Fisk. Dir. Skr., Ser. Ernæring. Vol. 1: No. 4, 137–144

MAJOR AND MINOR ELEMENT (MINERAL) LEVELS IN PRODUCTS AND OFFAL FROM THE FISHING INDUSTRIES

By
K. JULSHAMN, J. HAUGSNES and J. ERIKSEN
Institute of Vitamin Research
Directorate of Fisheries, Bergen, Norway.

ABSTRACT

80 samples representing 39 different edible products and waste products of cod, saithe, haddock, tusk and redfish have been analyzed for their element (mineral) contents, as a part of a study on the possible use of waste products from the fishing industry. All samples were obtained off the northern coast of Norway and in the Barents Sea. 14 major and minor element concentrations were determined by atomic absorption spectrophotometry. All details on the methods of analysis are given in the preceding report.

The results are given in 8 tables as average values for each product and element. All elements except potassium, magnesium, selenium, arsenic and mercury were found in lower concentrations in the fillets than in the intestines of the fish species investigated. Cadmium, mercury and lead, which are of interest as contaminating elements, were generally found in low levels near the detection limits of the methods.

INTRODUCTION

The Norwegian Government appointed in 1973 a committee with mandate to evaluate the amount of byproducts and waste products in the fishing industry, further, to obtain a total nutritional characterisation of the different products and lastly to propose possible ways of increased utilization of these protein resources. Waste products which are lost during industrial processing of fish, represent a considerable protein resource which should be exploited.

This report is concerned with the contents of minerals and trace elements in fish products and waste, and is a part of the survey of nutrients in these products.[1]) In addition, it adds to our knowledge of the distribution of elements in different fish species and tissues.

The preceding paper in this publication was based on a nutritional survey of several fish species.[2]) The present study deals with a few species only, whereas several different parts of the fish were analyzed.

---

[1]) Report no. 2 from the committee on fishery byproducts. Fiskeridirektoratet, Bergen, June 1977.

[2]) JULSHAMN, K., HAUGSNES, J. and UTNE, F., 1978. Fisk. Dir. Skr. Ser. Ernæring *1*. 117–135.

METHODS

The fish samples were collected during the years 1974 and 1975 off the northern coast of Norway and in the Barents Sea during normal fishing operations. No precautions were taken to prevent contamination of these samples during handling, transport and storage. The fish were brought whole to the factories and a random number were taken out for sampling. The fish were weighed, measured, nobbed and gutted. Different parts were collected, weighed and frozen. The samples were made up from pooled individuals of an appropriate number, the total weight of each sampling being at least 1 kg. Thus, for the sample of fillet five individuals were used, whereas for the sample of gall bladder at least fifty individuals were used. At the laboratory the samples were ground and at least 100 g was taken out and freeze-dried to constant weight, whereafter the dried material was homogenized and kept in tightly closed jars until analysis.

The analyses of all 14 elements were made by atomic absorption spectrophotometry. Details of all methods, including digestion of the freeze-dried samples, pretreatments of the solutions and intrumental modifications are given in the preceding report. Further are evaluated the accuracy and reproducibility of the methods.

RESULTS AND DISCUSSION

Results of the determination of 4 major and 10 minor elements in 80 samples, comprising 15 from different parts of cod, 7 each from different parts of saithe and redfish and 3 samples of tusk are reported in tables 1 to 4 and 5 to 8. The tables give average values where more than one sample of each product were analyzed. A full report on all single values are given in the report no 2 from the committee on fishery byproducts.

Additionally, tables 1 to 4 give the number of samples analyzed from each product, the percentage which each sample represents of the whole fish and the percentage dry matter as determined by freeze-drying. Samples of edible parts of cod are shown in tables 1 and 5 as the first group of values. Mature cod roe had the highest percentage of dry matter, 30.5%, whereas

Table 1. Major elements in edible parts of cod, g/kg wet weight.

Sample	No of samