-mesh trays and so could be dried sufficiently rapidly for bacterial and oxidative deterioration to be inappreciable (Cutting, Reay 1944).

In the Torry Research Station in Aberdeen, herring fillets were cooked in steam in ordinary cooking retorts under 0.14 to 0.42 kg. per cm^2 (2 to 6 lb. per sq. in.) pressure for 30 to 20 minutes, respectively,

Fig. 5. *Herring filleting machine in use in dehydration plant. (U.K. Ministry of Food, Crown Copyright).*

so that the juice running out of the fish (25 to 30 per cent, depending on the fattiness of the fish) drained away through perforations in the cooking trays and left a drier product in consequence, which minced well to give open, fluffy pellets which dried quickly and reconstituted well. The mince was then spread evenly, on wire-mesh trays, without packing down, at a tray loading of about 10 kg per m^2 (2 lb. per sq. ft.). The loaded trays were put into an overdraught truck-and-tray-dryer and air at 80° C. (176° F.) was blown over them at a speed of about 3.7 m. per sec. (12 ft. per sec.). The relative humidity was controlled during the first hour only by means of ventilators, so that the wet-bulb temperature to which that of the fish would approximate whilst it was still wet did not fall below 50° C. (122° F.); this because of bacteriological considerations, bacteriology obviously playing a large part in a process such as this (Shewan 1945 B). As the material dried, the dry-bulb temperature was lowered to meet the actual temperature of the fish which was never allowed to exceed 70° C. (158° F.) above which slight scorching begins to be apparent.

The drying normally took between 4 and 5 hours, depending on the

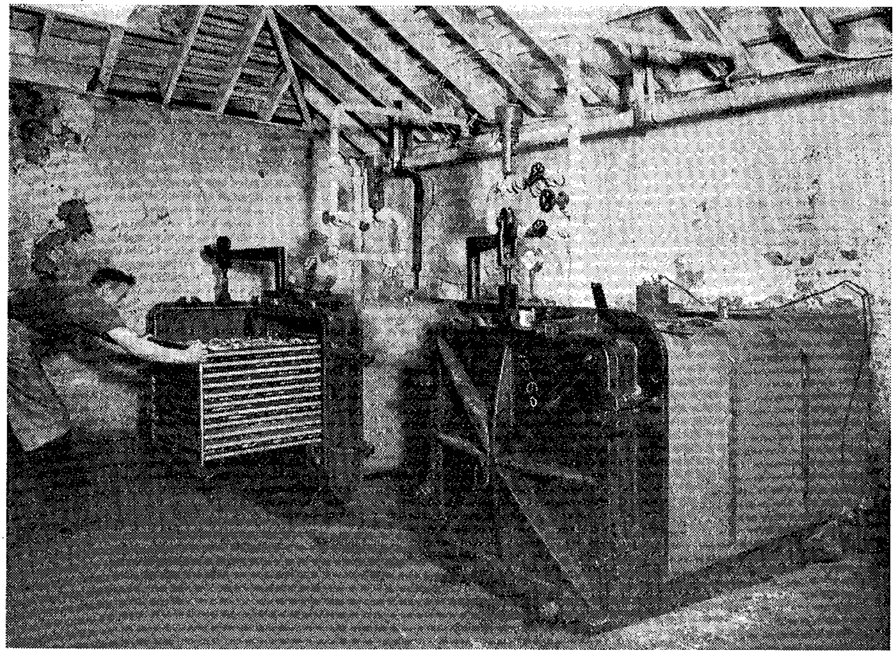

Fig. 6. *Retorts in which the herring are cooked about half an hour prior to dehydration. (U.K. Ministry of Food, Crown Copyright).*

fat content of the fish and the dried product was then shaken off the trays and packed in tins which were closed by seaming and then evacuated in a vacuum cabinet, filled with nitrogen and sealed up again.

From discussions:

Reay, United Kingdom, added some details of the process of dehydrating herring in the Torry Research Station. The herring was taken from the washer to a splitting and boning machine of a type very commonly used in Great Britain and throughout Germany, very similar to a machine manufactured by "Nordischer Machinenbau", Lübeck, Germany. After cooking the fillets were cooled in an air cooling tunnel. This was done to reduce the temperature to a safe bacteriological level and also because it facilitated the mincing of the product and also reduced the water content somewhat. The air-drying kiln was actually a modification of the Torry smoke-curing kiln, which has been described in the literature. One of the advantages of that kiln is that it gives very uniform drying throughout the cross section. Adaptation of the smoking kiln for

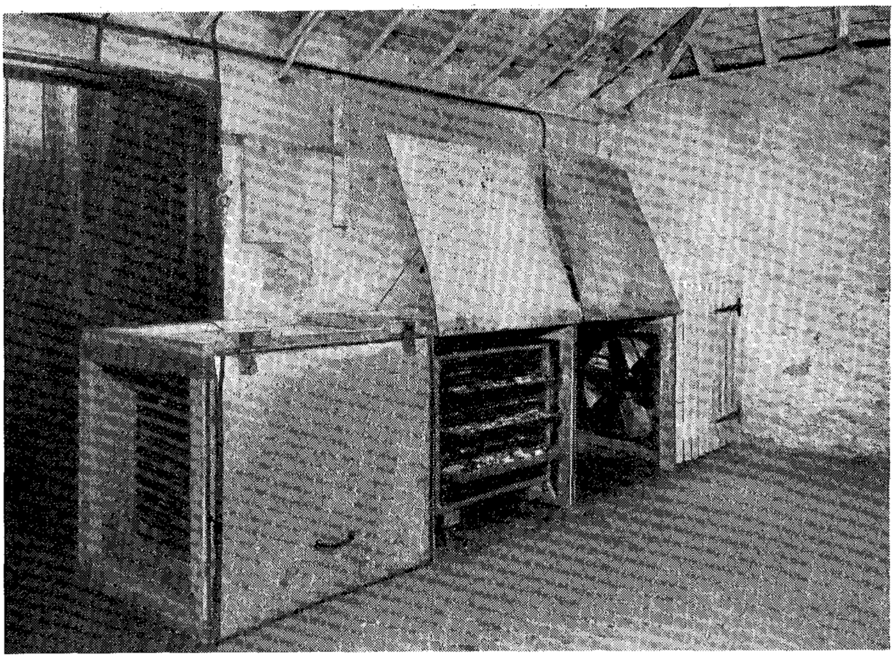

Fig. 7. *Tunnel in which the cooked herring are cooled under forced air circulation. (U.K. Ministry of Food, Crown Copyright).*

drying only required arrangement for some additional heating and insulation. The fish were packed into metal cans, about 4 lb. (about 2 kg.) of fish to each can. The cans were fitted with a hopper facilitating filling; a small hand press was used to press the dried fish down to the level of the top of the cans. These were then double-seamed and gas-packed. For this purpose 12 cans were put on a tray and punched. The tray was placed in a vacuum cabinet. The air was then removed from the cabinet and nitrogen was led in at a slightly positive pressure. The positive pressure made it possible to remove the cans from the chamber and solder them up without any appreciable exchange of air. By this process four 8 stone boxes (total 203 kg.) fish were reduced to ten 4 lb. cans (total 18.2 kg.).

From *Cutting's* paper:

Herring yields a darker dehydrated product, stronger in flavour than white fish which was generally preferred during consumer tests in Great Britain. Dehydrated herring is, of course, very oily, since the fat content

Fig. 8. *Mincing the cooked and cooled herring fillets.* (*U.K. Ministry of Food, Crown Copyright*).

of the undried fish is often higher than that of the protein and other solids. No appreciable quantity of fat is lost in the process so that the dried fish can contain more than 50 per cent of fat.

After earlier trials during World War I (Tressler 1923), it was considered to be practically impossible to dry and store fatty fish successfully. However, the process described above yields a product that, with careful preparation, makes quite a palatable savoury dish which has on numerous occasions met with a favourable reception, although canned herring would generally be preferred.

In its dry, granular state, the product does not much resemble fish and whereas minced meat, for example, is an accepted dish in Great

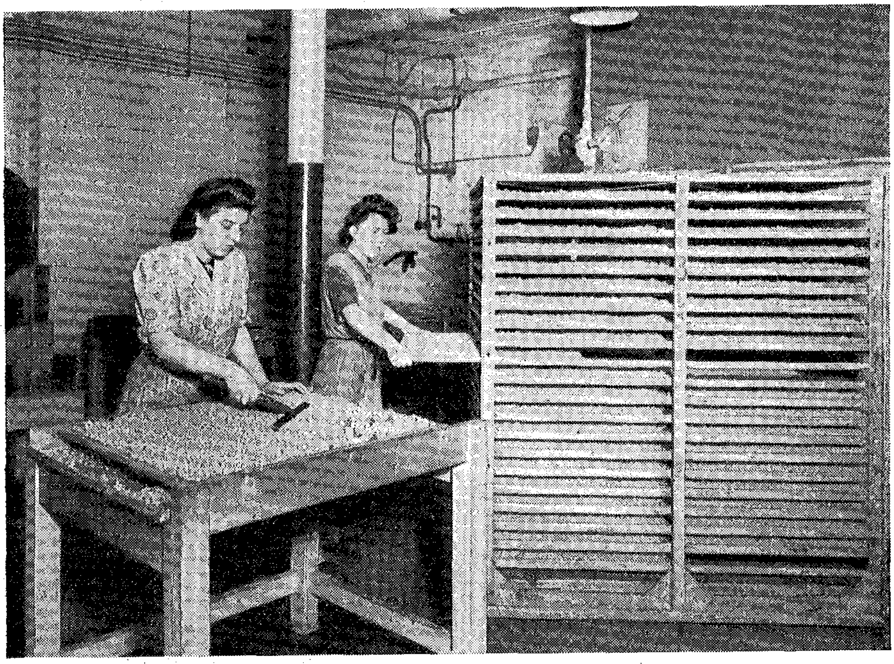

Fig. 9. *Spreading of minced herring on wire-mesh drying trays.* (*U.K. Ministry of Food, Crown Copyright*).

Britain, dried fish can only be utilised in secondary, composite dishes, such as fish cakes, which many people regard as decidedly inferior to fish in a more recognisable form.

Although texture and flavour are noticeably altered by the drying process, and the water reabsorbed during reconstitution is probably held only by capillary forces, nevertheless some fishy flavour is retained and also fishy texture if the particles are not broken down.

Dehydrated fish can normally be kept without becoming too unpalatable at tropical temperatures (25 to 37° C. [77 to 99° F.]) for about 6 to 9 months; at ordinary British temperatures (10 to 15° C. [50 to 59° F.]) for a year or two; and at freezing temperatures (0 to —10° C. [32 to 14° F.]) for several years.

During storage the product develops an unpleasant flavour and odour somewhat resembling cabbage water, and toughens and darkens considerably. The rate of deterioration is increased by raising the temperature, but seems to be independent of water content between about 2 and 14 per cent on a fat free basis, above which mould growth develops.

Dehydrated smoked herring ("kipper") is generally preferred, because the smoke tends to mask the oiliness and also storage changes, so that its "life" is therefore somewhat longer. Small amounts of smoke introduced during drying impart significant antioxygenic properties (Banks 1950).

Dehydrated fish possesses all the usual advantages of dehydrated foods in economy of space and weight carried; whereas dehydrated white fish consists almost entirely of protein, dehydrated fatty herrings, of course, have a higher energy value. Under suitable conditions it can be compressed to provide an extremely compact food.

Following on the laboratory trials in 1944, 25 tons of dehydrated herring and kipper was made in Aberdeen in a pilot scale batch-truck-and-tray-dryer based closely on the smoke kiln previously mentioned. The product was packed in cylindrical cans 157 mm. ($6^{3}/_{16}$ in.) diam. and 232 mm. ($9^{1}/_{8}$ in.) tall, each holding 1.8 kg. (4 lb.) in wooden crates holding 6 tins, and delivered to the service departments (Anon. 1944). A larger repeat order was received for 1945, but only about 50 metric tons could be produced in the pilot plant.

In tests of the dehydrated products in various parts of the British Commonwealth (such as Hong-Kong, Sarawak, West Africa, *etc.*), a favourable reception was given to dehydrated minced whole herring including guts, which required precooking at 0.43 kg per cm^2 (6 lbs. per sq. in.) for one hour in order to soften the bones. This product would obviously be more economical to make than dehydrated fillets.

From discussions:

Reay, United Kingdom, related that the dehydrated products prepared at the Torry Research Station, both the one prepared from whole herring and the one prepared from filleted herrings were test-marketed in Africa. It seemed that in general, the population there rather preferred the more highly-flavored product made from whole herring, which has a slightly more meaty taste, to the other product. However, it was a difficult problem to judge the reaction of the native population in some territories if a marketing study was not carefully carried out. The natives have a tendency to give whatever answer they think will please the person asking. Also, they seem inclined to eat anything if they get it free. The dehydrated herring product test-marketed in West Africa was actually sold from a shop at a price of 6 d. ($ 0.07) for a "Goldflake" cigarette tin canful. It appeared that a "Goldflake" cigarette tin can was the normal measure for volume in that particular area. The products were sold very rapidly and the supplies exhausted quickly. One

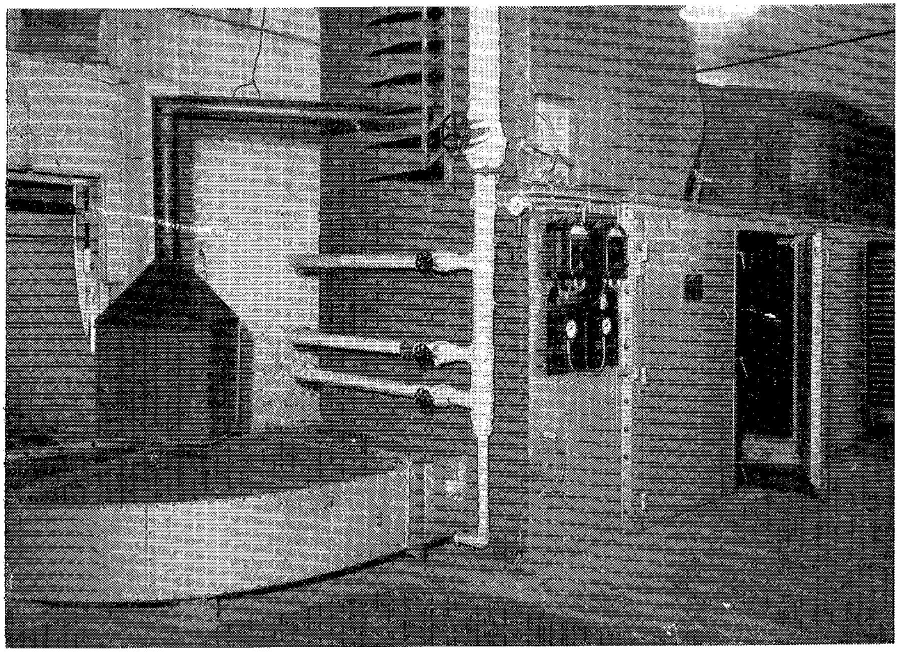

Fig. 10. *Dryer for herring dehydration. The air intake and exhaust ducts are visible. The smoke generator is seen in front of the aggregate. (U.K. Ministry of Food, Crown Copyright).*

had to keep in mind, however, that this was in Sierra Leone during the war where, due to war-shipping *etc.*, salaries and wages undoubtedly were somewhat higher than normal. The product was generally eaten just as it came, without preparation of any kind. The product had also been tested in Borneo and the reception had been quite favorable. (For further information see Hickling's statements pp. 128—31).

Cost Considerations

From *Cutting's* paper:

The costs of production are determined principally by the cost of the raw material. The average ratio of weights of input to output for herring fillets was about 6:1 and for whole herring about 3.5:1.

In the United Kingdom herrings cost between $ 0.068 per kg. (at $ 2.80 to the £ 1) (2¾ d. per lb.) for freshing and $ 0.023 per kg. ($1^{1}/_{16}$ d. per lb.) for fish meal and oil. The actual processing costs for dehydrating herring on the pilot scale amounted to about $ 0.256 per kg. (11 d. per lb.) of product, of which about $ 0.064 (2½ d.) was for

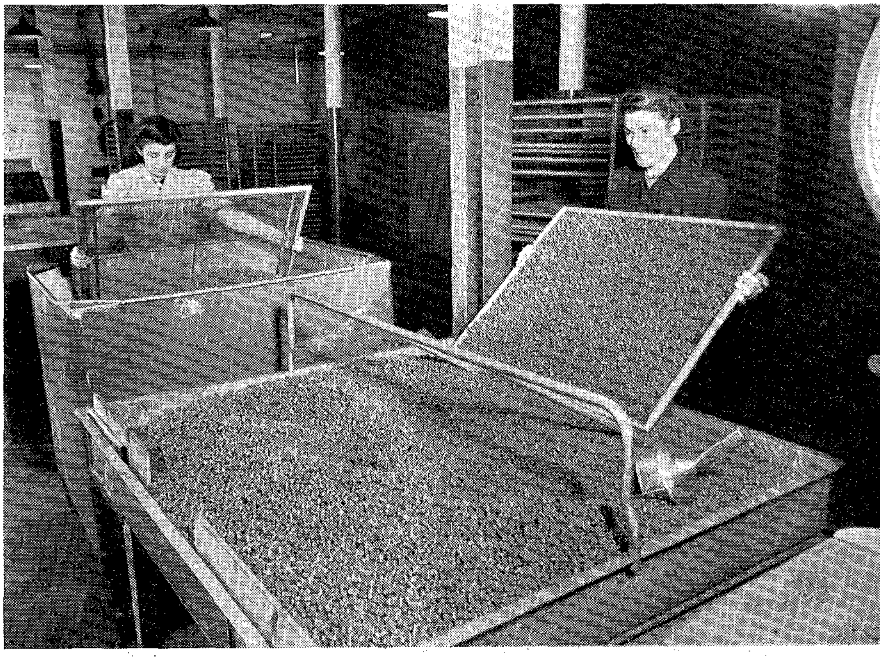

Fig. 11. *Dehydrated minced herring material being unloaded into storage bins. (U.K. Ministry of Food, Crown Copyright).*

labour and $ 0.077 (3 d.) for tins and crates, while steam power and water amounted so $ 0.013 (½ d.) and depreciation $ 0.026 (1 d.). Dehydration of whole herring would involve certain economies in processing, but not in packaging, unless some cheaper method than cans and crates could be devised. All in all the cost of dehydrating whole fish might be $ 0.31 per kg. (1 s. per lb.).

Samples of dehydrated herring sent to West Africa were reported to be capable of fetching between $ 0.31 and 0.42 per kg. (1 s. and 1 s. 4 d. per lb.) so that the process is on the verge of possibility. Cheaper herrings, more mechanised processing and cheaper packing with compression might just make the process pay.

It might be considered that some much less elaborate method of processing might be more sensible than dehydration as described above. In fact, it has in the past sometimes been suggested that ordinary fish meal or herring meal, in sacks at about $ 0.066 per kg. (2½ d. per lb.) (say $ 70 [£ 25] per metric ton), which is pratically speaking a by-product of oil manufacture, or some similar product, might well be just as acceptable and good enough in protein-deficient areas. Whilst

Fig. 12. *The dehydrated herring material is packed under pressure into the cans. (U.K. Ministry of Food, Crown Copyright).*

this may be so, the fuel, power and water costs of the present dehydration process are relatively a small proportion of the total cost, so that a thermally more efficient process would not result in a great advantage. Secondly, the major processing cost is that of tins and crates. Presumably even a lower-grade product such as fish meal would require the same measure of protection against oxidation of fat, insect attack, *etc.,* whilst a cheaper pack, if successful, could be used equally well for dehydrated fish.

The labour costs of \$ 0.064 per kg. (2½ d. per lb.), which might well be reduced in large-scale production are really the only component

Fig. 13. *Apparatus in which cans with dehydrated herring are gas-packed. The closed cans are pierced and introduced into a vacuum chamber where the air is removed. Nitrogen is then let in at a slightly positive pressure, and the cans are closed by soldering immediately after their removal from the chamber.* (*U.K. Ministry of Food, Crown Copyright*).

that might be reduced. But even if the labour costs of a fish-meal type of process were only \$ 0.013 per kg. (½ d. per lb.), the much higher quality of the dehydrated product might more than justify the \$ 0.053 per kg. (2 d. per lb.) difference in cost between say \$ 0.206 and \$ 0.256 per kg. (8 d. and 10 d. per lb.).

From discussions:

Reay, United Kingdom, mentioned that the cost of the product obtained by dehydration, as carried out in Aberdeen, is about the maximum price which one could expect native populations in economically underdeveloped areas to pay. He called attention to the fact that by far the largest cost factor in the production of cheap dehydrated herring products was that of the herring itself. If one, for instance, were to take ordinary fish meal, packaged in such a way that it could be retailed as food, one would probably arrive at a cost which could not be much reduced. He felt that the difference in cost between a product manufactured according to the more refined method and a crude ordinary fish meal would be about 2d. per lb. The conclusion was that under no circumstances could one produce anything which would cost much less than 10d. to a shilling per pound. In the production of dehydrated herring one could use a much higher degree of compression when packaging the product in the cans than in the method previously described. This might reduce the cost somewhat.

From *Cutting's* paper:

Another important point is that the dehydration process is all ready for large-scale development.

The pilot-scale stage of the World War II product has been passed. Much useful data and experience was obtained, and specifications for process and product have been worked out. It should not, therefore, be difficult to get into full-scale production quickly. Supplies of raw material should certainly present little difficulty, since the bulk of the world herring catch at present goes for fish meal and oil, and only a small diversion would be sufficient to establish an industry.

From discussions:

Hanson, United Kingdom, called attention to the fact that there was one method of dehydrating fish without cooking and mincing it. This was the vacuum-drying method developed by the "Atlas Company", Copenhagen, Denmark. This method was at the moment being tried out in the United Kingdom by the Ministry of Food. It was being tried on "white" fish but would of course later be tested on herring.

Sigurdsson, Iceland, mentioned that the products he had seen produced according to the Danish vacuum-drying method, the so-called "press fish", had actually been subjected to such a high temperature that they showed definite signs of coagulation.

Hanson, United Kingdom, stated that the pilot plant for vacuum dehydration, which was being set up in Aberdeen, would be capable of producing a higher vacuum and, therefore, a lower drying temperature than that obtaining in the plant which had been in operation in Norway and to which Mr. Sigurdsson was probably referring.

Elliott, United States, referred to three papers on the dehydration of fish published in American periodicals during World War II (Hamm et al. 1944; Shockey et. al. 1944; Stansby 1944). The papers dealt with work carried out during the war in an effort to find a product which could be used in military rations. Quite satisfactory products were obtained by methods very similar to those described by Dr. Reay. The products were used experimentally for the preparation of chowders, fish cakes, *etc.*, after reconstitution. They kept well in nitrogen, but did not keep in air. The difficulties encountered were that production was not too successful from an economical point of view, and that there was a certain amount of flavor deterioration in storage. Lean products had a tendency to become toughened on storage.

Recommendations for Future Research

It was concluded that the main field of development of the trade in smoked and dried herring products lay in the development of products which would be acceptable to low-income population groups and that the action most needed, therefore, was the one recommended in chapter 4. Other topics for research as regards smoked products were:

1. The development of consumer packs.
2. The extended use of refrigerated transport.
3. Means of prevention of mold growth.

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Chapter 12

HERRING CANNING

This chapter includes:

HERRING CANNING[1], a paper presented by *J. G. Huntley,* Research Division, The Metal Box Company Limited, London, England;

Part of DRY SALTING AND CANNING OF HERRING IN BRITISH COLUMBIA, a special contribution by *P. A. Sunderland,* British Columbia Packers Limited, Vancouver, B. C., Canada;

and information from the discussions at the meeting.

Development of Herring Canning

From *Huntley's* paper:

Fish was probably one of the earliest foodstuffs to be preserved in metal containers by heat sterilisation and mention has been made of the packing in tin cans of salt and kippered fish, which may well have been herring, in the year 1800. Herring canning was begun in England on a commercial scale about the middle of the nineteenth century, and it is recorded that canned sardines were prepared in France in 1834 and that small herrings were packed into cans in Maine on the east coast of America in 1877.

However, since those days other fish such as salmon, tunny and pilchards have proved also to be very suitable for canning and they now surpass the herring *(Clupea harengus)* in the volume of canned product packed annually. For example, the following figures have been given for the 1949 production (FAO 1950):

Canned salmon	151 866	metric tons
Canned tuna	101 084	—»—
Canned herring and allied species . .	261 879	—»—

Of the last figure in this table I would estimate that *Clupea harengus* probably does not account for more than about 90 000 tons.

[1] Published in Danish in "Konserves", Feb. 1951 (Huntley 1951).

It will be seen, therefore, how great is the quantity of canned fish manufactured in the world today; when one considers that this quantity is consumed by only a small portion of the world's population, it is obvious that the potential consumption of canned fish is enormous, if products appealing to the particular tastes of all the various peoples could be prepared and if all the economic limitations which restrict the consumption of the desired products could be overcome.

From *Sunderland's* paper:

When in 1903 the canning of herring began on an experimental scale in British Columbia, Canada, it was undertaken because one of the canners had a surplus of salmon cans left over from a poor season which it was thought might as well be put to some good use. There was no well-considered plan to develop a new market and canned herring has never been a popular dish in Canada. The pack during World War I was also very small as compared to the enormous pack produced during World War II. It was then that the British Columbia fishing industry undertook to make as much herring as possible available to United Kingdom. The war had reduced the supply of canned fish while the demand was increasing. Herring had always been a popular food in the British Isles so it was natural that they looked toward British Columbia for their supply of the canned product, especially since the fishing operations there could continue uninterrupted by enemy action.

The World War I peak-production year was 1919, when the pack amounted to 64 002 48-lb. cases. Between the wars the production was only small. But from a production figure of 23 356 cases in 1938 the pack increased to between 1.1 and 1.5 mill. cases in each of the years 1942 to 1947. In 1949 it was back again to 75 342 cases.

From *Huntley's* paper:

At the present time each country seems to have its own particular techniques, firmly rooted in tradition, for treatment of fish for canning, but there is no doubt that many modifications of and improvements to these methods are possible whereby new and better canned foods could be prepared.

Methods of Manufacture

From *Huntley's* paper:

This paper is only concerned with the technology of the preservation in cans by heat of products prepared from the herring *(Clupea harengus)*, found in the Northern Atlantic, the North Sea and adjacent waters. However, other clupeoid fish such as the pacific herring *(Clupea pallassii)* found between Japan and the Pacific Coast of North America and the true sardine *(Clupea pilchardus)* found off the west coast of France, the Iberian Peninsula and Morocco, the Californian pilchard *(Clupanodon coeruleus)* found off the Pacific Coast of the United States and Japan, and the sprat or brisling *(Clupèa sprattus)* found in the North Sea, are processed and canned by methods very similar to those used for *Clupea harengus* and the essential details of these methods will be mentioned in this paper.

If, therefore, we consider those products resulting from the preservation by heat treatment in metal containers of the Atlantic herring *(Clupea harengus)* they can be divided, I think, according to their methods of preparation into four distinct groups:

1. Large herring packed in brine or various sauces or kippered herrings as produced in the United Kingdom.
2. Small herring packed in oil or sauce as produced on the East Coast of the United States and sold under the name of "Maine" Sardines.
3. Small herring packed in oil or sauce as produced in Norway and sold as "sild".
4. Large herring packed in a variety of flavoured sauces as produced in Germany.

While this classification does not include all heat-processed canned herring products packed in every country, it does, I think, cover all the basic principles of pretreatment and methods of canning which are now used in various parts of the world.

United Kingdom Methods

From *Huntley's* paper:

The bulk of the large herring canned is packed in the United Kingdom where the annual production is of the order of some fifty million 14-oz. (397 g.) and 7-oz. (198 g.) cans. The greater part of the pack consists of fish with tomato sauce or with no added sauce or liquid and a smaller quantity of kippered herrings and herrings in mustard or spiced vinegar sauces. For all products except kippered herring the process is briefly as follows:

On landing the fish are placed in boxes, sometimes mixed with a little salt, and carried to the canneries. These are usually situated close to a fishing port and although at certain times fish are carried up to some hundred of miles, this practice is not generally considered a very desirable one. Fish may also be placed in cold store or frozen and held for varying periods before canning; means for extending the canning season of good-quality fish are extremely desirable and necessary and need further development. (See also page 209).

Some years ago the normal practice on receipt of the fish at the cannery was for them to be well mixed with dry salt and allowed to stand for 16—30 hours. This procedure has now, however, been superseded by treatment of the fish in saturated brine after beheading and eviscerating. In the British canneries eviscerating machines are now almost always used from which the fish are conveyed along an inspection belt where the few badly-cleaned fish which pass the machines are dealt with by hand. Next the fish are washed in machines of the rod-washer type in which they are tumbled together underneath powerful water sprays. The fish after being washed are placed into baskets or conveyed automatically into wooden tanks filled with saturated brine where they are left for a period of about half-an-hour. This process gives a final wash to the fish and imparts enough salt to give an adequate salt flavour to the finished pack. So far, in United Kingdom, no mechanical method of brining herring has been found satisfactory but there is no doubt that such an item of equipment would meet a great need. The fish are then removed from the brine tanks by hand scoops and placed into baskets in which they are allowed to drain for perhaps 15 minutes. They then pass to the filling tables. These usually consist of a central conveyor belt and two outer belts. On to the outer belts are fed empty cans which prior to reaching the belt are passed through a saucing machine which, if the pack requires it, places a measured amount of sauce into the can. The actual packing of the fish into the can is a hand operation done by teams of girls, some selecting and weighing out a suitable assortment of fish and others packing them into the cans and placing the filled cans onto the central belt of the packing table which conveys them to the closing equipment.

At the present time in the United Kingdom two methods of closing are in use, either clinching, exhausting and seaming or vacuum closing. The former is, however, generally preferred. Admittedly vacuum seamers show a great saving in space but they are more complicated to maintain and the models at present available do not run at the high speeds of which non-vacuum seamers are capable. There is also less consistency with regard to the final vacuum produced in the finished pack since it depends to a great extent on the manner of packing the fish and the amount of air trapped in them. Heat exhausting on the other hand gives a more uniform product and a somewhat higher final vacuum provided proper times and temperatures are used. Normally the cans pass through a clinching machine before going through the exhaust box which is steam heated. Times of about 15 minutes at a temperature of about 205° F. (96° C.) are usually employed and the exhausted cans then pass directly to the seamers. The filled cans are washed before being retorted. For the 14-oz. (397 g.) oval can a process of about 60 minutes at 240° F. (116° C.) is generally used as this gives a product of reasonable texture as well as providing an adequate lethal margin for the destruction of spoilage organisms. Pressure cooling in water is usually practiced.

In the production of canned kippers the fish are split, brined and smoked in the normal manner, placed in flat oval cans holding 1 lb. (0.45 kg) with a paper disc between each fish. No liquid is added and the cans are exhausted with a clinched cover for about 12—15 minutes at about 210° F. (99° C.). They are then closed and processed for 70 minutes at 240° F. (116° C.) and pressure cooled in water. Sometimes vacuum closing is used.

United States Methods

From *Huntley's* paper:

The small herring of the Atlantic coast of North America are treated somewhat differently. The fish which are caught when the smaller sizes predominate in the shoals are held in the water for sufficient time to free them of "feed" (Editor's note: "impounded") and are then transported to the cannery. Salt is usually sprinkled in with the fish as they are loaded into the boat, but if this is not done they are brined in tanks in saturated salt solution after they reach the cannery. Some packers behead and eviscerate the fish as soon as they are received but most packers ensure that the fish are free from feed and then behead them immediately before packing into the can. Whichever way the fish are handled the next step is for them to be placed in a thin layer on wire-mesh trays or "flakes" on which they are either steamed or fried. Steaming is the method of precooking most widely used, but it is admitted that the flavour and texture of the finished product could be improved and that the frying method gives a better quality. In the steaming process the flakes are placed on trolleys and are then steamed at atmospheric pressure for 10—20 minutes in large chambers. After steaming the trolleys are moved into a tunnel with a current of warm dry air flowing through it and are left there for the fish to cool and dry out on the surface. This takes about two hours.

If the fish are to be fried, the chief objection to which is the high cost of the oil, the flakes are conveyed through a bath of oil, heated to about 225° F. (107° C.). The frying time varies from 3—6 minutes. After frying the flakes are placed on trolleys and, as for the steamed fish, are dried in warm dry air. From time to time attempts have been made to mechanise these whole series of operations and combine them into a continuous process, but until recently little success has been achieved.

When the fish are cool they are filled into the cans by hand, the size mostly used being the ¼ Dingley; if the fish have not already been beheaded this is now done by the packing operator. Care must be taken to see that the fish are roughly sorted so as to use only fish of a uniform size in any one can. After filling, heated oil or sauce is added to the cans by passing them through a filling machine, and they are closed immediately without any exhaust or vacuum sealing.

The cans are processed in vertical retorts for about half-an-hour at 240° F. (116° C.); in some canneries they are conveyed from the seamer by belt and allowed to drop into the retort through a small opening in the top, the retort containing enough water to prevent damage to the cans. After processing the retort is emptied by opening a door in the bottom and allowing the cans to fall out onto another belt which conveys them through a washing and cleaning process.

Norwegian Methods

From *Huntley's* paper:

The process of canning small herring normally used in Norway is typical of another form of treatment applied in the production of canned herring. In this method the fish are starved so as to get rid of feed before they reach the cannery. On arrival they are descaled and washed in a strong brine solution either mechanically in a continuous operation or by a batch process and are then strung through the eyes on metal rods by which means the fish are supported on racks which are used to convey them through the smoking ovens. The ovens may be either of the continuous type, or hand-operated batch ovens. After the completion of the smoking process the fish are allowed to cool; the bodies are then removed from the rods on which they have been smoked by severing the head at the neck by a band knife. The packing of the fish into cans is entirely a manual operation and is usually carried out on expressly designed filling tables fitted with conveyor belts for carrying the empty and filled cans, and trays of prepared fish. During the filling operation the fish are trimmed and graded according to size and the most popular size of can is the ¼ Dingley, ¼ Club and ½ Oval. Oil or tomato sauce is normally added to the can prior to the packing of the fish. The cans are then closed without heat exhausting or vacuum seaming and processed.

German Methods

From *Huntley's* paper:

Certain rather specialised techniques are also employed in Germany in the preparation of a range of herrings in flavoured sauces. Large herrings are used and are eviscerated and filleted by machine. The fillets are then brined usually in wooden tubs or brick tanks for about 10 minutes in a 10 per cent salt solution. On removal from the brine which is, of course, a hand operation, the fish is cooked in either steam or water. This cooking is usually done mechanically by placing the fillets on wire-mesh trays which are then conveyed through a tank of hot water, or alternatively, the trays are placed onto trolleys which can be wheeled into large chests where cooking in steam takes place. An additional treatment sometimes used is to dry the cooked fillets in hot air to which smoke can be added if desired. Mechanical equipment is available for carrying out this operation continuously. After these treatments the fillets are packed in cans by hand and oil or sauce added. They are then closed without exhaust or vacuum seaming and processed.

British Columbia Methods

From *Sunderland's* paper:

Prior to World War II most of the herring canned in British Columbia, Canada, was packed in 1-lb. (0.45 kg.) tall cans, and salmon canning equipment was generally used with the exception that heading machines and continuous scaler-washers were used. The "round" fish was allowed to remain in salt for 12 to 15 hours, using from 150 to 200 lb.(68 to 91 kg.) of salt per ton of fish. This salting of the fish was used for two reasons. (1) It tended to produce a firmer texture and tougher skin in the fish and (2) it was the means of obtaining salt taste for flavour.

After remaining in salt overnight, the fish was either headed by hand or by machines, leaving the roes and the milts in the fish. It then passed through a scaler-washer and was packed into one-pound tall cans which were conveyed through an exhaust box for about 12 minutes or longer, top end up, and closed on four-spindle closing machines after the addition of about 2 oz. (57 g.) of hot tomato purée. Some of the plants used the regular cannery retorts for the pre-cooking or exhaust instead of exhaust boxes, the time and temperature varying somewhat in the different plants. The pack was then cooked for 70 to 75 minutes at 240° F. (116° C.).

During World War II special canning lines were installed to handle the 1-lb. oval cans, and the plants were engineered to obtain a maximum production. Most of the pack during that period was packed in an oval container with tomato sauce or in natural oil. The pack was produced mainly from fish caught in the Gulf of Georgia in close proximity to the plants engaged in the canning operations. The larger plants had mechanical unloaders for the fish, which was landed from boats or scows. The fish was always transported in bulk and no ice was used for preservation. Some of the smaller plants did not have mechanical unloading equipment, as their capacities did not warrant the cost of installation. Where "marine legs", *i.e.*, continuous unloading equipment was used, the equipment could unload up to 50 tons per hour. The fish was weighed automatically through a continuous weighing machine. In some of the plants the fish then passed through a continuous rotary grader which selected the largest fish for smoking as kippered herring.

Quality control of the pack began as soon as the vessel landed at the plant and before unloading commenced. The fish in every load was carefully examined to insure that it was of good quality for canning and, above all, to make certain that it contained no "red feed" or "belly burn", which would ruin the pack. "Belly burn" is induced by the presence of large quantities of a shrimp-like organism *(Euphasia pacifica)* which is one of the main food items of the herring, particularly during the summer months. Usually, however, the fish do not feed during the fall run. When on rare occasions this trouble did occur, it was the duty of the sampler to detect it and make certain that the fish was not canned, since the rapid spoilage, usually within a few hours, made the fish entirely unfit for canning. Such fish had to be diverted to the reduction plants for oil and meal; during the war, permission for this had to be obtained from the Department of Fisheries, as regulations required that all of the fish from certain areas had to be canned.

While the storage bins, which had a capacity of from 10 to 20 tons of fish, were being filled, salt was mixed with the fish as it spilled from the conveyor or by having another conveyor spill the salt continuously over the fish before or while it entered the bin. The latter method resulted in the most uniform salting. The amount of salt ranged from about 160 to 225 lb. (73 to 102 kg.) per ton of fish and the fish was left in the bins for 15 hours or more.

In some plants the herring was flumed to rubber belts which carried it to the heading machines. Two girls operated each machine, feeding the fish belly down in a series of wooden buckets fastened onto a conveyor chain. In the case of the oval pack the head was cut off the fish by a circular knife, just back of the ventral fins, as the fish advanced. A stationary scraper bar pulled off the head with the gut attached to it, leaving the milts and the roes in the fish. For the 1-lb. tall pack the machines were equipped with two knives which cut a piece off the tail as well. The length of the cut was 4 in. (10 cm.). Two girls feeding one machine headed from 900 to 1 100 lb. (410 to 500 kg.) per girl per hour. After inspection of the cut fish at these machines the fish was flumed to the rotary scaler-washers and then conveyed to the filling tables, while the waste continued on to the reduction plant. The filled cans were placed on a belt conveyor after inspection and carried to the end of the filling table where they entered a disappearing frame, about 50 cans at a time. When this frame was filled with cans an inverted wire-bottom tray was placed over them, and the disappearing frame was lowered. The tray with the cans underneath was then pushed into a tray-inverter. The trays were turned over upside down so that the fish in the cans rested on the wire screen. The trays were stacked 4 or 5 high and carried on chain conveyors through an exhaust box.

The time of exhaust varied from 15 to 30 minutes and the temperature was usually maintained at 212° F. (100° C.) where exhaust boxes were used. Where ordinary retorts were used higher temperatures were sometimes used. Some of the exhaust boxes were equipped with automatic temperature controllers and recorders, insuring uniform cooking and good vacuum, since vacuum-closing machines were not used. The pre-cooking removed from 12 to 16 per cent oil and water, mostly water. The oil and water flowed to settling tanks where the oil was recovered.

From the exhaust boxes the trays passed into a tray-inverter again and were returned gently to an upright position. Then the trays were removed and chain conveyors carried the cans to the closing machines. Along the conveyors inspectors checked the filling weights and the quality control department removed samples at frequent intervals for acid value test of the oil, to insure that the quality of the entire pack was as high as possible. Here, too, the temperature of the product before closing was checked regularly since it governed the vacuum in the final product.

Before the cans entered the closing machines 2 oz. (57 g.) of hot tomato sauce were added, either as straight tomato purée or as tomato paste diluted slightly with salt brine, the strength of the brine depending on how long the fish had been salted. In some of the plants tomato paste and purée were mixed, for instance, one part of paste to two parts of purée.

When the temperature of the exhaust box was carefully controlled, and the temperature of the sauce was kept above 195° F. (91° C.), it was not difficult to maintain an average vacuum of 4 in. (0.13 atm.) or more. Overfilling had also to be guarded against, as it would naturally reduce the headspace in the container and would cause bulged ends and buckling when lowering the pressure in the retorts. In the case of the 1-lb. tall pack vacuum machines were used by all of the canners during World War II, and the tomato sauce was often added to the cans before filling. Salmon filling machines were also used to some extent, but resulted in a slice being removed from one or several fish by the cutting knife. It was also difficult to avoid cross-packing. When packing herring in natural oil, *i.e.,* without addition of oil or tomato sauce, some of the plants added brine where the pre-cooking was rather prolonged. In other plants, where the pre-cooking was brief, it was not considered necessary to add brine. The cooking times varied for both 1-lb. talls and 1-lb. ovals from 60 to 80 minutes at 240° F. (116° C.) followed by air cooling. Lower cooking temperatures have been successfully used in overcoming difficulties with buckling of the ends during the cooling of 1-lb. oval cans.

New Developments

From *Huntley's* paper:

Naturally enough all these processes which have just been described have various disadvantages and difficulties as well as points in their favour, and fish-canning technologists throughtout the world have constantly been trying to improve them. Recently, their endeavours have been directed mainly along three lines:

1. To effect an improvement in the quality of the finished product by modifications of canning techniques while maintaining its essential characteristics.
2. To reduce the cost of the pack by variations in the manufacturing processes and by increasing the degree of mechanisation.
3. To develop entirely new and different packs.

It would be convenient, therefore, to discuss each of the canning operations in the light of the methods used in the various existing commercial canning techniques and to point out what is being done to try and improve them and if I may venture to do so, make some suggestions for discussion as to possible future profitable lines of approach to some of the problems.

Handling the Raw Material

From *Huntley's* paper:

Before speaking of the developments which are going on in connection with the canning itself and of the problems which still remain to be solved, there is one rather obvious comment that must be made. It is, that no matter what improvements are effected in methods of handling the fish and in the treatments and processing to which they are subjected, the ultimate quality of the canned product will depend to a great extent on the quality of the raw material used in its preparation. Unless, therefore, the fish are entirely satisfactory when caught and are so treated that they reach the cannery in good condition it is not likely that the herring canning industry will be able to increase and expand its markets. Improvements in manufacturing technique and the development of new recipes never enabled inferior raw materials to be turned into good finished products.

From discussions:

Le Gall, France, stressed the importance of the control of the raw material when received at the cannery. He understood that several countries had such control and that in others private canners maintained close inspection, but he suggested that control methods should be standardised and uniformly adopted, possibly even on an international scale.

Copeman, United Kingdom, said that owing to the very soft and oily nature of North Sea herring, considerable attention had to be given to the handling of this fish at sea, as the condition of the fish when arriving at the cannery was one of the most important quality factors.

Haraldsvik, Norway, mentioned that in Norway there is official control of the size of sprats and small herrings to be used for canning. Both must be above a certain minimum. The sprats must, in addition, have a fat content above a certain minimum. All sprats and herrings used for canning shall be completely free from feed. The fish has, therefore, to be impounded, *i.e.,* kept in the net for some time after capture.

Aglen, United Kingdom, described how the Herring Industry Board, Scotland, had the rule that where a boat stayed out for two nights or more at a time, the herrings may only be used for certain purposes if they are landed later than 24 hours after capture unless they have been properly iced aboard. Normally, it may only be used for oil and meal manufacture. However, it was rather seldom that the boats stay out for two nights; icing is therefore not carried out to any appreciable extent. The feeling is that such icing aboard introduces several problems with regard to the layout and construction of the boat and the handling of the fish at sea, *etc.*

From *Heen and Karlsen's* paper "Freezing of Herring" (pp. 190—216).

In Norway effective icing of sprat just after catch, and during transport to the factory had been tried experimentally. This method has been compared with the usual practice of simply placing a scoop of ice on top of the boxes. The difference was striking. Testing of the canned goods showed a marked improvement both in appearance, taste and flavor. By effective chilling it was possible to cold-store the sprat for about 5—6 days or about 2 days more than by usual icing, before the quality of the canned product was noticeably reduced.

From discussions:

Sigurdsson, Iceland, had done some work on the storage of small herring for brief periods, *i.e.,* a few days prior to canning. He had done the work in connection with the Maine sardine industry in the United States, and similar work had been carried out with the California pilchard industry. He had found that small herrings with about 12 per cent fat after storage in refrigerated brine for several days gave a quite satisfactory canned product. Certain factors had to be considered very carefully, such as the temperature of the brine and its salt concentration. The experiments had also shown that it made a tremendous difference whether the brine was kept at a temperature of about + 1° C. (34° F.) or say —2 or —3 C. (28½ or 26½° F.). He felt that this method of storage would be an excellent way of taking care of the gluts of raw material which sometimes occurs. One place where this method might be used was for the storage of the herring aboard the boats, as well as for storage in tanks at the factory after landing.

Davis, United States: The possible extension of the storage time for pilchard prior to canning was of primary importance in California, United States, because in California the atmospheric temperature was around 75 to 85° F. (24 to 29° C.) and the temperature of the fish when delivered to the cannery might be as high as 60° F. (16° C.). Chlorination of seawater for this purpose had been used quite extensively in the sardine plants, at Terminal Island in California. It was used mainly because the seawater, which the plant had access to, was badly polluted.

Chlorinated water was for instance used for fluming the fish through the plant. It was found that fish flumed in chlorinated seawater would keep two to three hours longer than other fish. He mentioned that the chlorination was a comparatively simple operation. The prolongation of the keeping time of the pilchard by the use of chlorinated water was not due to any active chlorine in the water, because this is prohibited in the health laws of California. The water is dechlorinated with sulphur dioxide before it comes into contact with the fish.

Le Gall, France, mentioned that he had heard that in one instance large amounts of sardines had been transported successfully over longer distances to a Californian sardine cannery. The sardines were transported in trucks, preserved in a mixture of ice and salt.

Crowther, United States: The incident Dr. Le Gall referred to was a case where pilchards had been transported some 250 miles (some 400 km.). The fish were packed in large watertight trucks; salt and ice was added to the fish. The temperature in the fish was close to the freezing point when the fish arrived at the plant.

The fish appeared to be in fair condition when received at the plant and were inspected and passed by local authorities. The product which resulted from canning these fish could be classed as only fair in quality, especially after several months in storage. However, there is no record of the condition of the fish when loaded into the trucks at the beginning of the 250-mile trip. It is possible that prime fresh fish, properly handled, may be successfully transported by this means.

Huntley, United Kingdom, said that it was a not uncommon practice in his country to transport herrings from the ports to the canneries over distances of upto 200 to 300 miles (320 to 480 km.). They were generally preserved in ice or in ice and salt. He believed that the same procedure was used in French Morocco.

Davis, United States: Experiments were going on in his country which seemed to indicate that if one stored in inert gases, one could use storage at considerably higher temperatures than normally used. He felt that this might well be cheaper than the icing of fish, considering the labor, *etc.,* involved in icing.

Copeman, United Kingdom, suggested that technologists work on possibilities of salt-curing herring for storage purposes in such a way that it later could be reconstituted and used for canning. This would allow continuity of operations and might make production cost considerably lower.

Freezing of Herring Prior to Canning

This subject was discussed quite extensively, see pp. 209—13.

Eviscerating

Mr. Huntley stated in his paper that with the large herrings packed in the United Kingdom eviscerating is now normally done by machine. However, for small fish, no satisfactory eviscerating machine has yet been constructed. While better machines are being developed, improvements could be effected in the organization of hand operations and better design of other equipment for handling fish and offal.

Information on discussions of eviscerating and boning machines will be found in a special chapter, pp. 186—89.

Brining

From *Huntley's* paper:

This operation sometimes is done before eviscerating, sometimes after, but whenever it is done it offers great scope for improved methods of handling the fish. The old method of mixing the whole fish with dry salt for a period of some hours has now been largely abandoned in favour of immersion of the fish in strong brine, but at the present time nearly all canned herring are, I think, brined by batch methods in which the fish are placed in tanks or tubs made of wood, concrete, slate or other material and allowed to stay there for periods of about half-an-hour. They are then removed from the brine by hand, and placed in baskets or boxes to drain before going to the packing tables.

Mechanised continuous briners have been used, but in England, at least, they have now been abandoned. They operated on the principle of a conveyor carrying baskets full of fish through a through of brine; the main objection to them was that because a mass of fish was held tightly together uneven absorbtion of salt resulted. It should not be impossible, however, to design a machine in which the fish are not packed together but are conveyed through the brine either by a screw type of mechanism similar to that used in vegetable blanchers or by a slatted belt. In fact, the blancher type of machine has been used satisfactorily for some fish. Since the volume of fish to be handled is large and the immersion time is of the order of half-an-hour such equipment would necessarily be bulky but it would certainly effect considerable savings and give a more uniform product than do the present hand methods.

A further suggestion which might prove to be of value would be the elimination of the brining process altogether and its replacement by the addition of salt directly to the sauce or to the fish itself. Certainly this would be a less costly method and probably a more accurate one than that of soaking the fish in brine. The value of this method does, however, depend to some extent on the pretreatment of the fish and needs careful investigation to determine the best means of application.

From discussions:

Sarraz Bournet, France, felt that there was no difference between the brining in brine or salting in vats with dry salt. It would be very valuable if a continuous process could be worked out for the salting operation, may be some form of conveyor-belt arrangement, as suggested by Mr. Huntley, allowing the fish to stay in the brine for approximately 15 to 20 minutes.

Copeman, United Kingdom, also felt that brining or use of dry salt could be alternated in most cases, but that some fish in certain stages of maturity seemed to give the best results in brine. The British manufacturers were very interested in developing a continuous brining process.

Addition of Hardening Chemicals During Brining

From *Huntley's* paper:

In addition to getting salt into the fish the brining operation has also sometimes been used as the means of trying to harden the flesh and the skin of the fish by the addition of other substances to the brine. The main efforts have been made in connection with the packing of raw fish since it is in such packs that disintegration of the skin is most noticeable, but so far there is little evidence to show that any beneficial result is obtained. Such chemicals as calcium salts, alum, tannins, acetic acid and starches have been tried experimentally by private firms, but the results have not been too promising. There is undoubtedly scope here for more work.

From discussions:

Copeman, United Kingdom, felt that any steps which could be taken improve the firmness of the canned North Sea herring to avoid ushiness, especially as it developed during transport were very im- This and other problems were being investigated by an experi- nnery at Port Glasgow, operated by the Herring Industry o-operation with the United Kingdom fish canners. He felt ess like the one used for pilchard in the United States might e tried out for the North Sea herring.

Washing

From Hughes' paper:

s done either before or after brining. In most coun- t mechanically by passing the fish through a r water sprays.

g process that the possibilities for chanical ones, occur. They largely for removing water from the fish ances which after processing ge to the pack.

t in the raw state as are sirable pretreatments may water or "court bouillon", ese methods are all being used commercially either on herring or other fish in various countries and the mechanical details of existing equipment could be applied to the handling of large herring. Another method of pretreatment which has tory scale, is the by infrared f course, dy been ack that o layers on wire-mesh trays or baskets; known as "flakes" in the United States or "grilles" in France. This has meant in many cases handling each fish individually in order to place it in the basket; it is suggested that the principle employed in the canning of pilchards on the Pacific Coast of the United States might with advantage be adopted in European herring canneries. This is to pack the fish into the cans raw after eviscerating and brining and then to heat the can and contents by one means or another sufficiently to cause the bulk of the free liquid to separate from the fish, and then to drain off this liquid, add a suitable oil or sauce and close the can. During the last few years improved plant of this nature has been developed in Europe originally for use in the sardine industry of France and Morocco but now being tested in other countries. This equipment takes the can filled with raw eviscerated fish, adds brine, gives a preliminary cooking of 8—10 minutes in steam and drains off the resultant liquor. The cans are then conveyed through a hot-air oven at about 320° F. (160° C.) and again the can is drained. Oil or sauce is then added and the can exhausted and delivered to the closing machine. All these operations are performed mechanically and continuously on the one machine and its use is increasing steadily in the sardine canning industry (Cheftel 1950). Experiments have also been carried out to adapt it for use with large herrings, but so far no commercial production of this fish has taken place by this method.

Some way of removing water from the fish is of particular importance if improvement is to be sought in the sauces which are added to the canned product, for if any great quantity of liquor is going to separate from the fish after it has been closed in the can with the sauce, then a pack with a poor appearance on outturn is likely to result and in any event the types of sauce which can be used are limited.

It should perhaps be pointed out that the method of packing the fish into the can raw, adding sauce and closing, gives probably a product of minimum cost and that the adoption of any of the above methods of pretreatment since they involve a loss of water will, everything else being equal, increase the cost of the pack. However, if the improvement results in an increased demand this difference might be more than equalled by decreasing costs through improved methods of handling and in other directions.

From discussions:

Huntley, United Kingdom, related that in the sardine industries of Morocco and France some 30 machines of the above-mentioned kind are now in operation.

Le Gall, France, mentioned that there were several different ways of cooking fish. He felt that this problem should be studied further. In Spain and Portugal the sardines were cooked in brine while the California pilchard was cooked in dry air after it was packed in the can. Further experiments with drying by infrared rays were also needed. So far unsatisfactory results were obtained with drying due to the separation of water in the final product.

A communication from *Carter and Bailey* mentioned that the time required to preheat filled cans prior to closing in order to secure a vacuum, can be greatly reduced by using a bank of infra-red lamps as a heat source (Roach, Harrison 1949).

Huntley, United Kingdom, had no direct experience with the use of infrared drying of fish packed in cans but he felt that it was likely that the process would be uneconomical and inefficient as the infrared rays would mainly act on the exposed surface of the fish.

Sarraz Bournet, France, said that in France the fish was dried after brining. This was considered one of the most important phases of the manufacture. It was known that British and American manufacturers had adopted the process of packing the fish in the cans before drying, but experience in France had shown that the quality of the product definitely was better if the fish is dried before packing. For instance, otherwise the skin gets loose and separates from the flesh, resulting in an unsatisfactory appearance. In France the fish was placed on wire-mesh trays and dried in hot air. Herring is generally canned without cooking except for some factories in Belgium. After the herring was packed in cans, it was placed on conveyors which passed by a saucedispenser. The cans were then exhausted and then closed. They were processed and cooled in an automatic cooler under circulating water under counter pressure. Sardines were sometimes, even in France, placed directly in the cans before drying, but Mr. Sarraz Bournet felt that that always gave cause to some water separation.

Copeman, United Kingdom, also felt that an important problem was to find ways of eliminating surplus moisture and oil in the cans.

Crowther, United States, described some of his own experiments with electrostatic smoking intended for use in the Maine sardine industry. The fish was placed in small flat cans and exposed to electrostatic smoking. As expected the smoked flavour was deposited on the top layer only. However, the flavor would penetrate to the lower layers during processing and storage. The results of these tests were not entirely satisfactory. A smoked flavor was obtained but the color deposited on the fish was not very attractive. This principle of smoking fish is not in commercial use in the United States at the present time, but it may have definite possibilities for certain types of smoking.

Borgström, Sweden, felt that electrostatic smoking should, when properly adapted, be able to give a fairly even distribution of the smoke flavor.

Crowther, United States, said that the method of handling the fish in the experiment with the electrostatic smoker is somewhat different from that used in the normal canning operations. In Maine, for example, the fish are generally placed on trays or racks for smoking. In this particular experiment the object was to design a method for smoking the fish after it was packed in the can. One disadvantage of the electrostatic-smoking process, as used in this experiment, was that the film of smoke which was deposited on the surface of the fish was black, resembling soot. This condition may have been due to a basic fault in the smoke-generating system.

A communication from *Carter and Bailey* mentioned directions for smoking herring prior to canning were given by Sidaway (1942); the product thus prepared had a much better appearance than the usual raw pack.

From *Huntley's* paper:

At the present time the majority of herring canned in the world are either packed in oil or tomato purée; there exists, I am sure, considerable scope for ingenuity in the development for new and attractive-looking sauces. A range of herrings in various sauces is packed in Germany, and many of these are extremely palatable and appetising.

The sauces used are of many types and flavours such as mustard, mushroom, shrimp, tomato, wine, beer, mayonnaise and cream. Basically they consist of milk, flour, oil, vinegar and water with some stabilizer and flavouring ingredients.

Development on these lines offer also means whereby the canned herring could perhaps be made to appeal to markets in those parts of the world where it has not hitherto found acceptance. Here a close study should be made of local preference for flavours. Tests should also be carried out to find the best ratio of sauce to fish in the can and also the total net weight which gives the best appearance and the greatest resistance to damage during transport to the consumer. Whether the sauce should be added to the can before or after the fish is another small point which needs testing but it is, of course, bound up with method of treatment of the can after filling. The composition of sauces in relation to their physical properties also needs further study, the degree of dispersion of the solids and the stability of the emulsions produced by homogenising being of particular importance.

Exhausting and Vacuum Closing

From *Huntley's* paper:

The technique of closure used for heat-processed canned herring products varies widely throughout the world. Some packers close the cans immediately after adding either cold or warm sauce or oil, as for instance many brisling canners. Some pass the cans through a steam-heated exhaust box for varying periods either with or without the cover loosely clinched onto the can, *e.g.*, the large herring as canned in the United Kingdom; again, others close the cans on a vacuum-sealing machine usually with the contents filled cold. There exist considerable differences of opinion as to the advantages and disadvantages of the various methods, but in actual practice, when fish are packed raw and get no subsequent heat treatment before closing it is the majority view that vacuum sealing does not give a very satisfactory product. The final vacuum in the can is likely to be variable due to the different amounts of air that may be trapped in the fish during packing and the result may be a slack-filled pack. For this type of product, therefore, particularly when packed in large cans, it is usual to exhaust the can in steam before closing. In order to get a higher final vacuum and to prevent contamination of the product by condensed steam the lid is generally first clinched loosely on the can.

Where, however, the product has had some form of pretreatment, which enables trapped air to be avoided during packing, then vacuum closing can be used. With small-size cans this is probably adequate, to give a commercially satisfactory pack, even if the product is closed on a non-vacuum seamer.

This question of the final vacuum in the can is of importance particularly in relation to cans for export to tropical countries since, if the vacuum is low, it is probable that under warm storage conditions and particularly if the barometric pressure is low as well, the ends of the can may bulge and give rise to suspicions of bacterial spoilage. In addition, of course, the presence of air in the can will lead to internal corrosion of the containers.

From discussions:

Copeman, United Kingdom: Mr. Sunderland's paper mentioned that one factory in Canada tried to obtain a vacuum in the can of at least 4 inches (0.13 atm.). In United Kingdom one aimed at a vacuum of at least 8 inches (0.27 atm.).

Processing Times and Temperatures

From *Huntley's* paper:

It is generally agreed that the heat treatment given to canned herring should be kept as low as possible consistent with the prevention of spoilage. This treatment, of course, will vary with the type of product and size of can and should be determined by heat-penetration measurements and heat-resistance studies. In the United Kingdom the effect of short times at high temperatures has been compared with that of longer times at lower temperatures and at least from experience with the British pack of large herrings in tomato there appears to be little difference in the flavour and appearance produced by the two methods.

Canned Herring as an Export Article

From *Huntley's* paper:

As regards the acceptance of canned herring in export markets I can really only speak in relation to the pack of British-canned herring sold either in tomato sauce or as "fresh". Of this pack some 6 700 metric tons were exported in 1949; the bulk to Australia and New Zealand. Other countries taking smaller quantities were the United States, West Indies, Fiji and Malaya, but very little trade was done with any European country, largely due to economic limitations of one sort and another (U. K. Min. Agr. & Fish. 1949). Experience in these overseas markets has shown that in many cases the herring is preferred to other packs of allied fish but that it is essential that it should reach its destination having a good texture and appearance and that the fish in the can should remain whole. It is to attain this end and to make the fish more resistant to the mechanical hazards of transport that much of the experimental work described above has been done. It is recognised that there is a considerable variation in the texture and firmness of the different species of herring landed at the various ports in Great Britain, and the oil and water content and the state of maturity of the fish is taken into consideration when determining firmness of fish suitable for export packs.

Early landings of herring at the Scottish Moray Firth ports during the summer fishing are usually small and, before roe formation commences, have an oil content of up to 25 per cent. These fish are usually very soft and unsuitable for the transport conditions that are likely to be experienced when shipping to many export markets. It has been found that the most suitable fish for export are those which have matured to the state of filling or are full of roe. Even so, it has not been found practicable to ship them until some considerable time after canning, which time depends on the type and actual condition of the fish used. Experience has shown that the "firming-up" period in the can takes anything from 2 to 6 months; if shipped earlier the appearance of the contents is likely to be adversely affected, some of the fish being broken and, in some instances, the whole contents of the can turned to mush. It has even been found that labelling and cartoning will adversely affect the condition of the fish. When it is considered that the fish are sufficiently firm, a range of samples — taken at random from each day's production — should be put through an agitation test to determine the suitability of the fish in respect of firmness for labelling and despatching. Similar precautions are necessary with fish landed at North Shields, Clyde, and some other ports. The herring landed from the autumn fishing in East Anglia are usually much firmer, and generally are suitable for shipment in a shorter period after canning.

Canned kippered herring is not subjected to this long storage as during the process of kippering the moisture content is reduced and the fish are sufficiently firm after canning to be shipped after a normal incubation period.

Another important factor in relation to the suitability of canned herring for export is the degree of vacuum in the can which it is considered should be at least 8 in. (0.27 atm.) before shipment.

Quality Control of Canned Product

From *Sunderland's* paper:

During World War II all of the canned-herring pack in British Columbia, Canada, was inspected by the Canned Fish Inspection Laboratory and the pack was graded according to the acid value of the oil, as follows:

Average acid value of oil	Grade	Size of sample examined
Les than 2.25	A	6
2.25 to 2.75	B	12
Greater than 2.75	condemned	12

This test was extremely useful to the canners as it meant that there was no excuse for packing anything but Grade A herring. The Laboratory also introduced the carbon-dioxide test which was carried out on the raw ground tissue. The latter test in particular demonstrated clearly how rapidly the herring deteriorated on storage.

The Dominion of Canada Specifications for the Packing and Inspection of Canned Herring also included specifications for the tomato sauce, net weight, vacuum and firmness. A pack showing a greater percentage than 25 per cent mushy or pulpy cans were graded B.

The following is an analysis of canned British Columbia herring, caught in the Gulf of Georgia about the middle of November and canned in tomato sauce:

	One-pound tall herring	One-pound oval herring
Moisture	64.9 %	64.4 %
Crude fat (oil)	15.9 %	13.0 %
Crude protein (Nx6.25)	16.6 %	18.6 %
Crude fibre	0.1 %	0.1 %
Ash	2.9 %	4.6 %
Calorific value	980 B.T.U. per lb. (544 Kcal. per kg).	895 B.T.U. per lb. (497 Kcal. per kg)

A communication from *Bolton*, Canada, called attention to work carried out by Charnley and Davies (1944) concerning estimation of the freshness of canned herring from determinations of the acid value of the oil.

Recommendations for Further Investigations

It appeared from the papers presented at the meeting and from the discussion that further technological research was particularly desirable in the following fields:

1. Improvements of the quality of the raw material for herring canning through chilling, freezing and better methods of handling.
2. The various methods of removing water from the fish and of obtaining a firmer texture of it, both through brining or dry salting, cooking, drying or smoking before or after the fish is placed in the can. A method for mechanization of the brining operation was desirable.
3. Development of new sauces which would appeal to new markets and a study of the behaviour of sauces in relation to their chemical and physical properties.

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Chapter 13

MANUFACTURE OF HERRING OIL AND MEAL

This chapter includes:

THE PRODUCTION OF HERRING OIL[1], a special contribution for the meeting by *J. A. Lovern,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland;

NEW REDUCTION PROCESSES, a paper presented by *Gudmund Sand,* The Herring Oil and Herring Meal Industry's Research Institute (Sildolje- og Sildemelindustriens Forskningsinstitutt), Bergen, Norway;

and information from the discussions at the meeting.

Importance of Production of Herring Oil

From *Lovern's* paper:

The major producing countries for herring oil are Norway, Iceland, Canada and the United States. With such a markedly fluctuating fishery as that for herrings, an estimate of the average annual production for any country can only be a very rough one, based on examination of the figures over a considerable number of years. In certain years the production in one area may be virtually nil, and on the other hand, there may be years of unusual abundance of fish. With this qualification in mind, the average annual production (in thousands of metric tons) of herring oil by the above countries may be given as Norway, 30; Iceland, 20; Canada, 15; United States, 10 (Fats, Oils & Price Div., OFAR 1946; FAO 1949). The Norwegian and Icelandic production is entirely from the species *Clupea harengus,* the Canadian and United States production

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Department of Scientific and Industrial Research. Paper for Publication No. T. 50/26. Published in "The Fishing News" (Lovern 1951). British Crown Copyright Reserved.

mainly from the closely-related Pacific herring *Clupea pallassii.* Thus, of the United States production, only about 500 tons is made in Maine from *Clupea harengus* and the rest in Alaska from *Clupea pallassii.* Production from *Clupea harengus* in the Canadian province of Newfoundland is steadily increasing, but does not yet appear to have passed the 1000 tons per annum mark, and production in the province of New Brunswick, Canada, is probably at about the same level as that in Maine, United States, being in both cases almost entirely associated with cannery operations.

In addition to these major producing countries, all countries having herring fisheries produce small amounts of herring oil. In the United Kingdom it has been the policy to encourage the herring fishermen to land as much fish as possible, with the surplus over direct food outlets being converted into oil and meal. The effect of this policy, for the implementation of which the Herring Industry Board has been made responsible by the Government, is clearly shown by the increasing scale of herring-reduction operations. In 1946, the first year of the scheme, some 2 000 metric tons (11 800 crans) of herring were sent for reduction. In 1947 the figure was 6 000 tons (40 000 crans), and in 1948 it reached 12 000 tons (68 000 crans). The 1949 figure was 22 000 tons (124 000 crans), and the estimated targets for 1950, 1951 and 1952 are 44 000 metric tons 71 000 tons and 142 000 tons respectively (250 000 crans, 400 000 crans and 800 000 crans). When the scheme is fully developed, the estimated annual tonnage of herring going to reduction should be about 200 000 (Gr. Brit. Herr. Ind. Bd. 1946, 1947, 1948, 1949, 1950). Assuming an average oil yield of 10 per cent, which is probably a little on the low side taking into account the main British catching seasons, it can be seen that this development will eventually put the United Kingdom in a prominent position among the major producers.

Quality and Preservation of Raw Material

From *Lovern's* paper:

One of the most difficult aspects of the herring fisheries is the uneven nature of the landings — alternating scarcity and glut are the rule rather than steady supplies. Therefore a reduction factory must either have sufficient capacity to deal with maximal rates of supply (*i.e.*, glut landings), or else there must be storage arrangements for the surplus at periods of heavy landings. The latter raises two additional problems — the public-nuisance problem and the deterioration in the yield and quality of both oil and meal. North American practice seems to be to install adequate capacity to deal with all raw material within 24 hours of receipt at the plant, whatever the rate of landing (Lovern 1948). This results in good quality products and permits the factories to operate fairly near urban areas, but means that for much of the season the plant is partly idle. In Norway and Iceland, storage of raw material, perhaps for weeks, is the general practice, and the plants are kept operating continuously over a lengthy period. The fish are usually kept in large bins or pits with no preservative other than a little salt, and putrefaction goes on rapidly. Fortunately, in the case of Norway, the main season is during the winter, when the low temperature markedly retards putrefaction. In the development of the industry in the United Kingdom an attempt is being made to avoid the undesirable features of both these types of practice — the aim is to avoid unpleasant smells, to store glut landings without deterioration in oil yield and quality, and to keep our plants operating at a steady rate over a lengthy period. It is believed that it can be done, as I shall describe later.

Further consideration to problems of preservation of raw material is given in the section on addition of coagulating agents during the cooking process, on page 339.

From *Sand's* paper:

In Norway we feel that more time should be devoted to the problems connected with preservation and storage of herring for non-food purposes. I trust that those sharing my interest will present this question in the discussions.

From *Lovern's* paper:

It has been mentioned that salt is used as a partial preservative for herring stored at reduction plants. Some of this salt is removed in the press-water, but part of it remains in the press-cake and it lowers the value of the resultant meal. For processes involving direct drying of the fish, followed by solvent extraction, the use of salt will obviously have a far more serious effect on the value of the meal. In any case, salt in the small proportions used is far from being a complete preservative, and it does little to retard the development of free fatty acid from the oil in the stored fish. (It has less effect on the lipolytic enzymes of the fish than on bacterial growth).

From discussions:

Hanson, United Kingdom, drew attention to the statement that preservation with salt, the common Norwegian practice, had been examined in the United Kingdom and had been found satisfactory so far as inhibition of bacterial decomposition was concerned. It had, however, less effect, in the concentrations normally used, on the fish-enzyme systems and so, for example, did not prevent lipolysis of the fat to fatty acids.

Notevarp, Norway, referred to quite extensive experiments in Norway with the various types of preservatives. It had been proved in these experiments that salt was one of the most satisfactory preservatives for herrings. Especially the formation of free fatty acids was studied and it had been found, contrary to the results just quoted, that salt was one of the most effective means for reducing the activity of fat-splitting enzymes.

From *Lovern's* paper:

The best general preservative would seem to be formaldehyde, and both laboratory experiments and full-scale factory experiments have been made with it. Its use demands the provision of sealed storage chambers instead of the cheaper open pits, and it is, in addition, an unpleasant substance to handle on a large scale. Its toughening action on the fish is, however, an asset in facilitating pressing (Bjarnason 1941).

The use of formaldehyde as a preservative was also discussed in relation to its as a coagulating agent, see page 338.

From a communication[1] from *Carter and Bailey,* Canada:

Herring can be preserved for use as bait by a method involving the use of 10 per cent salt brine containing 0.5 per cent of formalin (Tarr 1943).

From discussions:

Notevarp, Norway, mentioned that a Norwegian preservative treatment which was said to give a very long-keeping quality of the herring, had mainly been known from newspaper articles. He had no information

[1] "A Review of the Technology of British Columbia Herring Products Investigated at the Pacific Fisheries Experimental Station of the Fisheries Research Board of Canada", a paper prepared for the Meeting by *Neal M. Carter* and *Basil E. Bailey,* Pacific Fisheries Experimental Station, Vancouver, B. C., Canada.

about what chemical had been used. At any rate the information given seemed to indicate that the preservative was so expensive that the method would hardly have any practical value. However, large-scale experiments, in which another chemical was used, were now being carried out in Norway under the sponsorship of the Norwegian Government. It had proved to be possible to keep herring for five or six weeks before processing. Feeding tests had been carried out with meal made from such preserved herring and with meal manufactured from fresh herring; no differences had been found in nutritive value between those two meals. These experiments were carried out on swine by the Norwegian College of Agriculture, at Aas, and on chicks by the Herring Oil and Herring Meal Industry's Research Institute in Bergen.

Ólafson, Iceland: One problem related to the preservation of the herring in connection with solvent-extraction processes was that of preventing enzymatic action. This could be done by heating but it would be preferable to find simpler methods. He felt that more research was needed with regard to those autolytic processes.

The Orthodox Wet-rendering Method

From *Lovern's* paper:

In all the main producing countries, herring oil is mostly made by essentially the same process. The raw material (whole fish, or processing offal, or a mixture of the two as the case may be) is passed through a continuous cooker to a screw press, in which a mixture of oil and water is squeezed out through openings in the press casing, and a press-cake is obtained containing still about 50 per cent of water and some 5 per cent of oil. The press-cake is dried to a meal, without further oil recovery. The oily and aqueous phases of the press-liquor are separated centrifugally. Several features of this process merit further consideration.

The cooking of the herring before pressing is a critical operation, and either over-cooking or under-cooking leads to poor performance of the press. The experience of the foreman is the best practical guide of proper cooking, the extent of which varies with the condition of the raw material. Apart from the degree of cooking, the aim is generally to feed the fish to the press as hot as possible, and without too much pulping-up having occurred in the cooker. Notevarp and Tornes (1943) have studied various conditions of cooking before pressing, and shown the desirability of high temperature and of avoiding undue comminution of the fish. Their results are in complete agreement with unpublished observations made at the Torry Research Station, Aberdeen, Scotland.

It has been mentioned that, in addition to some 50 per cent of water, the press-cake contains about 5 per cent of oil. No second pressing is given, but experiments at Torry Research Station (unpublished) have shown that only a small part of this oil can be recovered by allowing the press-cake to absorb water or various aqueous solutions, followed by re-pressing. Since the original herring vary very widely in oil content, it follows that the efficiency of oil recovery by the traditional cook-and-press procedure also varies with the quality of the raw material. For example, with fish containing 20 per cent of oil, recovery would be 90 per cent, but with fish containing 10 per cent of oil recovery would be only 80 per cent. (Assuming a yield of 20 per cent of meal containing 10 per cent of oil and disregarding processing losses). With still poorer raw material the yield falls off sharply, *e.g.,* herring containing only 5 per cent of oil would give a yield of 60 per cent, the rest being left in the press-cake.

Drying

From discussions:

Sand, Norway, referred to the question of various types of dryers. It is generally believed that flame dryers do not give the meal as high a digestibility as that obtained by vacuum or steam dryers. He felt that more important than the type of drying method used was the extent to which the meal is dried. Meal is generally dried to a moisture content of 5 to 7 per cent in the United States, while the permissible water content in Norway is 12 per cent. Most Norwegian meal contained about 10 per cent. He felt that the damage due to overheating mainly occurred where the last percentage of moisture was removed. Quite extensive experiments carried out by the Agricultural College in Norway with the feeding of sheep had shown that the biological value is essentially the same in steam-dried and flame-dried meal. Preliminary experiments carried out at the Herring Oil and Herring Meal Industry's Research Institute in Bergen had failed to show any appreciable difference between these meals.

Lassen, United States, also felt that there was a considerable correlation between the degree of final moisture content in the fish meal and its digestibility. Such results had also been obtained in California; his experiments had shown a great difference between meal dried with steam dryers and meal dried in flame dryers, even if dried to the same moisture content. It might be that the differences in results obtained in the United States and in Norway were due to differences in the methods according to which the digestibility was determined. In pepsin-digestibility tests flame dryers definitely gave lower digestibility than ordinary steam or vacuum dryers. Still higher digestibility was obtained with a new type of dryer, the so-called "airlift dryer", where the meal is dried in a current of air at a low and carefully-controlled temperature.

A note from *Sand,* Norway:

Recent experiments (1951) at the Herring Oil and Herring Meal Industry's Research Institute, Bergen, Norway, show practically no correlation between the pepsin-digestibility method and chick-growth methods. Heated meals of widely differing pepsin digestibility were found of about equal value as protein supplements to growing chicks. The rations contained about 13.5 per cent true protein.

From discussions:

Notevarp, Norway, felt that another question was that of proper operation of a flame dryer; the air leaving the flame dryer should not have a temperature higher than 100° C. (212° F.). Under these conditions, the meal will not at any point be heated above 100° C., as the meal in the earlier stages, while it still contains a considerable amount of moisture, cannot be heated over that temperature due to the evaporation which must take place. Also, the drying time should be considered. In a correctly operated flame dryer the drying time should be only 10 or 15 minutes, as compared with several hours in the manufacture of stick-water by multiple evaporation, at a temperature which may be something like 50 or 80° C. (122 or 176° F.). He felt that more effort should be made to achieve proper designs of flame dryers and that there was no justification for concluding that flame dryers were not satisfactory. He felt that experiments should be carried out with flame dryers, measuring the temperature throughout the dryer and with outlets at various points in the dryer in order that samples might be taken out.

From a communication from *Carter and Bailey:*

The scorch and ignition temperatures of herring meal show a fairly uniform tendency to rise with decreasing oil content and increasing particle size of the meal (Mahadevan, Carter 1948).

Obnoxious Gases

From discussions:

Lassen, United States, said that the best way of dealing with the obnoxious odors in gases from herring-reduction plants was that of leading the gases through a gas-fired oven.

Bramsnæs, Denmark, confirmed this by referring to experiments in Denmark, only there coal ovens had been used.

Hanson, United Kingdom, mentioned that some dryers had asserted that they could not afford the fuel necessary to "burn" the gases in an oven. He referred to the completely successful use of chlorine gas and the less efficient use of bleaching powder in the deodorization of gases from fish-meal factories operating in towns in the United Kingdom. Offence could still be produced by stocks of fish awaiting processing, and in Aberdeen, for example, there was a time limit on such storage.

New Hering-reduction Processes

From *Sand's* paper:

Until recently only few processes existed for the manufacture on non-food products from oily fish. In fact, only one reduction process, the one ordinary referred to as the cooking process or the wet-rendering system, was of practical importance. Although there were minor differences in the design and construction of the machinery, the method on the whole was the same in most factories.

Even today the old wet-rendering method is by far the most important, but thanks to increased research activity within the fish industry a number of new methods have been suggested in recent years. Some of these have shown quite promising results and are gradually being put into full-scale operation. Others are still in a very early developmental stage — existing only on paper, or tried out on laboratory or pilot-plant scale.

Some methods which introduce entirely new principles, and require machinery quite different from that ordinarily used, will be of interest only in connection with the building of new factories. Others are trying to use the elements found in the usual factories and are actually a modification or a refinement of the old wet process.

General Criteria for Evaluation of Methods

From *Sand's* paper:

Before starting a discussion of the various methods I should like to stress that a correct evaluation should no longer be based on strictly technical data of yields, *etc.* While the industry's attention has been primarily directed toward increased capacity and efficiency, the buyers of the products, realizing the great variety of grades found on the market, have become more interested in quality. Therefore, the merits of a method should be apparent in favorable technical data as well as in high-quality end products. As to the last point we are far behind in research, and know very little about the influence of manufacturing conditions on quality. Also only little systematic work has been reported on the composition of the available raw materials. It is obvious that complete information on the raw material is essential for planning a sound production.

There is no reason to believe that one method eventually will prove superior under all conditions. Local circumstances should be carefully considered before a decision as to method, storage facilities and machinery is made. Among factors of importance in this connection one might mention:

a) Length and stability of the operating season which in turn will decide whether most attention should be paid to the fixed or the variable costs.
b) Climatic conditions during the season, determining how long the raw material could be stored.
c) Type of raw material, and
d) Market and distribution problems.

The last point should, of course, be considered first, because it is the buyer who eventually decides which products can be successfully marketed.

From discussions:

Lassen, United States, called attention to an excellent paper prepared by a Swedish research worker, Ågren (1944), and the work by some Americans (Dunn, Camien, Eiduson, Malin 1949; and Neilands, Sirney, Sohljell, Strong, Elvehjem 1949). In these works concerning the composition of fish protein a surprisingly high similarity in the composition of the proteins of various species was found. He felt, however, that it would be of minor importance to devote too much time to find out in detail the composition of the proteins of various raw materials. More important would be an investigation of the influence of the freshness of the raw material on the results obtained by the various reduction processes. For instance, he had found in his laboratory that the amount of stick-water protein which was obtained in the reduction process and which was still more or less a loss, varied as much as 50 per cent, depending on whether one used entirely fresh or partly decomposed raw material. He suggested that this problem be added to the important points mentioned by Mr. Sand.

Sparre, Norway, stressed that one should especially consider the problems mentioned in Mr. Sand's paper, one of them being the influence of the raw material, as mentioned by Dr. Lassen. Secondly, one should consider whether it would be more advantageous to make whole meal containing all the matters originally present in the herring or possibly be better to make more or less traditional herring meal and then the fish solubles. Thirdly, was the time coming where it was advantageous to prepare a herring meal which was substantially free from fats? Traditional methods give about 10 per cent of fat, but this could be extracted. This did give a better meal, but at a higher cost. It also provided a certain amount of fats, which looked somewhat like pitch or coal tar. He felt that the content of this fat in the meal was certainly of no advantage to the animals, it might even be detrimental. Some of the methods mentioned in Mr. Sand's paper (see later in this chapter) would accomplish this, either for instance the Nygaard's method or the wet-extraction method. These methods also gave a higher recovery of oil. For instance, the amount of oil lost in meal in Norway through the use of the traditional reduction method was in a normal season 10,000 tons. This amount would be recovered by any of these processes.

Modifications or Improvements of the Orthodox Cooking Methods

From *Sand's* paper:

Although years of experience have made the old cooking or wet-rendering method reliable for the usual raw materials, I am quite convinced that systematic investigations could still considerably improve many steps in the process. However, this paper is not intended to deal with details, but more with general features of the various methods. Therefore, presuming that the audience is familiar with the orthodox procedure, I shall just make a few comments on some of the weak points of the method.

Indirect Cooking

From *Sand's* paper:

The main objections that can be raised against the old method could be met, first by the introduction of indirect cooking, thus reducing the amount of stick-water by at least 20 per cent and secondly by the utilization of the stick-water in one way or another. As the latter point will be more thoroughly discussed elsewhere (see pp. 337—38) I shall here mention only briefly the problems of indirect cooking of herring, that is cooking methods where any direct contact between steam and raw material is avoided.

Although the advantage of indirect cooking should be obvious where the stick-water solids are recovered, little work in this direction is reported. In Norway we consider the solution of this problem a key to a number of methods for stick-water utilization, and, therefore, during the last season our institute has conducted quite extensive experiments on pilot-plant scale.

Indirect Steam Cooker

From *Sand's* paper:

An ordinary cylindrical steam-jacketed cooker has proved quite successful when certain precautions are taken. In order to increase the heating surface, steam was also supplied through the screw conveyor. The main difficulties with this type of cooker, low heat transmission and scaling of the heat surfaces, were overcome by using press-liquid as heat-transmitting medium. As it was essential to keep the cooker well-filled with liquid, the cooked herring had to be discharged by a screen conveyor placed at a suitable inclination, through which the surplus liquid was allowed to drain off. There was some evidence that oil would prove even better as heat transmitter.

Indirect Cooking With Fuel Gases

From *Sand's* paper:

Another interesting type of indirect cooker, designed by Mr. G. Bojner of "AB Torkapparater", Stockholm, Sweden, has given quite promising results, although further experiments are needed before a conclusive statement can be given. The cooker is principally a boiler where the water is replaced by the herring. The fuel gases pass through a rotating set of tubes, which during the rotation pass through the mass of herring. No scaling of the tubes has so far been observed. This cooker requires somewhat more space than a steam cooker, but has the obvious advantage of saving boiler capacity. Most likely, the heat economy will also be improved by this more direct use of the fuel gases.

Direct Cooking With Fuel Gases

From *Sand's* paper:

Still better heat economy might be expected if the herring could be cooked by direct contact with fuel gases. If parallel flow is used, difficulties will be encountered in attaining sufficiently high temperatures in the raw material to bring about coagulation. Increasing the initial moisture content of the gases, for instance by recirculation, would retard dehydration and thus raise the temperature to some extent. However, countercurrent methods should offer greater possibilities of raising the temperature in the raw material. The capacity and heat economy might be vastly improved, as water evaporated in one end of the cooker could be more or less condensed in the other end, thus returning latent heat that would be lost in a parallel-flow cooker. Such methods as here outlined have merely been suggested, and no reports on results with them have yet become available.

Recovery of the Stick-water Solids

From *Sand's* paper:

The main disadvantage of the old method, the waste of considerable amounts of valuable dry matter in the stick-water, has in the United States been eliminated to a great extent by condensation to fish solubles. Due to market and distribution problems this is not quite as attractive a proposition in Norway as in the United States. Efforts have, therefore, been made to achieve a successful admixture of the stick-water to the press-cake, and thus by subsequent drying arrive at a so-called "whole meal". This designation is given to indicate that the meal contains all the constituents of the raw material less the major part of oil and water. A great advantage of methods of this type is that they utilize the machinery ordinarily found in a reduction plant, with the only reservation that the dryer capacity must be tripled to enable the factory to process the same amount of raw material.

The method is also well justified even with normal dryer capacity, when in periods of limited and uneven supplies a reduction of the capacity to one third is of no importance.

One factory in Norway, "Lysøsund Sildoljefabrik A/S", seems to be working successfully along these lines, the stick-water being thoroughly mixed with sufficient press-cake.

Personally, I am inclined to believe that straight evaporation of the stick-water to say one fourth of the original amount would facilitate the absorption in the press-cake and greatly simplify the process. Such an arrangement would also leave open the possibility of making solubles, if the market should be in favor of this product. A further discussion of these questions will be found in the following chapter.

Use of Coagulating Agents

From *Sand's* paper:

The use of coagulating agents must be mentioned, if only in a few words, as the use of formalin both as a coagulant and a preservative has attracted considerable interest. There is strong evidence that formalin is very active in both respects and, especially for bad raw material, greatly facilitates pressing. However, to my knowledge, few really convincing experiments have yet been reported to prove that the reagent is entirely or practically harmless to the protein and other nutrients in the products.

From discussions:

Lassen, United States, mentioned that the use of formaldehyde as a coagulating agent had been tried out some fifteen years ago in the United States. It had been very successful, both as a coagulent and, even more important, as a preservative.

Crowther, United States, referred to experiments which in 1936 resulted in a patent for the use of formalin for coagulating and especially for the preservation of fish proteins. The experiments were particularly aimed at the preservation of such fish as herring, menhaden, *etc.,* aboard boats before reduction. There were no difficulties with the preservation itself, but the fact that bulkheads often were not completely watertight, *etc.,* caused many complications. The scope of the work had later been changed. The experiments were concentrated on adding the formaldehyde to the material where it is introduced into the cooker, especially for the coagulation of herring, *etc.*, in poor condition. By the addition of only small amounts of formaldehyde, a normal reduction procedure could be followed. Tests were made to check on the nutritional aspect of this treatment. Herrings were preserved in a very strong solution of formaldehyde by the former Bureau of Fisheries, which is now the Fish and Wildlife Service of the United States Department of the Interior. The preserved fish were later put through a regular reduction process and converted into meal and oil. Feeding tests with meal produced indicated that the treated meal was equal to or superior to untreated meal in nutritive value. He himself did not have the complete documentation regarding this problem but felt that the "Aquacide Company" which handled this particular process in the United States had sufficient information on file to substantiate that the formaldehyde gave no toxic effect on the final protein.

Lassen, United States, reported on some test on the influence of formaldehyde on the digestibility and toxic action of casein. Ordinary commercial casein was submerged for various lenghts of time in a 10 per cent formaldehyde solution. The casein was then dried in a vacuum oven, and fed to rats for a period of two months. It was found that the digestibility of the casein decreased as the time of contact with the formaldehyde increased. However, the decrease in digestibility was not very pronounced. No evidence of any toxic effect was found in the organs of the rats at the conclusion of the experiment.

Thorbjarnarson, Iceland, mentioned that formalin had been used quite extensively in Iceland since 1941. It had principally been used as a coagulant to facilitate the processing of a partly-spoiled raw material and it had been found that the formalin was very useful in increasing the capacity of the presses when pressing fresh herring, especially when the herring was very fat. Fat herring was considered difficult to process while entirely fresh; it was, therefore, customary to store it a short period before processing. The use of formalin as a preservative agent for herring had been used in Iceland with fairly good results, but to his knowledge it was not being used for that purpose at that moment.

Hanson, United Kingdom, said that he had tried one small experiment on the preservation of herring with formalin. He found that the herring kept well without any putrefaction. The flesh was toughened so that it could be pressed more easily, but it was also found that the fat was oxidized. He felt that this might be the main difficulty when that chemical was used for preservation.

Crowther, United States, mentioned that the normal use as recommended by the "Aquacide Company" and described in its patent was that of adding a very small amount of formalin to the fish where they are introduced into the cooker. The quantity added was extremely small, and through several experiments workers had not been successful in finding any trace of the chemical in the fish as it leaves the cooker. He felt that in that case there would be no need for considering its possible effect as a pro-oxidant. When formaldehyde was used for the preservation of fish stored in bins there was no detectable oxidation of fats as long as the material was kept completely submerged in the preservative solution. The chemical was sometimes used in combination with other chemicals for the preservation of cod livers. It had been used for keeping cod livers for as long as three years. The free-fatty-acid content of the cod-liver oil was then approximately 0.3 per cent.

Sand, Norway, did not feel that the documentation he had received from the "Aquacide Company" had been sufficient to prove conclusively that the addition of formaldehyde does not have any detrimental effect on the protein. However, recent experiments in Norway, in which differences in raw materials and manufacturing conditions had been eliminated, failed to show any differences in nutritive value between fresh and formaldehyde-preserved herring meal.

Crowther, United States, felt that when formladehyde is used according to the directions given by the "Aquacide Company", it did not leave any toxic effect. He felt that the company probably had further evidence which it might submit to Mr. Sand and anyone else interested.

Notevarp, Norway, mentioned that it was not sufficient to consider the possible toxic effect of the addition of the formaldehyde. It might affect the nutritive value of the proteins which should be studied in feeding tests.

Methods Effecting Different Degrees of Dehydration Prior to Oil Extraction

From *Sand's* paper:

In order to avoid waste of water-soluble matters a number of methods are designed to prevent or reduce stick-water formation by more or less extensive dehydration of the raw material prior to extraction of the oil. The more moisture one removes from the herring, the higher pressure will have to be applied to effect a satisfactory yield of oil.

In this connection I would like to mention a few typical methods arranged in the order of increasing dehydration of the herring.

The Notevarp Method (dehydration to 40—55 per cent of water)

From *Sand's* paper:

This method was developed during the war in an effort to recover the dry matter of the stick-water. Like the previously mentioned Lysøsund method, the process can, with some minor changes, utilize ordinary reduction machinery, requiring, however, 3-fold dryer capacity to maintain the same level of meal production.

The herring containing around 70 per cent of water is dehydrated to about 50—55 per cent of moisture in directly-heated rotary dryers. The exact moisture content ensuring successful operation depends on the age and freshness of the raw material. To prevent its sticking to the drum walls, the herring is thoroughly mixed with press-cake before entering the dryer. The partly dehydrated mass leaving the dryer at 60—65° C. (140—149° F.) is then passed through a steam-jacketed preheater and heated to about 90° C. (194° F.) before treatment in ordinary screw presses. At a moisture content in the material of the order stated, the major part of the oil can still be expressed at the relatively moderate pressures obtained in the ordinary screw presses, yielding a meal which is sufficiently low in fat contents. Although laboratory investigations point to the use of modified screw profiles, ordinary screws have been used successfully. The recirculation of press-cake might have been expected to represent an extra load on the presses. However, this is not quite the case, as the filtering properties of the mass is vastly improved by the admixture of more press-cake and the amount of oil to be expressed remains constant, independent of the recirculation.

Due to the dehydration of the herring, the press-liquor will contain only about one third to one fourth of the stick-water ordinarily obtained, which means a corresponding relief of the separators. The stick-water is returned to the process, mixed with press-cake and dried together with it to a whole meal.

Whether this direct drying of stick-water and press-cake adversely affects the vitamins still remains to be settled. There is, however, little reason to expect any appreciable destruction, when the dryer is properly operated.

The method has been successfully used for large winter herring. For small summer herring the method as here outlined has failed, presumably because of the less fibrous material, causing difficulties in the press. There is some evidence that coagulation of the herring before entering the first dryer would eliminate or reduce this difficulty.

The Pehrson Method (dehydration to 20—40 per cent of water)

From *Sand's* paper:

Another dehydrating process, the Swedish Pehrson method, should be mentioned for the sake of completeness. Briefly, the method consists of the following steps: dehydration of the raw material ordinarily to 25—30 per cent of moisture with subsequent extraction of the oil in screw presses. (Dehydration to less than 20 per cent moisture will result in an unduly darkened oil). I presume that at these low moisture contents significantly higher pressures will be needed than can be obtained in ordinary screw presses. On the other hand, it is likely that all the moisture is retained in the press-cake. The press-liquor consisting of moisture-free oil needs only "polishing" in a centrifuge to remove suspended solids. Thus there is no tick-water to take care of.

As I have only very slight information about this method, I am not in a position to make further comments on it.

The Nygaard Method

From *Sand's* paper:

This method has attracted great interest in the last years in the herring industry as well as in the whale industry. The method effects complete dehydration of the herring, that is to say to a moisture content that assures a stable product, of the order of ten per cent based on fat-free solids. The dehydration is carried out in a specially-designed apparatus, a horizontal cylinder with revolving steam coils. To secure good heat transmission and avoid coating of the coils, a liberal amount of oil is added to the herring. The bulk of water is then evaporated under vacuum. So far only operation in batches has been used, but continuous two-step dehydration has been suggested.

The dehydration is discontinued at a moisture content of about 10 per cent based on fat-free solids, and the "free" oil removed. Continuously working Oliver filters have been tried for the removal of surplus oil. The filter worked satisfactorily on certain raw materials, yielding as low as 40 per cent fat in the filter cake at a reasonable capacity. In other cases, however, the results were very disappointing, and filtering has now been given up as not sufficiently reliable. Settling in tanks by means of gravity seems to be the most reliable separation method so far, the oil being floated off on top and leaving a sediment with about 50 per cent fat.

I understand that the method is still being modified and further developed, but leave it to the inventors to supply further information.

One of the most fascinating features about this method, is that this oily intermediary product has excellent keeping properties. Consequently, the final pressure or solvent extraction of the remaining oil can be carried out when the season is over, either in the individual plants or in a central plant receiving dehydrated herring from cooperating factories.

The remaining oil can be removed either by pressure or by solvent extraction. In the former case rather high pressures will have to be applied to give a satisfactory meal. Expellers have been given up on account of excessive scorching of the meal. Hydraulic presses give quite satisfactory results at pressures of 3—400 kg/cm^2 (43—5700 lb. per sq. in.), leaving 8—10 per cent of fat in the meal. They have, however, low capacity, and require much manual labor.

Solvent extraction seems to be the most promising method for the final treatment of the intermediary product. Of the solvents in question the hydrocarbons seem preferable to the chlorinated solvents, yielding a lighter oil than the latter. One of the main obstacles encountered in the solvent extraction is the formation of finely suspended solids in the miscella (fines); therefore, systems with the least possible stirring are to be preferred. The formation will be most troublesome with autolyzed and very small herring which is less fibrous than larger, unspoiled herring.

If the dehydrated herring is to be stored with about 50 per cent of oil left, the process will require a minimum fat content of the herring of about 20 per cent in order to be self-supplied with oil. There will be a temporary consumption of oil in raw material of lower fat percentage and "outside" oil will have to be added. This is a rather serious drawback, as a considerable amount of oil will be necessary, resulting in additional capital investment. However, other methods for further reduction of the oil content of the intermediary product are being tried.

It is hard to evaluate the method at this time, as no complete plant is as yet in operation. One plant in Iceland has so far been lacking raw material. Another plant is being built in Norway and will most likely be operating next year. It appears from preliminary tests that the method yields a high-quality meal.

Extraction Processes

From *Lovern's* paper:

Several other processes of herring reduction are in operation in various localities, and some of these are designed to recover the total oil of the fish by solvent extraction. These processes are usually either regarded as to some extent secret, or else have been patented. Solvent extraction is preceded by drying the fish, usually under vacuum, in special equipment, to such a low moisture content that direct extraction in a continuous solvent extraction plant is possible. Oil extracted by solvents is commonly somewhat darker in colour than that recovered by steaming and pressing, although the nature of the solvent used also affects the colour of the oil, *e.g.*, hexane will extract fewer impurities than will triclorethylene, and so gives a paler oil. Any serious overheating during the drying of the herring will also darken the oil, hence the use of vacuum equipment.

From *Sand's* paper:

Solvent-extraction processes are preferable to pressure extraction as far as oil recovery is concerned, the former yielding a meal with 0.5—2 per cent of fat against 6—10 per cent with the latter. As high amounts of marine fat in feeds are apt to cause off-flavors in various agricultural products, a reduction of the fat content of the meal might mean an appreciable expansion of the market. Furthermore, such low-fat meals could most likely be sold at a premium.

Most solvent-extraction methods require very extensive dehydration before the raw material is exposed to the solvent. However, by the use of solvents with boiling points significantly higher than that of water, dehydration and extraction may be carried out in one operation. Such systems are now being advertised by a number of firms. When a mixture of oily fish and the high-boiling solvent, for instance, perchlorethylene ("per"; boiling point 121° C., 250° F.), is heated, the major part of the vapor leaving the apparatus will be water. As the dehydration proceeds, the oil is gradually extracted by the solvent, and when the moisture content is reduced to only a few per cent, the extraction is fairly complete. The miscella is then removed, and the residue washed with more solvent. The miscella is distilled and the meal freed from solvent in the ordinary way. As high temperatures are destructive to essential nutritive factors present in raw material, the operating temperatures may advantageously be reduced by the use of vacuum.

This method has the advantage common to all extraction processes of yielding a low-fat meal. As to the quality of the meals manufactured by extraction methods, there is no reason to expect any detrimental effects on the protein. The fate of the vitamins, however, may be expected to depend somewhat on the type of solvent. Some of the vitamins are soluble in the organic solvents, and will in that case pass over from the meal to the oil, where they ordinarily are of no value as they are not used for feeding purposes. It could be mentioned that vitamin B_{12} is easily soluble in a number of polar-organic solvents, but not in non-polar ones. Solvent-extracted meals could, of course, in contrast to ordinary meals not be considered as sources of fat-soluble vitamins.

As previously mentioned, the type of solvent has a deciding influence on the quality of the oil. For instance, chlorinated solvents tend to dissolve coloring matter and thus yield an oil of inferior quality.

The direct-extraction method is still being investigated, and a more detailed discussion should probably await the results of such further tests.

As a number of the fat solvents also act as preservatives, it has been suggested that methods like the one outlined above could be combined with preservation of the raw material with a suitable solvent. Whether or not this is a practical proposition has not been proved.

Dewatering and oil-extraction with solvents miscible with water, *e.g.*, acetone and ethanol, has been suggested, but there is little reason to expect this to be a practical solution. More interesting, but equally impractical is a method suggesting extraction of the minced and frozen raw material with solvents un-miscible with water.

From discussions:

Ólafsson, Iceland, mentioned that in the discussion regarding traditional cooking-reduction processes versus more modern methods one should keep in mind that the operation of a modern extraction plant required much more skilled labor than the other type of plant. On the other hand, less total labor was required. It was believed that the solvent-extraction method was likely to give an inferior oil as compared with the traditional reduction process. This was due to the fact that in the traditional process a considerable amount of oil was left in the meal. This part of the oil contained the highest amount of free fatty acids. He felt that the less oil is left in the meal or press-cake after extraction the more free fatty acids it contains. For instance, if there was 1 to 2 per cent fat left in the meal, the content of free fatty acids in it might be up to 20 per cent or higher. This oil also seemed to be quite different from the ordinary fish oil. He felt that more knowledge was needed regarding this question. He also felt that solvent extraction of wet herring was much to be preferred to a process where the herring was first dried in oil, which to a considerable extent would have to be recirculated depending on the fat content of the fish, and the cake then extracted by filtration or some other process. Observations which he had made had indicated that direct extraction of wet herring was not as difficult a process as was generally felt. The whole field of solvent extraction offered very important promises for the herring preservation and reduction. In the first place it gives a 100 per cent recovery of the product. Secondly, it is possible to preserve the herring in the same solvent which is later used for extraction. No preservatives would be left in the product. The solvent could be recovered and re-used. The preserved herring could be stored in tanks which also could be used for storing oil or even meal. The herring had to be disintegrated which made it possible to pump it and thus simplify its handling and transportation. He mentioned that those advantages had been stressed by Professor Notevarp, Norway. Certain of these processes were capable of handling very large quantities.

Methods Effecting "Solubilization" of the Solids

From *Sand's* paper:

A number of methods which convert the raw material entirely to the liquid state have been suggested and developed; they result in either true solutions or finely dispersed suspensions. The purposes of work along these lines have been different.

The "Liqua Fish" Process

From *Sand's* paper:

This process was undoubtedly inspired by the success of fish solubles; in a similar fluid product, it tries to preserve all the nutritive factors originally present in the raw material. I gather from the descriptions and claims in the Norwegian patent application that the method so far is used primarily for lean fish. The method consists essentially of a solubilization of the minced fish by treatment with steam in autoclaves at pH 2.8—3.7; and subsequent concentration in ordinary tube evaporators to about 50 per cent solids.

When carried out on oily fish, the process involves the following steps: After addition of acid to pH 4.5, the raw material passes through an ordinary steam cooker. Then the major part of oil and water is removed either in ordinary screw presses or in suitable centrifuges. The press-liquor is separated, and the stick-water mixed with the press-cake to form a suspension. By the addition of further amounts of acid, pH is reduced to 2.8—3.7, and the suspension is subjected to treatment with steam under pressure and violent stirring. This treatment is continued until all solids are either entirely solubilized or, according to the claim, reduced to particles near the colloidal size (max. diameter 50 microns). The resulting free-flowing liquid is finally concentrated to about 50 per cent total solids by ordinary vacuum evaporation.

The product "Liqua Fish" is claimed to remain homogeneous under storage without any sedimentation of solids. It is also claimed to be in possession of vitamin-like factors not found in the raw material or only in reduced amounts. Although considerable quantities of liquid fish seem to be produced and marketed in the United States (Boston area), some of the larger feed companies state that feeding experiments have not shown the product to offer any advantages over fish meal and fish solubles. (For lean fish I can see that this method which recover also the water-soluble components, may yield a product superior to ordinary fish meal where the major part of water solubles have been expressed and wasted).

Even if there were a market for such a product, one may raise the objection that shipment of 50 per cent water seems quite uneconomical. From a Norwegian point of view the distribution and use would also present quite serious practical problems. Altogether it seems more logical to convert the original 80 per cent of insoluble dry matter into a meal as ordinarily practised.

Having no data on plant and operating costs, I find it difficult to give the method a fair evaluation. I feel, however, that the low pH must introduce quite serious corrosion problems, making expensive stainless-steel apparatus necessary. Also, comparing the method with the classical one, I find that the Liqua Fish process requires all the usual machinery, except that the driers are replaced by the more expensive press-cake acid-stick-water mixers, acid-resistant autoclaves for the solubilization, and stainless-steel evaporators. It should also be noted that the use of direct steam in the autoclaves means an increase in the amount of water to be evaporated. Everything taken into consideration it is hard to believe that the method can offer any advantages for use for oily fish, compared with an improved cooking method, indirect cooking and stick-water evaporation being used.

The British Alkali Process

From *Sand's* paper:

Another interesting "liquid process", the use of which may be justified under special circumstances, is the alkali process developed in the United Kingdom. The process is chiefly designed to secure a satisfactory oil recovery from glut landings with the least possible nuisance to the neighbourhood of the plants. In the first instance less attention has been paid to protein recovery. The general features of the process are: solution of the herring in caustic soda, which due to the high pH, also acts as a preservative when the raw material has to be stored. From this solution the oil is satisfactorily recovered by separation. As to the utilization of the dissolved protein, the major part may be precipitated by the addition of acid. The technical performance of the protein recovery is still in the developmental stage. The question of possible reduction in the nutritive value of the dry matter, destruction of vitamins and racemization of amino acids, still remains to be settled. I am inclined to believe, however, that the alkaline conditions are not very beneficial to the vitamins. Otherwise, as far as preservation of the raw material and recovery of oil is concerned, the method should have the advantage of being extremely simple and cheap.

From *Lovern's* paper:

In this development in the British industry (by the Herring Industry Board, on behalf of the Government) much thought has been given to the question of preservation of glut landings. The authorities were from an early date impressed with some of the advantages which seemed to be offered by the application of the well-known alkali-digestion technique, widely used in the production of fish-liver oils, to the recovery of oil from whole fish or fish offal. Some experiments on the adaptation of this process to reduction of salmon cannery offal have been published (Anderson 1945; U. S. Fish and Wildlife Service 1949). As a means of oil recovery it is superior to the traditional cook-and-press method since it gives a nearly theoretical yield, regardless of the oil content of the raw material. Moreover, the oil is very pale in colour and contains virtually no free fatty acids. Even stale herring, which would give a dark, strongly-smelling, highly-acid oil by the usual process, yield a pale, almost odourless, neutral oil by the alkali technique. True, the free fatty acids present in the fish are lost as soaps, but although recovered in the oil fraction by the usual process they are subsequently lost if the oil is refined.

As mentioned above, it has been found possible to combine the alkali-digestion process with simple storage conditions for raw material, and both laboratory tests and full-scale plant experience have shown that this process can deal with glut landings without the need to install plant of excessive daily-throughput capacity. The process itself and the storage arrangements are free from the customary offensive smell of a herring-reduction factory, and the oil is uniformly of first quality suitable for use in the edible-fat industry (Herr. Ind. Board 1949). We may say, in fact, that from the aspect of oil recovery the process has everything to commend it. It has been realised from the beginning, as indicated previously, that meal recovery by the alkali process is another matter. Obvious drawbacks are the destructive action of alkali on protein quality (racemisation, destruction of certain amino acids, *e.g.*, methionine and cystine, and possible production of toxic by-products) and the fact that the protein must be recovered from solution. Research on these matters is going on actively, and in the present stage of this development I do not feel I can say more than that I am confident that the process of alkali digestion will play a valuable role in the future British herring-reduction industry.

The Sharples Method

From *Sand's* paper:

This is another process which reduces the raw material to the liquid state. The process is really ordinary cooking with the presses and screens replaced by centrifuges — in this case, the continuously working "Super-D-Canters". After coagulation of the protein and liberation of the oil, the cooked mass is supended in sufficient stick-water to give a consistency suitable for the centrifuges. The continuously discharged solids are dried in the ordinary manner, and the liquor separated into oil and stick-water, the latter being partly returned to the process. The amount of stick-water to be recirculated is not known. To my knowledge the resulting meal has a fat content of the same order as that in pressed meal.

As the centrifuges certainly are no cheap equipment, I do not think that the method is justified for normally available raw materials. For autolyzed and small herring, however, containing too little fibers to allow satisfactory expression of the oil in the continuous screw presses, centrifuges might offer certain advantages. The process is still not beyond the experimental stage, and one should, therefore, await further information.

From discussions:

Thorbjarnarson, Iceland, felt that in order to evaluate the Sharples reduction method one had to know the capacity of the "Super-D-Canters" when working on liquidized herring. He understood that the "Super-D-Canters" when working on stick-water had a capacity of around 10 tons per hour. He felt that it was reasonable to expect that the capacity would be lower when the centrifuges were working on whole herring.

Sand, Norway, said that he had just received information regarding this point. One part of herring for one part of stick-water was used in the process. This gave some idea of the capacity of the "Super-D-Canters" for this purpose.

Acid Preservation

From discussions:

Hanson, United Kingdom, felt that he might mention a liquid process additional to those described by Mr. Sand. The whole fish or fish offal was minced and mixed with acid. In an older form, attributed to A. I. Virtanen, mineral acids were used; after stirring up, the mixture had a pH of about 2.0 to 2.3. It had to be neutralized by the farmer before use in feedingstuffs, an obvious disadvantage. There were also corrosion difficulties. More recent developments involve the use of organic acids which might be used by a farmer-fisherman in a remote community or mixed directly into feedingstuffs and corrosion is much reduced. With the addition of only some 2 per cent of reagent, the product has, in effect, the composition of fish, and the process was normally used for white fish or perhaps herring of the lowest fat content. Dr. Lovern is now undertaking experiments on its application to fat herring. A special feature of the method was its simplicity, the equipment required being limited to a mincer and containers. An account of the processes has been published by Hanson and Lovern (1951).

Harms, United Kingdom, felt that the method just referred to was especially interesting because of its simplicity. It was a type of process which might be used by a farmer fisherman in a remote community or in a small township. Use of this method might be very important because small fish-processing plants often had difficulties in getting rid of the offal from, for instance, white-fish filleting. Farmers in the vicinity of the plants would be able to use directly the material preserved according to this method. He mentioned that this was a process that would not at all compete with the normal production of fish meal, but felt that it might be effectively used in parts of the world where fishing was carried out on a smaller scale, and where transportation of the offal to a fish-meal producers center was not practical. The process was said to have been developed by a Danish concern.

Crowther, United States, mentioned that there had been rumors about a similar process in North America. He had attempted to get some information from the manufacturer but had so far not received any definite data.

Autolysis of the Herring

From *Sand's* paper:

The rapidity with which autolysis or self-digestion of the herring takes place is entirely dependant on the amount of protein-splitting enzymes present in the fish when caught. The amount of enzymes in turn seems to depend on the condition of the fish, feeding fish containing considerable amounts, non-feeding fish very little. In small feeding herring, like the Norwegian fat summer herring, sufficient amounts of enzymes are often secreted to effect solution of the herring in the course of a very short period after capture, making the raw material entirely unfit for ordinary reduction machinery. For such raw material it seems logical to convert the whole fish into a liquid by means of its own enzymes. The oil could then be recovered by separation and the water phase evaporated to "liquid fish".

For livers it has been suggested that the lipases could be inhibited by the addition of alcohol, and undesired bacterial action by some of the lower fatty acids, benzoate, *etc*. The usual methods suggested for the control of the autolysis of livers would hardly be economical for herring, but it may well be that work along these lines eventually will be successful.

Nutritive Value of Herring Oil

The nutritive value of herring meal is discussed p. 368.

From discussions:

Lassen, United States, answered a question posed by Mr. Sarraz Bournet, France, regarding the possibility of continued use of herring oil for food purposes to the effect that he did not feel that polymerized herring oils had a great future in human nutrition. He felt that sufficient work had not been done to determine how this oil was metabolized. One thing that one did know, however, was that when polymerized oils are fed to rats, a considerable amount of high-molecular fatty matter appears in the feces of the rats. He did not feel competent to say whether that was detrimental or not, but it was of course an abnormal condition to have large amounts of fats pass the intestinal without being absorbed. It was probably not a very desirable thing especially if one considered the relationship between such an amount of high-molecular fat to the bacterial flora. Many important biological processes did take place in the intestinal tract. For instance, many of the bacteria present in the secum and colon, produced very valuable vitamins, some of which were fat-soluble. Vitamin K, for instance, was produced in sizeable quantities in the colon of normal human being. If the person does not have a large intake of vitamin K, it might be that the amount produced in the intestinal tract became critical. It would then be very undesirable if parts of it were removed by being dissolved in non-digestible fatty matter. He felt that the polymerized oils had been very useful as an oil substitute where vegetable oils were scarce. They were also very good from a taste point of view, although not as palatable as high-grade olive oil or other vegetable oils such as cottonseed- or soy-bean oil.

Notevarp, Norway, related that the production of polymerized herring oils in Norway started at the beginning of World War II. It was very successful because Norway at that time had a shortage of fat. The oil was not used only for canning of sardines, it was also used as frying oil and as an edible oil for other purposes. He agreed with Dr. Lasson that too little knowledge was available regarding the nutritive value of this oil, although several experiments had been carried out. He felt that the question was how much oil of that kind was used. The digestible part of polymerized herring oils may be 85 to 90 per cent. The rest of these fats are not being metabolized. But, for instance, in the case of sardines, the intake of oil by a consumer is very small, probably much less than 5 or 10 grams in one meal. He felt that the amount of digestible fatty matter in this small amount of oil would be too small to have any noticeable effect. He felt that further development of the industry would depend very much on the development of the price of vegetable oils. In the future it might often be more profitable to use herring oil for purposes where use was made of its specific properties, for instance, as drying oils, or for extraction of cholesterol or vitamin D.

Lassen, United States, said that as long as the quantities of polymerized herring oils actually consumed were as low as those mentioned by Mr. Notevarp, it was very likely that the misgivings he had mentioned would be only of an academic nature.

Conclusion and Recommendation for Future Research

From *Sand's* paper:

Before concluding I again stress that comparatively few plants use methods other than the classical. Some of the methods are still in the laboratory- or pilot-plant scale, or exist only as possibilities, and much research remains to be done before definite statements as to merits and disadvantages can safely be given.

In the above paper and during the discussions it was stressed that all experiments regarding the evaluation of reduction processes, should take into account not only products in efficiency but also quality and nutritive value of the finished products. As these factors are discussed in the following chapter, the recommendations for future research in this field have all been placed at the end of that chapter.

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Chapter 14

FISH SOLUBLES, WHOLE MEAL, ETC.

This chapter includes:

FISH SOLUBLES, a paper presented by *Trygve* Sparre, The Herring Oil and Herring Meal Industry's Research Institute (Sildolje- og Sildemelindustriens Forskningsinstitutt), Bergen, Norway;

NOTE ON PROTEIN PRODUCTS FROM HERRING[1], a special contribution for the meeting by *J. A. Lovern,* United Kingdom Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland,

and information from the discussions at the meeting.[2]

Introduction.

From *Sparre's* paper:

The subject of this chapter unfortunately still has a flavour of sensation about it. The newspapers devote headlines to it, telling the public about the millions of kroner, dollars or pounds that are going to waste. Of course it is good that we now all realize what is being wasted, and do our utmost to recuperate these values. But there has been a little too much talk about the millions that are being wasted, and too little talk about the practical difficulties and the expense involved in the recuperation. We have seen the estimates compared with the still more fantastic speculations about the quantities of ice that are being wasted in Norway, and that could be exported to Africa at a good price. Such calculations give even more astronomical figures!

You all know that the waste I have referred to is due to the loss of the glue-water (stick-water, Norwegian: Limvann) resulting from the

[1] This paper has been prepared as part of the program of the Food Investigation Organisation of the United Kingdom Department of Scientific and Industrial Research. Paper for Publication No. T. 50/27/2. Published in "The Fishing News" (Lovern 1951). British Crown Copyright Reserved.

[2] Due to mechanical failure of the recording equipment, about one hour of the discussion on this subject was lost.

"orthodox" herring-reduction processes. These processes consist, as has already been fully explained in the previous chapter, in cooking the herring, in order to coagulate its protein, and break the fat cells, in short to render the mass pressable. After pressing, the oil is separated from the press-liquor in centrifugal separators, and it is the resulting practically fat-free liquid, which at present is run to waste, that is known as glue-water.

The name glue-water, incidentally, is something of a misnomer. The liquid, it is true, contains gluey substances, but not a pure glue such as can be obtained from purified raw materials. It would yield a very impure fish glue indeed, and attempts to utilize the glue-water for this purpose have all been abandoned.

Composition of Stick-water

From *Sparre's* paper:

It has, of course, long been known that with the glue-water, practically one fifth of the solid matter in the herring is lost. A typical Norwegian herring glue-water is composed as follows:

Dissolved solids.	5.2	%
Suspended solids	0.8	»
Fat	0.5	»
Total.	6.5	%
Water	93.5	»

Possibilities for Manufacture in Europe

From *Sparre's* paper:

No harm is done in calculating the potential production of "solids" from this glue-water. Norwegian factories during the 1950 winter season handled 6.7 million hectoliters of fish, about 600 000 metric tons. In the usual reduction process, one obtains about 70 per cent of this weight as glue-water, in other words 420 000 tons. With an average total content of solids of 6.5 per cent (including sediment and fat) this gives us 27 000 tons of solids or nearly 55 000 tons 50 per cent concentrate, so called fish solubles.

We will not calculate any hypothetical sales value for such a production, even assuming that this enormous quantity could be marketed at current prices. But the above figures amply explain the interest being taken in Norway in the utilization of the glue-water.

Earlier Efforts in Norway

From *Sparre's* paper:

As a matter of fact, efforts to utilize glue-water are nothing new in Norway. As far back as 1912, in a factory in Svolvær, and later in other establishments, the glue-water was concentrated on an industrial scale. But the enterprise proved a commercial failure, for obvious reasons. The resulting sticky mass was very difficult to handle in transport and difficult to apply. Its protein content was of inferior nutritive value, and its value as a source of B vitamins was not appreciated at that time. Some of the concentrate was re-incorporated into the fish meal — in other words "whole meal" was manufactured, but this meal suffered a reduction in price proportional to its content of water-soluble protein. This contrasts markedly with today's premium for whole meal, with a minimum of 20 per cent soluble protein. Under those circumstances it is small wonder that efforts to utilize the glue-water were abandoned.

Present Situation

From *Sparre's* paper:

Real interest was not awakened in Norway until it was learned at the end of World War II that glue-water from herring, or rather pilchard, was being concentrated and marketed in the United States because it contains a whole series of vitamins of the water-soluble B complex. I have always felt that much credit for this development is due to Dr. Sven Lassen. One of the motives for concentrating the glue-water was undoubtedly an endeavor to get rid of a most troublesome waste product. But Dr. Lassen was among the first to carry out actual determinations of its growth-promoting factors, start a successful manufacture, and establish regular sales.

From discussions:

Sparre, Norway, explained that in Norway there were some 70 to 72 herring-meal-and-oil factories spread along the coast. Most of the plants lay quite far apart, except around Haugesund and Stavanger where from 4 to 7 factories are situated close together. Here one might conceivably build one large installation for treatment of the stick-water from all plants. Most of the plants had a capacity of what was normally referred to as "one aggregate", meaning that they could take between 4 000 and 5 000 hectoliters herring per day. He felt that any plant of that size should be able to afford a fish-soluble installation of its own, provided the installation was reasonably cheap. A few plants were smaller and would probably not be able to make the necessary investment for a stick-water-processing plant of their own. However, they were few and meant little in the total production.

Borgström, Sweden, felt that it might sometimes be academic to talk about the large amounts of nutritive substances which were "available" in the stick-water. For instance, large amounts of stick-water were available along the Norwegian coast. But it was spread about among the various factories, and it was doubtful whether all those factories would be willing to invest in stick-water-utilization plants where the capital investment often may be higher than the total investment in the original herring-meal-and-oil plant. Therefore, one could really not say that all the stick-water is "available". One should also keep in mind that there was a considerable difference between the fishing industry of Europe and that of the United States. In Europe the industry is far more spread out along the coast lines and waste products do not normally occur in large quantities in any one place. He was wondering whether this might bring in a new aspect of the problems involved in the manufacture of fish solubles and whether there were any minimum size of plant under which operation would not be feasible.

Manufacture of Fish Solubles

From *Sparre's* paper:

When the actual manufacture of fish solubles is considered, it may be asked what it is that makes this such a problem. The concentration itself should be simple enough, and indeed, much of the evaporating equipment used in other industries has proved entirely satisfactory for the concentration of glue-water. In selecting the equipment that is best suited for the purpose, one has, of course, to take into consideration the special characteristics of the glue-water. The routine analysis already given shows a sludge content of about 0.8 per cent. In concentrating the diluted liquid to $^{1}/_{7}$ or $^{1}/_{8}$ of its original weight, the suspended matter may form some 6 per cent of the finished product, and thus considerably increase its viscosity. The reduced flow creates difficulties during the concentration process, and the heating surface becomes coated with scorched material, thus reducing the heat transmission, impairing the quality of the product and making it difficult or impossible to attain the accepted standard of 50 per cent total solids.

Acidulation and Sludge Removal

From *Sparre's* paper:

For the reason mentioned above, one of the original processes developed in the United States employs a continous sludge-removing centrifuge to clarify the glue-water before concentration. The glue-water is acidulated with sulphuric acid to a pH of about 4.5. At this pH the solubility of the sludge is at a minimum, and it is claimed that the subsequent centrifuging is able to reduce the sludge content by about one-half (to 0.4 per cent). Excess fat is also said to be liberated by this acidulation, so that the content can be reduced to about 0.3 per cent. The acidulated liquid is very corrosive to the evaporating equipment. It has been difficult to verify these results on Norwegian raw materials.

We have in Norway tested and successfully carried out glue-water concentration without previous acidulation and sludge-removing. A further reason for the acidulation is that the vitamins are less likely to be destroyed by heat at the lower pH. Even in this respect it appears, however, that acidulation is superfluous when certain precautions are taken. To avoid the difficulties of coating indicated above, we have in Norway carried out the concentration with rigorous stirring or forced circulation of the liquid.

The fish solubles must in any case be acidulated after concentration to avoid putrefaction. It has generally been the practice to acidulate to a pH of about 4.5 as at this degree of acidity no putrefactive bacteria can develop and the product keeps "indefinitely". There is the question, however, of whether such an acidity is not creating difficulties during the subsequent handling and shipping of the product.

From discussions:

Sparre, Norway, mentioned that it was very costly to separate the last solids from the stick-water, as very costly centrifuges, *etc.,* were required.

Lassen, United States, agreed that one of the most expensive items in the cost of any fish-solubles plant nowadays seem to be equipment for separation. He felt that it was essential that as much oil as possible be removed from the stick-water before processing. Further, he felt that also as much of the suspended solids should be removed.

High-temperature Evaporation

From *Sparre's* paper:

It is here an advantage to evaporate at temperatures as high as possible without causing damage to the vitamins. The viscosity of the concentrate in the evaporator is thereby reduced. When working in multiple-effect evaporators, where a considerable saving of steam is of course attained, it is advantageous to conduct the flow of liquid under-current so that the most concentrated liquid boils at the higher temperature in the first body of the aggregate. The concentration can very effectively be carried out in a so-called heat exchanger, in which the liquid circulates with great velocity, but with little difference between the temperatures of the two sides of the heat-transmitting surface. The actual liberation of steam takes place in special expansion chambers and coating or incrustation is avoided. In all these cases a concentration of 50 per cent can be attained, but the concentrated material is not very fluid at room temperatures, but rather paste-like. We have, however, noted that a decided liquifaction takes place after some time, so that the product becomes easier to handle.

Pressure Evaporation

From *Sparre's* paper:

An interesting principle is evaporation under pressure at temperatures sometimes as high as 150° C. (302° F.). In this case no difficulty is encountered due to surface coating, and the resulting product is much more fluid. This is due to the dissolving effect of the high temperatures on the sludge, and also the breaking down of the original soluble protein to simpler, less viscous products. As the steam, after having been utilized in a multiple-effect evaporator, is taken out from the last effect with a temperature high enough to be used for cooking in the reduction plant, this process is very economical so far as fuel consumption is concerned. The effect of such drastic conditions on the vitamin content of the fish solubles remains to be investigated.

From discussions:

Sparre, Norway, mentioned that with the use of pressure evaporators one could go up to 70 per cent solids in the solubles instead of the usual 50 per cent. Fish solubles with 50 per cent solids were quite liquid, with a 50 per cent concentration in the product derived by pressure evaporation the resulting solubles were so liquid that one would have a considerable separation. Most of the sediment would settle quite quickly. It therefore looked as if by using this inexpensive way of separation one might get a product which was substantially free from insoluble materials. This was, however, just a thought; more investigation would be needed before it could possibly be put into practice.

Sparre, Norway, said that a quotation which he had received from the Sharples Corporation indicated a cost of 89 Norwegian kroner per ton of fish solubles. According to his calculations, however, one would get a very substantial steam saving by using pressure- or high-temperature-evaporation equipment. According to fairly large-scale tests the steam consumption would be in the neighborhood of 6.80 Norwegian kroner, that is, less than one tenth. The total variable cost with the use of that type of equipment would only be 12.80 Norwegian kroner as against 113.80 Norwegian kroner for the Sharples process. In addition, one would save boiler capacity because only one boiler was needed for producing steam for both evaporation and cooking, the same steam being used for both purposes.

Lassen, United States, said that one of the advantages of the pressure evaporation mentioned by Mr. Sparre was that the steam coming out from the last effect of the multiple-effect evaporators was of such a high temperature and pressure that it could be used for cooking. He was doubtful about whether it was possible to obtain a higher evaporation per pound of steam at those higher temperatures than at the usual low temperatures. In the multiple evaporators in use, one worked under slightly reduced pressure in the first effect, 15-in. (0.50 atm.) vacuum in the second effect, and 28-in. (0.93 atm.) vacuum in the third effect. This insured a fairly low temperature of evaporation. In this process there was evaporated about 2.4 lb. of stick-water per lb. of steam originally put in, which was considered a fairly good steam economy. This economy was of great importance in as much as the major cost of producing fish solubles is that of steam consumption.

Ettrup Petersen, Denmark, mentioned that his company had made quite large experiments on pressure evaporation of stick-water. It had been found that the steam consumption for the evaporation of 1 kg. of water was 0.2 kg. of steam. His company had installed plants using this principle for the concentration of stick-water and the cost was not more than 25 per cent of the cost of a triple-effect vacuum-evaporation plant. In the pressure evaporation a final dry-matter content of 70 per cent had been reached, which was a higher concentration than that obtained in triple-effect vacuum equipment. The reason was that the glue material is broken down by the higher temperature.

Sparre, Norway, agreed with Mr. Ettrup Petersen, Denmark, with regard to the cost of the pressure-evaporation equipment as compared with the mutiple-effect vacuum equipment. Mr. Ettrup Petersen had said that it cost about 25 per cent of the other equipment. In the calculation carried out at the Norwegian Herring Research Institute they had arrived at a cost for the orthodox Sharples-Lassen method of 1 560 000 Norwegian kroner for evaporation equipment. To this must be added that for the orthodox vacuum stick-water method one needs an additional boiler which is calculated at the price of 180 000 Norwegian kroner, while for the pressure-evaporation method, no extra equipment is needed.

Thus, the total cost, including buildings, *etc.*, for pressure-evaporation-method equipment is 800 000 Norwegian kroner as against 2 100 000 for the Sharples-Lassen method. He stressed the fact that this is particularly important for a country like Norway where stick-water installations can only be used for a period of about 30 days, due to the shortness of the season.

Hanson, United Kingdom, felt that these figures should not stand unqualified. As indicated in Dr. Lovern's paper, methods of concentration should perhaps be compared also in terms of, for example, racemization of amino acids, destruction of vitamins, and production of toxic substances. It had just been mentioned that pressure evaporation produced a highly concentrated, but liquid, material owing to hydrolysis of the proteins. Was it not likely that vitamins were hydrolised at the same time?

Ettrup Petersen, Denmark, said that the sole purpose of the project he had referred to had been to recover the dry matter. His company was quite aware of the possibility that a destruction of the vitamins might be taking place.

Spray Evaporation

From *Sparre's* paper:

Besides the previously mentioned, more orthodox concentration methods, an entirely different principle has also been employed. Here the glue-water is concentrated in direct contact with fuel gases. The liquid is broken up into minute droplets which are exposed to very hot gases, with a temperature of 400° C. (725° F.) or more. In spite of this high temperature, the operation can be carried out in such a way that no over-heating occurs. The temperature of a moist surface will tend towards a condition of equilibrium, the wet-bulb temperature, which can be kept quite close to the adiabatic saturation temperature of the initially very hot gas. It should be possible, therefore, to conduct the concentration in such a way that the temperature of the liquid does not rise too high. Besides, the fuel gases are of such a reducing nature that no oxidation of the vitamins or the unstable amino acids (lysine, methionine) takes place. An advantage of this method is the relatively low capital investment needed. The need for both steam boilers and expensive multiple-effect evaporators is eliminated; this may compensate for the less satisfactory heat economy which characterizes a one-stage evaporation. The heat economy is, however, somewhat improved by the elimination of heat losses through steam production.

From discussions:

Notevarp, Norway, was under the impression that the Renneburg process had not been too successful when put into practical operation and did not know whether it was in use anywhere at that moment.

Lassen, United States, said that he had been informed that in 1948 there were three plants in operation in the United States using the Renneburg process for stick-water concentration, while at the time of this meeting there was only one. He had not been able to check this information himself, however. He understood that one of the difficulties encountered was in the spray-drying operation.

Sparre, Norway, understood that the Renneburg process has met some difficulties due to the fact that it attempts to carry out the evaporation in two steps which seem to cause serious difficulties. He understood that the company now made use of one-step evaporation which, of course, is much more fuel consuming. He felt that the process had not been worked through yet to such an extent that it was to be recommended for use in Norway. He felt that it might be a comparatively simple matter to manufacture equipment for such a process locally in Norway, utilizing traditional spray dryers, *etc.* At the Norwegian Herring Oil and Herring Industry's Research Institute a very simple spray evaporator had been used for the concentration of stick-water with 6.5 per cent solids to a fish soluble with about 50 per cent solids. It was done on a small scale but did not cause any difficulties whatever. The spray evaporator itself was 2½ m. (8.2 ft.) in diameter. Experiments on the nutritive value of the product manufactured in this experimental evaporator had been carried out and it seemed that it had not lost any of its nutritive value. He therefore felt that the data he had given for the Renneburg process might apply to other spray-evaporation processes.

Low-temperature Evaporation, Vapor Condensation

From discussions:

Ólafson, Iceland, recommended that one considered the possibility of vapor compression in addition to multiple-effect evaporators. He understood that this particular process was more widely used in Europe than in the United States and that it was getting grounds in the salt industry and the cellulose industry. He understood that so far there was no information available regarding the possibility of the use of this method for the manufacture of fish solubles.

Lassen, United States, assumed that what Mr. Ólafson meant by vapor compression methods was what in the United States was generally designated the Goldschmidt process. This system was used extensively during the war and his company had been able to acquire such a surplus plant on very favorable conditions after the war. It had been tested by his company for one week, but was then abandoned, as the results were not favorable. However, the main reason for this may have been the design rather than the principle itself. He felt convinced that it was possible to build a plant which could be used economically, but the design would have to be entirely different from the design of the plant he had tested, the evaporators of which had been designed for the evaporation of sea water.

Cost Considerations

From *Sparre's* paper:

As has been seen in the preceding paragraphs, fish solubles can be manufactured according to various methods. It is not claimed that all manufacturing difficulties have been overcome. It must be mentioned that difficulties of quite a different character present themselves, these difficulties account for the fact that fish solubles have not yet been manufactured on a large scale in Norway.

First of all the economical side of the question must be considered. Supposing for the moment that there were a fairly stable market for fish solubles, an installation for treating the output from a medium-size herring-oil factory might cost anything up to 2 million Norwegian kroner. Last year the Herring Oil and Herring Meal Industry's Research Institute in Bergen, Norway, carried out some comparative cost estimates, based on a factory treating 4800 hectoliters (430 tons) of herring every 24 hours. The corresponding quantity of glue-water is 300 tons, of which quantity 260 tons of water must be evaporated, yielding nearly 40 tons of fish solubles. Over a 30-day period, the total production would amount to some 1170 tons.

From discussions:

Sparre, Norway, gave some cost figures for various installations for the manufacture of fish solubles. He said that these figures mainly apply to Norway and felt that they also may apply to the other Scandinavian countries and the United Kingdom. The figures he had based his calculations on were quotations obtained from companies manufacturing the installations. He had made some slight alterations, but none that would alter the total picture. He gave the installation cost for three methods: the Sharples-Lassen method, the Renneburg method, and a method utilizing the high-pressure evaporation principle. The essential differences between the three processes to which his calculations applied were that one used mutiple-effect equipment, the other spray-evaporation equipment, and the third pressure concentration. The figures were converted at one United States dollar equal to 7.20 Norwegian kroner.

It was estimated that the building cost was the same in the three cases, or that the difference at least would be immaterial. The cost of the Sharples-Lassen installation was 1.56 million Norwegian kroner. The cost of a Renneburg installation was 855 000 Norwegian kroner, that is a little more than half, and a high-pressure evaporation installation quoted from "Rosenblad" in Sweden would cost not more than 530 000 kroner. To this may be added that the last installation eliminates the need for an extra boiler. If one calculates the total cost, including building, extra boilers, *etc.,* the cost is 2.1 million for the Sharples-Lassen process, 1.1 million for the Renneburg process, and 800 000 for the Rosenblad process. The variable cost was the same for the Sharples-Lassen and Renneburg processes and amounted to about 114 and 111 Norwegian kroner per ton, respectively, while it was 12.80 kroner for the high-pressure evaporation. The fixed cost was, of course, very much higher with the Sharples-Lassen process. If amortization cost was calculated at 15 per cent — which probably might be considered too low for a project of this nature — it would be 430 000 kroner for the Sharples-Lassen process as against 270 000 for the Renneburg and only 175 000 for the Rosenblad process. He had assumed that 500 kroner per ton could be obtained for the product. He then got a sales value of 571 000 kroner for the product from the Sharples-Lassen method, because the yield is slightly less than by the other methods. On the other hand, that method does yield a little more oil and meal. Sales values were estimated at 585 000 kroner for a 30-day season for the two other methods. Subtracting the cost of the Sharples-Lassen method from the sales value gives a net profit of 16 000 kroner, which, of course, is a very small margin, hardly justifying the investment. The net profit for the same 30-day period would be 185 000 kroner for the Renneburg process and 395 000 kroner for the Rosenblad process. The relation between these figures would of course change considerably if the duration of the operation could be extended beyond 30 days. For instance, for 60 days operation the net profit is 462 000 kroner for the Sharples-Lassen process; 640 000 kroner for the Renneburg process; and practically 1 million kroner for the Rosenblad process. Mr. Sparre stressed the point that he in these calculations had considered the cost question only and had not gone into the question of possible differences of quality of the final product.

A note from *Sand,* Norway:

Recently (1951) a Norwegian firm has started offering large vacuum evaporation equipment at a price considerably below the figures mentioned above. An evaporator of the above mentioned capacity would, in accordance with this, cost 220 000 to 250 000 Norwegian kroner only, boiler not included.

From *Sparre's* paper:

In a country like Norway where the season is so hectic, and limited to such a short period, it is necessary, in order to cope with the flood of raw material, to install equipment with a capacity seemingly out of proportion to the yearly output. This same state of affairs makes the building of new reduction plants very difficult, and in our opinion it rules out any solubles plant requiring a heavy investment, let alone one that needs dollar expenditure.

It will be readily understood, that if an installation for treating the glue-water from say 150 000 hl. (13 400 tons) of herring during one season costs anything between 1 and 2 million Norwegian kroner, the total investment for installations to cope with the total Norwegian output of glue-water might easily reach 50 millions ore more. Nobody could seriously consider such a program before a very thorough market survey had been carried out.

From discussions:

Sand, Norway, mentioned that one would not have to take into account, separately, the quality of the product, or the installation and operating costs, but rather both factors judged together to estimate the possibilities for such processes in various places.

Sparre, Norway, stressed that he entirely agreed that one could not judge one system as compared with the other on account of the cost of operation and of capital equipment alone. One certainly had to take into account the quality of the finished product. It was well known that the capital cost involved in the Sharples-Lassen process was quite high. But on the other hand, fish solubles manufactured according to the Sharples-Lassen process were a well-established and well-recognized product. Anyone who instigated the possibility of using cheaper methods should keep this in mind.

Manufacture of Whole Meal

From *Sparre's* paper:

The difficulties of finding suitable ways of shipping the corrosive fish solubles have led to studies regarding the possibility of drying the solubles paste down to a dry powder. With modern spray-drying equipment this offers no technical difficulties. The Norwegian Herring Oil and Herring Meal Industry's Research Institute has had several large lots prepared by manufacturers of such equipment, and has also carried out spray-drying in its own pilot installation with complete success. Tests on the biological value of such a powder have not as yet been completed, and such tests are, of course, essential. However, judging from the experience gained in the manufacture of spray-dried milk products, there seems to be little danger of damaging the vitamins present. Such a dry powder should theoretically be much easier to handle. It has, however, the disadvantage of being very hygroscopic. It must be packed in absolutely moisture-proof containers, impregnated bags or drums, or else the contents will harden and be next to impossible to handle in the feed mills.

We might in this connection also mention other ways of handling fish solubles, namely to absorb them in some porous material preferably one that is itself a feed product. A mixture of 40 per cent solubles plus 60 per cent dried alfalfa meal is said to give a free-flowing powder without any tendency to cake or to deteriorate. Such a solution might be practical in other countries, but hardly in Norway. The possibility of absorbing the solubles in dried, ground seaweed ought, however, to be examined.

This leads us also to consider the possibility of mixing the powdered solubles back into the herring meal, obtaining a "whole meal". A 20 per cent admixture to powder seems to give a product that remains quite free-flowing without caking tendency even in damp weather. Such whole-meal mixes could also be prepared by spraying the concentrated 50 per cent solubles directly into the herring-meal dryers, together with the wet press-cake. Several other ways of carrying out the admixture and blending are, of course, also feasible.

Nutritive Value of Herring Meal, Fish Solubles and Whole Meal

Herring Meal

From discussions:

Davis, United States, had not heard of any case where the oil in fish meal was detrimental, except in cases where extreme oxidation had taken place. He felt that that tied up with the problems involved in advances in the methods for drying the meal. He mentioned that agricultural colleges in Norway and particularly in Sweden had advanced a theory that meal produced by traditional reduction processes lacks some of the very desirable quality which it could have if dried at lower temperatures and with less oxidation. He felt that if one could eliminate the oxidation, the oil left in the meal would have the same feeding value as any other fat. He added that particularly in the feeding of cattle and swine the oil was a very desirable part of the feed. It, of course, depended also on economic questions whether it would pay more to sell the oil separately or to leave it in the meal. He felt that more research should de done on the question of feeding value of the finished product, in order that the techniques could be adapted appropriately.

Bramsnæs, Denmark, referred to Danish experiments carried out a few years ago. Here pigs were fed with herring meal. The rancidity of the oil was detectable in the fats in the meat. It is not so objectionable in unsalted pork, but when the pork was salted, the off-flavor became very distinct. The general feeling was that due to these reasons, feeding with fish meal should be stopped two months before slaughtering. However, the latest experiments had shown that this is not sufficient in bacon production. In the experiments other meals were also used, one with 2 per cent fat and one derived from the Nygaard method where the fat had been extracted. The meat was judged by large taste panels. The only meat that scored as high as the one derived by the ordinary feeding method, that is, by the uses of skimmed milk, was the one where Nygaard meal had been used, *i.e.,* meal with about 0.5 per cent fat. Even feeding with this meal had to be discontinued two months before slaughtering.

Sparre, Norway, mentioned that it is very difficult to avoid the oxidation of fats in the fish meal. Meal may contain 10 per cent of fat, extractable with ethyl ether or benzene. After two months one may find that only two thirds of the fat can be extratcted by the solvents, and after a long period there will hardly be any extractable fats left. The fat is quite black, looks like tar. He understood that it went through the intestine tract without being digested at all, and did not know whether it was actually harmful but it was at least well-known that oxidized fatty acids have a considerable laxative effect. In addition the oxidized fat may cause an off-flavor of the flesh or the fats of the animal fed with the meal, or to the eggs where the meal is used for poultry feeding. He did not feel that this was only a question of economics, but that it was up to the manufacturer to have the farmer properly educated as to the relative value of the various meals. In addition, it was quite obvious that the fat content in the meal was not paid for at all, because meal was sold entirely on the basis of protein content.

Hanson, United Kingdom, referred to some experiments related to gas-packing of milk powder. It had been shown that oxidized milk powders led to gastro-intestinal troubles. There were a number of fatalities among children which could be traced back to such causes. He also referred to a discussion regarding the use of paper bags for the storage of fish meal as contrasted to the ordinary storage in textile bags. It had been proved in that work that a considerable heating of the meal takes place due to oxidation of the fats. One should keep in mind that if the fats were removed by solvents, one was at the same time removing the fat-soluble vitamins.

Lassen, United States, had found that the determination of digestibility through animal experiments were too costly and too time consuming. He found that suspending a certain amount of fish meal in water and adding to it a standard solution of pepsine gives results which, at least to a sufficient degree, corresponded with those obtained by animal-feeding tests. The method had the great advantage that it was inexpensive and tests could be concluded in a matter of hours.

Notevarp, Norway, mentioned that some experiments had been carried out with chemical digestibility determination of fish meal according to the method referred to by Dr. Lassen. Both flamed-dried and steam-dried meal and also the press-cake itself were tested to determine whether any of the drying methods had any influence on the digestibility. All experiments were carried out with meal made out of the same raw material. Very small differences were found in digestibility. It was possibly slightly less for the meal than for the press-cake, but the difference was only slight. This was in spite of the fact that the flame dryers here used were not of the best construction.

Lassen, United States, recommended that the method of chemical digestibility determination be tested elsewhere, for instance in the Norwegian experiments, as it would be very interesting to see how the results compared with those obtained in the United States.

Sand, Norway, stressed the importance of having exactly comparable raw material and an exact description of the manufacturing method involved when feeding tests or digestibility tests on herring meal were carried out. He gave reference to an article published in *Poultry Science* (Clandinin 1949). In this various meals had been prepared and it had been found that meal dried in flame dryers had very low digestibility. Few data had been given regarding the conditions of manufacture. He had written to the author asking for such further information. The answer was that the meal which had been reported to be of inferior quality had a moisture content of 5 per cent while the other meal had a moisture content of 7 per cent. This excessive dehydration rather than the drying method probably caused the damage.

Mjelde, Norway, called attention to a paper by Breirem (1950), in which is discussed the nutrition value of herring meal and the use of this product for dairy cows. Up to 4 to 4.5 lb. (1.8 to 2.0 kg.) of herring meal was fed per cow per day with good results. It is, however, considered preferable to use oil cake and herring meal together. The daily amounts of herring meal will then seldom exceed 2 to 2.5 lb. (0.9 to 1.1 kg.). Norwegian experiments and practical experience have shown that there is no risk of a deleterious effect on the flavor of milk and butter when feeding herring meal in daily amounts of 2.2 to 3.3 lb. (1.0 to 1.5 kg.). The paper concludes with a feeding plan for dairy cows, incorporating herring meal.

Fish Solubles and Whole Meal

From *Sparre's* paper:

It is appropriate in a general survey to examine a little more in detail the composition of fish solubles which is the accepted commercial name for a glue-water concentrate with approximately 50 per cent total solids content. A routine analysis gives approximately the following result:

Crude protein	38—40 %
Fat	3— 5 »
Salt	3 »
Phosphates	1.5 »
Total ashes	6 »
Water	50 »

But this analysis tells us very little about the real value of the product; the quality of the various items must be considered.

A table is reproduced below giving the main constituent amino acids of the glue-water protein, calculated as percentage of the crude protein or, which is the same, in grams per 16.0 grams of nitrogen. The table is taken from American data (Block and Bolling) as data on Norwegian products are as yet incomplete. Furthermore, the picture is not entirely reliable in all details. Data differing from those given below will be found in the literature. Discrepancies will especially be found in the figures for the leucines (the last three components in the list below) where higher figures are often quoted, and also for cystine.

Arginine	5.4	Methionine	1.5
Histidine	2.6	Threonine	2.3
Lysine	4.1	Glycine	6.3
Tyrosine	0.8	Leucine	2
Tryptophan	0.8	Isoleucine	1
Phenylalanine	1.9	Valine	3
Cystine	+		

Unfortunately, the protein contained in fish solubles is not a "complete" or "balanced" protein, as it is rich in glycine and the basic amino acids, and poor in tryptophan and cystine. Indeed, actual tests have shown it to have a biological value of only 40 per cent of that of a complete protein. Therefore, fish solubles are deficient as a sole protein source, but they may well supplement other proteins, making up for their deficiencies, thus becoming a very valuable nutrient. This does not alter the fact that judged by its protein quality alone, this product must be a low-priced feedstuff.

The following table of accessory components, is based on analyses of Norwegian products.

	Microgram per gram of dry matter
Riboflavine	30
Pantothenic acid	200
Nicotinic acid (niacin)	350
Pyridoxin	25
Choline	6000
Vitamin B_{12}	1.5

It will be seen from this table that the vitamins constitute only a very small fraction of the concentrated fish solubles. However, the vitamins are such highly active substances, that even these minimal doses are significant. The above table thus shows fish solubles to be an uncommonly rich source of these vital compounds. This has been fully demonstrated by a very great number of feeding tests. Here I shall, however, not enter into further details regarding the biological significance of the vitamins.

This short survey on the composition of fish solubles would not be complete without mentioning the important minerals or trace elements it contains. While vegetable feedstuffs often lack these elements, due to the gradual washing out of the soil, the fish products contain them in optimum proportion; during the reduction process, they are partly concentrated in the glue-water and consequently recuperated with the fish solubles. Some of them are listed below, the figures being based on a product with 50 per cent total solids.

Iron	0.025	%
Copper	0.007	»
Manganese	0.0004	»
Iodine	0.007	»
Aluminium	0.005	»

From discussions:

Sparre, Norway, understood that fish solubles contained matters which were very important for chickens but not so important for cows and similar animals. He felt it desirable that further information be obtained as to the nutritive substances which fish solubles contain and their effect upon the various animals.

Lassen, United States, felt that in the process of concentrating stick-water any higher temperatures were detrimental to the vitamins which were the most important part of this product. He felt that the high-temperature multiple-effect evaporation, which Mr. Sparre had referred to in his paper, would not be practical as it would destroy too much of the vitamin content in the product unless the evaporation could be carried out extremely fast. It was his experience that very high vitamin retention was made possible in the vacuum-evaporation method. He was wondering whether the vitamin retention in the other processes mentioned by Mr. Sparre was similar.

Sand, Norway, mentioned that the Norwegian Herring Meal and Herring Oil Industry's Research Institute had been interested in determining the stability of the vitamins in the stick-water at various temperatures. A treatment of stick-water of the order of 3 hours at 135—140° C. (275—284° F.) showed no destruction of niacin and choline and very little of riboflavin and vitamin B_{12}. Further investigations regarding this matter were under way. pH was a very important factor in relation to this problem. He felt that the importance of reducing pH to a fairly low level had been exaggerated but that this question also was one which merited further investigations.

Notevarp, Norway, mentioned that when one evaporates at a high temperature, one may have some racemization or may get a change in the amino acids. He did not feel that sufficient knowledge was available on this point.

Bartz Johannesen, Norway, said that feeding experiments both in Norway and abroad had shown that especially for pigs and chickens it gave much better results than ordinary herring meal.

Notevarp, Norway, mentioned that ordinary herring meal contains 6 to 7 micrograms per gram of riboflavin, while whole meal contained 10 to 11 micrograms per gram. The content of water-soluble vitamins, of choline, and of water-soluble minerals were also much higher for whole meal. This higher nutritive value should certainly justify a higher price.

Sand, Norway, answered a question from Dr. Lassen to the effect that so far not very extensive experiments had been carried out in Norway with regard to the nutritive value of the fish meals prepared according to the various methods mentioned in his paper. A few experiments had been carried out at the Norwegian College of Agriculture. They indicated a higher nutritive value of the whole meal. However, the experiments were designed in such a way that the main factor had been probably the riboflavin content. In some experiments a direct relationship had been found between the riboflavin content and the growth response. Some experiments had been carried out on pigs, with meal prepared according to the Nygaard method and the results were excellent, both with regard to gain and flavor of the bacon. A special shortcoming of many of the experiments was that there had not been complete comparability between the raw materials used. The quality of the raw material was a particularly important one to take into account in all such experiments. This was especially true in Norway where the herring may have been stored for three or four weeks, or even longer. Also, in Norway, essentially different types of herring were used; some of them contain roe and milt, others are taken after spawning. That might, of course, result in quite appreciable differences of the meal. A shortcoming of many experiments similar to those mentioned had been that the meal used in the experiment had not been sufficiently well-defined to make it possible to draw any definite conclusions.

Notevarp, Norway, said that Norwegian experiments seemed to have shown that there was no material difference between the nutritive value of feeds containing either ordinary herring meal combined with fish solubles or whole meal. He also felt that the effect of temperature by the drying of herring meal was likely to be exaggerated, and called attention to the fact that the reduction of nutritive value by exposure to high temperatures was effected not only by the actual temperature, but also by the time of exposure. One hour or more in an multiple-effect vacuum evaporator at 50 to 90° C. (122 to 194° F.) may be as detrimental to heat-sensitive substances as 5 to 10 minutes in an direct meal dryer at about 100° C. (212° F.) which is likely to be the maximum temperature which the meal will reach in such a dryer as long as the meal is moist. The small differences found by feeding tests made whole meal dried in direct dryers and in vacuum dryers should also indicate that the destruction of heat-sensitive nutrients in direct dryers, that is flame dryers which are properly designed and properly run, is of negligible practical importance.

Sand, Norway, said that it was too early to say whether the vitamins were just as well preserved in the form of whole meal as they were in the form of fish solubles. The evidence so far obtained had not been sufficient, as the experiments carried out had not considered all factors. He felt reason to believe that some of the whole meal processes did not destroy the vitamins but so far he lacked evidence. Whole meal may be manufactured according to a great many different processes. The drying procedure deserves further attention.

Lassen, United States, supported the view of Mr. Notevarp that the destruction was dependent both on time and temperature of exposure. Vitamins would be destroyed just as much by being kept at a lower temperature for a longer time as at a high temperature for a brief period. He had no information on the time-temperature relationship, however.

Notevarp, Norway, agreed with Mr. Sand that the evidence was not sufficient, although quite a few experiments had been carried out. They had not indicated any appreciable destruction of the vitamins or of the other essential nutrients from the stick-water contained in whole meal.

Bramsnæs, Denmark, recommended that one should also include for study the question whether whole meal and fish solubles are of any value at all. In comparison with ordinary fish meal, some Danish experiments had so far not shown any beneficial results from the use of either. This might apply to other European countries as well. The work he referred to had been carried out on pigs and chickens. He felt that agricultural experimental stations should be encouraged to do more work on this problem, as this would be most valuable to the fishing industry.

Lassen, United States, mentioned that the results reached in the Danish experiments might partly be due to the fact that Denmark was in a different position from that of most other countries. In most countries there was a definite shortage of animal proteins. It seemed that in Denmark the opposite was the case. Fish solubles were, of course, to be considered as a vitamin concentrate; one of its distinguishing features was that besides its vitamin B complexes it contains a large amount of animal protein factor. The explanation to the surprising results obtained in the Danish experiments might be due to this difference in basic diet. If one already used a diet rich in animal protein factor and B complex vitamins such as obtained when meat meal, fish meal and milk were used, there was really little extra that condensed fish solubles could add. Furthermore, when experiments were carried out with condensed fish solubles, they should be fed in normal amounts. In the United States one used 3 to 5 per cent fish solubles in feed mixtures. He understood that in the Danish experiments one had used an amount of fish solubles of about 20 g. per pig which is a much smaller amount than is usually added to the ordinary pig feed mixtures in the United States. This also might explain why the results so far obtained in Denmark were in contradiction with the results obtained elsewhere.

Bramsnæs, Denmark, confirmed that the pigs were fed only 20 g. of fish solubles per day. This was due to consideration which had been given to the fat content which, it was felt, limited the amount of fish solubles which could be used. As far as chickens were concerned, the amounts used were 1.25 to 2.5 per cent. The results were still negative.

Some additional information on the influence of the various processing methods on the nutritive value of the end product is given in the sections where these methods are discussed, both in this and in the previous chapter.

Standardization of Products

From *Lovern's* paper:

The typical protein product from herring is, of course, herring meal intended for use in animal feeding stuffs. In this connection, it is important to note that, in addition to protein, herring meal contains numerous other substances of significance in animal nutrition — fat, vitamins and minerals. The relative value of two different samples of herring meal when added to any particular diet will depend on the net effect of all these factors in relation to the composition of the rest of the diet, and in relation to the particular nutritional requirements of the animal to which the diet is fed. All this, of course, is well known, but I feel it deserves to be stressed since it introduces so many difficulties into any attempt to evaluate the quality of herring meal as affected by processing conditions, and also raises acute problems in advisory work.

To take one outstanding example of this — the relative values in a practical ration of herring meal and herring solubles. This is an item which we have found to be associated with much confusion in the minds of many would-be users of herring solubles. Each product contributes protein, vitamins and minerals useful to the animal, but in very different proportions, and the effect of addition to the diet is going to be markedly dependent on the composition of the rest of the diet, and on the species of animal in question. Thus, if the rest of the diet is deficient in total protein, but adequately supplied with the so-called animal protein factor, APF, or if the animal itself possesses adequate reserves of animal protein factor, the addition of herring meal is likely to be far more effective than the addition of an "equivalent" amount of herring solubles. Conversely, if the animal's own reserves, and/or the diet, are critically low in APF rather than in protein, herring solubles are more likely to be of value than an "equivalent" amount of herring meal.

The foregoing paragraph raises another outstanding practical question — "equivalence" of different dietary supplements. Equivalent in what? If we make additions on the basis of nitrogen content, we at once come up against the relatively high ration of non-protein nitrogen in such products as herring solubles. If we take the basis of total protein content, we have the problem of protein quality, which is different not only as between solubles and meal, but probably also from one meal to another if for instance processing conditions (*e.g.*, drying temperatures) have been very different. Even the analysis of the amino acids contained in the protein may be misleading, as part of the protein may be so altered by heat (*e.g.*, in flame-dried meals) as to be indigestible (March, Stupich, Biely 1949). Moreover, any one feature, such as nitrogen or protein content, fails to take into account the value of the other dietary factors also present.

The answer to these difficulties would appear to be the selling of feedstuff supplements, such as herring meal or herring solubles, on the basis of a guaranteed and very full specification. This might be met in practice either by blending or, if necessary, by fortification with synthetic or concentrated factors. The specification should cover all those items which the product contributes in significant amounts and which are likely to interest the user, to enable him to use it intelligently in compounding his rations. It may be noted that there is a growing demand for such standardisation in many quarters, *e.g.*, in the United States, and our experience at the Torry Research Station in the United Kingdom in dealing with queries on the subject has strongly emphasised the practical value of standardisation.

When a completely new product is being developed and tested, in addition to determining its detailed composition and its intelligent use in test diets, it is essential to test it on the species of animal for which it is intended, and for the particular purpose, *e.g.*, growth, egg laying, hatchability of eggs, milk production and so on. This has been brought out very forcibly in some experiments now going on with protein products recovered from alkali digests of herring in the process mentioned on p. 347 ff. As regard this product, no-one on present knowledge can predict how many species will respond to a partly racemised protein, and it is quite clear that different species are able to make use of the *d*-amino acids with widely differing efficiencies. If toxic by-products are produced — as we have reason to believe may be the case under certain conditions — the effect of these is very different from species to species. Also, the essay of the product itself for various factors, *e.g.*, amino acids, extent of racemisation, content of various vitamins, *etc.*, must always be related to the processing conditions, since quite small change, *e.g.*, in alkali strength, temperature or time of heating, may have marked effects on composition.

To sum up these few remarks, may I call them a plea for fuller information as to the composition of various products relating to herring meal, for standardisation of composition, and for adequate planning and control in their evaluation in animal nutrition?

From *Sparre's* paper:

The problems confronting anyone who contemplates the establishment of a fish-solubles or whole-meal industry in Europe are thus by no means exhausted by considerations of processing techniques. Those who want to establish such an industry, based mainly on overseas export must first of all carefully ascertain the type of product the market actually requires. One then has to secure, from a bewildering variety of raw materials, a product as uniform as possible, and find means of standardizing and controlling the quality. A very intimate contact with the prospective buying market is therefore a necessity. In Norway, we feel that essential information is lacking in this respect. We do know, however, that the market wants a product with the highest possible content of accessory food factors, and more especially of the APF (animal protein factor) complex. It is consequently indispensable that we continue investigating the influence of all the manufacturing conditions on the preservation of these factors. What is the maximum temperature the various vitamins can stand? Is acidulation before concentration necessary, would it perhaps permit the use of higher temperatures during the process? What compromise could be made in order to secure a satisfactory product under the most practical operating conditions? Much research has already been carried out along these lines, but many questions remain to be settled.

The market would presumably require solubles with a low oil content, in order to avoid any possible influence on the flavor of eggs and pork. During rush operations in the herring-meal factories, it may well happen that the separation of oil leaves much to be desired. In such cases the fat content of the solubles might even reach 10 per cent. How can this be avoided?

The market would require a product that is easy to handle. So far it has taken a 50 per cent concentrate; this should be of a free-flowing consistency so that it is easy to apply in the feed mills. The question arises whether a concentrate with a fairly high percentage of insoluble matter will be sufficiently fluid at 50 per cent concentration. Or, if a thinning takes place during storage, will the solids stay in suspension or will they form troublesome sediments.

Above all, the market would require a uniform product, and again the problem of standardization would arise. Herring oil and meal is being manufactured from a great variety of raw materials. In Norway, we have the "great herring", the "spring herring" and various kinds of "summer herring". Some of these fish are processed quite fresh, some after weeks of storage under varying conditions. Some are unsalted, other parts have been salted before processing. Now even other preservatives may come into regular use. Some of the fish contain milt and roe, and some are empty. It is difficult to predict the effect on the quality of the fish solubles of all these factors. Besides, if both the fat and the salt content may vary from say 3 to 10 per cent, it is unreasonable to expect the market to continue stipulating "50 per cent total solids" only. The buyer is mainly interested in getting his full vitamin value. He would therefore want to know the exact nutritive value of the solubles. Not only do we have here an immense field for further systematic research, but as feeding tests are both costly and time-consuming, tests must be devised that will permit quick assays and thus make possible an efficient control of all exported goods. It would seem that continued scientific research is the most "practical" way of attacking the fish-solubles problem.

From discussions:

Lassen, United States, stressed the importance of obtaining some standardization of the various products now sold under the designation of fish solubles.

Notevarp, Norway, mentioned that the usual way of distinguishing analytically between whole meal and ordinary herring meal was through a determination of the content of water-soluble proteins. This, however, did not mean that these water-soluble proteins had a higher nutritive value than the other proteins; it was merely a useful analytical method.

Sparre, Norway, said that a content of 20 per cent water-soluble protein is generally used as an indicator for whole meals, but he felt that this might be a very poor indicator indeed. For instance, nothing was stipulated about the vitamin content. Thus it was not a true indicator of the nutritive value of the whole meal at all and it was such a poor method that another, more scientific method should be devised. He felt that this had to be developed before it would be possible to obtain a substantially higher price for whole meal.

Lassen, United States, recommended that the various products sold under the name of fish solubles be standardized and properly tested. He felt that it should be done by the various government authorities who are concerned with feed-stuffs. Such standardization would give the user the protection to which he is entitled. In the United States three types of fish solubles were recognized, namely herring solubles, sardine solubles and menhaden solubles. Very little work had been done on comparing the biological value of these three products. Very little also had been done regarding the biological value of products produced according to one method compared with those produced according to another. He mentioned that fish solubles were, of course, mainly used because of their vitamin content. Nevertheless, in his laboratory he had carried out a considerable amount of work to find the composition of the protein available in the fish solubles, and he had found a very great variation among various solubles. In some, up to 25 per cent of all the protein were amino acids. In some cases large percentages of the total nitrogen was present in the form of amine or ammonium salts which had small value as a protein for animals. Such a composition of the solubles indicated that the raw materials used had been badly decomposed. It was not known what effect such decomposition of the raw material had on the nutritive value of the final product. This was a question that was probably worthwhile looking into further.

From discussions:

Sand, Norway, said that some preliminary experiments to determine the influence on the fish solubles of the quality of the raw material whether fresh or partly decomposed had been carried out. The amount of simple nitrogen compounds in stick-water made from fresh raw material was about 15 per cent of the total nitrogen; this increased to about 20 per cent in stick-water from herring which had been stored during winter time for three weeks. It seemed that the B_{12} vitamin content had increased so that it was 45 per cent higher than in that made from fresh raw material. This vitamin content was determined microbiologically. It might be that this increase in vitamin B_{12} corresponded to a decrease in vitamin-B_{12} content in the meal. However, it might also be due to bacterial action. This whole question was being investigated further in Norway and results here mentioned were only to be taken as preliminary.

Aglen, United Kingdom, recommended that FAO should undertake to encourage agricultural research to look further into the question of fish solubles, whole meal, *etc.*

Marketing of Fish Solubles and Whole Meal

Fish solubles

From *Sparre's* paper:

The marketing possibilities for fish solubles still appear somewhat obscure. While it has been stated — based on calculations of the total quantity of feed mixes produced — that there will be an "unlimited" demand for the product, it has been difficult for us in Norway to verify such a statement. It should of course be pointed out that the fish solubles with their growth- and health-promoting principles are mainly of value in the development of chicks and pigs. The ruminants are capable of producing the various B vitamins, including the Animal Protein Factor, the so-called APF, in their own intestines, and an admixture of fish solubles to their rations would therefore be of less importance.

The replies to a questionnaire, circulated by the Herring Oil and Herring Meal Industry's Research Institute, Bergen, Norway, to some 30 feed mills in the United Kingdom and the United States have been rather vague. None have, for instance, been prepared to enter into long term contracts. There has also been a certain anxiety as to the influence of the new synthetic vitamins, and, more especially, the APF concentrates on the price of the solubles. We have lately seen a decided drop in the price quotations from America, and we therefore do not know what selling price to use in our estimates. It is to be hoped that discussions at this conference will help to clarify the marketing problems.

From a communication[1] from *Carter and Bailey,* Canada.

The "condensed solubles" prepared from the stick-water in British Columbia, Canada, is now an increasingly important commodity. Slightly over 1000 tons were produced in 1948.

From discussions:

Lassen, United States, felt that it might be of interest to know that on 10 August 1950 five tank cars of condensed fish solubles, produced on the West Coast of the United States, were sold at 5¼ cents per lb., which was close to the price level at which fish solubles had been

[1] "A Review of the Technology of British Columbia Herring Products Investigated at the Pacific Fisheries Experimental Station of the Fisheries Research Board of Canada", a paper prepared for the meeting by *Neal M. Carter* and *Basil E. Bailey,* Pacific Fisheries Experimental Station, Vancouver, B. C., Canada.

sold for the last one or two years. Therefore, he did not feel that any drastic decline in prices had taken place.

Sparre, Norway, mentioned that one should also consider the possibilities of competition that might derive from the developments in the manufacture of the whole vitamin-B complex and the animal protein factor by synthetic processes.

Lassen, United States, related that just when fish solubles first were brought on the market, concentrated riboflavin had been brought on the market. Two years later riboflavin was synthetized and the price was now down to 12 U. S. cents a gram. At least 5 or 6 of the many vitamin-B complexes which were discovered in the subsequent years had been synthetized, and the price of them has come down, bringing them within the reach of the feed manufacturer. In spite of this, the price of fish solubles have remained steady. We, therefore, felt that a natural product like fish solubles would always be able to retain enough popularity to make it demand a good price in spite of many synthetic products put on the market. Another prospect was the competition from other types of manufacture of products such as the animal protein factors, *etc.* He had tried synthetic product in experiments within the last six months. In these experiments a basic ration was fed containing vegetable proteins only and either synthetic APF or solubles were added. Chickens were used in this experiment. They grew considerably faster on the ration containing fish solubles than on the one to which the synthetic APF had been added. This led one to believe that fish solubles not only contained the factors that one already knew about and which have been isolated and identified, but also others that are still unknown.

Crowther, United States, said that the United States market for fish solubles was strong and stable for the moment. One should keep in mind that the whole menhaden industry recently had begun the manufacture of fish solubles and undoubtedly in the future would supply very large amounts. He felt that the European manufacturers should look not only to the United States market but also to potential markets in Europe.

Sparre, Norway, mentioned that there were some indications that the United States market for fish solubles might soon be saturated and the United States be able to supply its own need. Therefore, European manufacturers should investigate very carefully the marketing possibilities in Europe.

Harms, United Kingdom, felt that the fish solubles might be used for human nutrition in, for instance, the Far East.

Possible Competition from Whale Solubles

From discussions:

Lassen, United States, mentioned that the amount of proteins available in fish solubles was very small; their main value was derived from their content of vitamin B_{12} and other factors. The amount of fish solubles used in a feed ration seldom exceeded 5 per cent, thus the protein content, which generally was about 35 per cent in fish solubles, was of minor importance. In this respect the product was different from a product which was coming to the fore at that moment, namely solubles made in the processing of whales. These solubles have an entirely different function; they do not contain the vitamin-B complex factors in any appreciable amounts except the animal protein factor itself. But whale solubles were a very valuable protein supplement. It had been possible to add 20 per cent whale solubles to a ration and thereby supply more than half the total protein requirement, and without experiencing any decrease in growth rate when this mixture was used for young animals. He felt that it was likely that large amounts of whale solubles would be put on the market in the near future, but they would not represent any real competition to fish solubles.

Shipment

From *Sparre's* paper:

Another problem that merits most careful consideration is that of handling and shipping. In the United States a product with 50 per cent moisture has been definitely established. This is a thick, viscous liquid which seems to be transported mostly in tank cars. The problem confronting European producers is not so simple. To ship concentrated solubles in tank ships hardly seems feasible. Even if shipping space could be found, there is the danger connected with the shipment of a corrosive fluid. The smell of the product is decidedly "fishy", making it difficult to clean the tankers for other cargo. Big storage tanks would need to be erected at the receiving end to hold the product when it is discharged and before it can be sent inland in tank cars. A load of say 5000 tons would require perhaps 200 such tank cars, which possibly would have to be used exclusively for this trade. Due to these considerations, shipments of fish solubles might have to be effected in drums or barrels and consequently at quite high shipping costs.

From discussions:

Thorbjarnarson, Iceland, said that export of fish solubles seemed to be out of the question for Iceland unless the product could be shipped in tank ships. He was under the impression that fish solubles had been shipped in tank ships from Alaska to the United States for several years. He was wondering whether any serious corrosion difficulties had developed.

Lassen, United States, said that condensed fish solubles were sent from Alaska to Seattle in tank ships. These boats were also used for fuel oils. There were no particular corrosion problems, but the tanks should be coated on the inside before they were filled with fish solubles. This coating might be done with herring oil. Tank cars have also been used extensively and while it was possible that some corrosion did take place it certainly was extremely limited, as he had never heard any complaints from transport companies or anyone else about it.

Whole Meal

From *Sparre's* paper:

In Norway whole meal is at present sold at a premium, but it is doubtful that this is possible on the export market. Whole meal and ordinary meal cannot readily be distinguished by the buyer. The criterion in Norway is, as mentioned above, that whole meal contains 20 per cent of its protein in water-soluble form. One might fear that by disposing of the fish solubles as an integrating part of herring meal one would lose the advantage of its higher value as a vitamin source.

From discussions:

Notevarp, Norway, felt that whole meal represented a good solution of the problem of stick-water utilisation and that a good-quality whole meal should obtain a premium price on the feeding-stuff market. The added cost of installation when one wants to manufacture whole meal instead of ordinary herring meal was small, compared with what was needed for the manufacture of fish solubles. The total cost of the additional equipment might not be more than 20—25 per cent of the cost of the total machinery already required for a traditional herring-meal plant, and the cost of production was very low. It seemed that experience in Norway had shown that manufacturers get at least 30 Norwegian kroner more net profit per ton of raw material when manufacturing whole meal than when they manufacture ordinary herring meal. This included a premium price on the whole meal of about 10 kroner per ton more than ordinary meal. This net profit would pay off the whole installation in one year, if one calculated as Mr. Sparre did, with a production of 15 000 tons of herring a year, in a plant having a capacity of 4—500 tons a day.

Bartz Johannesen, Norway, mentioned that he felt it quite logical that a special price would develop for whole meal.

Comparison

From *Sparre's* paper:

It is felt that with the present prices of fish solubles, their reconversion into whole meal would be a half-measure. The most flexible solution would still be to prepare fish solubles as a separate product with 50 per cent moisture. It could then be sold as such, or subsequently spray-dried and sold as a powdered product or eventually be added to the herring meal, as demands arose.

From the paper "New Reduction Processes" by *Sand,* Norway:

It is likely that the industry would be better off with a variety of products, designed, on the basis of market analysis, to meet specific needs in the different parts of the world. A variety of products, but with uniformity of each type and satisfactory guarantees for the buyer, would probably be the most satisfying solution.

From discussions:

Bartz Johannesen, Norway, felt that one should try to develop markets both for whole meal and for fish solubles. He did not see that one needed to exclude the other.

Davis, United States, mentioned that it was more a matter of economics than technology to figure out whether one should make whole meal or ordinary fish meal and solubles, as it depended on marketing conditions. He felt that it is better economically to have two products. One product might help if the market for the other, for some reason, is declining.

Lassen, United States, said that in his country there was no question as to whether one should manufacture whole meal or herring meal as a separate item and fish solubles. The feeling in the industry was definitely that fish meal and fish solubles individually have specific qualities and should not be mixed. Lately, between 100 and 150 million lb. of condensed fish solubles had been sold in the United States each year. He felt that Mr. Sparre in his paper possibly had been a little too pessimistic about the market outlet for this product. He felt that there was quite a stable market for condensed fish solubles, and the price had not varied very much. There was a decrease in prices for fish meal as well as fish solubles late in 1949 but while the decrease in fish-meal prices had been very considerable, the price of fish solubles had varied only a fraction of a cent per pound.

Other Methods of Utilizing Stick-water

From discussions:

Roskam, Netherlands, suggested that as long as it was only the vitamins one was after in the fish solubles and as long as the cost of evaporation was the biggest item in the manufacturing cost, one might consider whether it would be possible to separate the vitamins by absorption methods, for instance by the use of fuller's clay, bentonit, *etc.*

Lassen, United States, mentioned that several efforts had recently been made towards finding some way of separating and utilizing the vitamin complexes in stick-water through absorption methods. It seemed possible to obtain a 10- to 100-fold concentration. He had made some very early experiments with fish stick-water and fuller's earth. A considerable amount of the B-complex factors were actually absorbed on fuller's earth. However, one ran up against the problem of the so-called filtrate factor. An important part of the B-complex factors would not absorb on fuller's earth at all. This discovery had also been made by other centers and might in fact lead to the discovery of certain additional vitamin-B factors of a non-absorbable nature.

Cholesterol Recovery

From discussions:

Lassen, United States, gave reference to some experiments and calculations regarding recovery of cholesterol from fish oil or fish meal. The experiments that had been done primarily with the purpose of obtaining complete removal of the cholesterol in the fish oil were only partially successful. It was found that by the use of a liquid-extraction method using methyl alcohol it was possible to remove up to 75 per cent of the cholesterol content which was between 0.5 and 1 per cent in usual sardine oil. Such solvent-extraction method removed also the free fatty acids, which of course was only an advantage, but, in addition, sizeable amounts of the neutral oil were also removed. This solubility of the oil itself in methyl alcohol, is a serious objection to this method. A high concentration of cholesterol was obtained in one fraction, however, and he felt that if work in this field were continued one might very well eventually arrive at a practical method for the removal and recovery of cholesterol. There was similarly a possibility of recovering cholesterol from the herring meal. He had found by analyzing various types of fish meal such as mackerel meal, tuna meal and sardine meal that there apparantly is from 3 to 5 lb. (1.4 to 2.3 kg.) of cholesterol per ton of meal. The highest content was found in mackerel meal. Cholesterol was assuming an increasing importance in the synthesis of hormones and similar products. One should keep in mind that large amounts of cholesterol were being produced from other sources such as spines, brains, *etc.* He understood that Mr. Thorbjarnarson, Iceland, recently had succeeded in proving the presence of considerable amounts of cholesterol in the testes of cod.

Lassen felt that it was possible that the extraction processes for the manufacture of fish meal could be combined with the extraction of cholesterol, and, that even the extraction from ordinary fish meal might have possibilities. The price of cholesterol at that moment was about 6 United States dollars per lb. Therefore, a ton of fish meal would contain about 30 dollars worth of cholesterol. This was really a very substantial amount considering the total value of a ton of fish meal. The extraction will, of course, cost somewhat, but it seemed that the margin was sufficient to merit investigation to try to find economical extraction methods, so much the more as one at the same time would improve the quality of the fish meal by removing all fats from it. Unfortunately, extraction plants were very expensive. He understood, however, that prices for such plants were coming down as simpler methods were being developed. It might well some day prove possible to carry out such an extraction. This would, of course, be of interest mainly in the case of meal from fatty fish.

Notevarp, Norway, related that in Norway some experiments had been carried out under him regarding extraction of cholesterol from herring oil. The method worked satisfactorily as far as free cholesterol is concerned, but about ⅔ of the cholesterol was found as esters of fatty acids which were very difficult to extract. He added that it was a question whether the extraction of cholesterol from herring oil was profitable when the amount of cholesterol was for instance around ¾ per cent.

Recommendations for Future Research, Etc.

In summing up a few of the most important problems, the solution of which will make it easier to sort out or design sound processing methods, the meeting called attention to the following points:

1. More research is needed with regard to the preparation of the raw material and to the relative merits of the various manufacturing processes, both for fish solubles, whole meal and possibly both. One should keep in mind the advantages of as flexible a production as possible, and the quality of the products obtained, when comparing the cost of production.
2. To establish needs and desires in different regions; perhaps also education of the buyers. More analysis is needed of the marketing possibilities for the various products.
3. There is a great need for additional work on methods for evaluation and standardization of the products.
4. Agricultural-research institutions should be encouraged, possibly through FAO, to undertake more studies of the question of the nutritive value of fish solubles, whole meal, *etc.*, keeping in mind the need for carefully controlled experimental conditions and also the need for complete data regarding the composition of the raw material and the method used in the manufacture of the product tested.

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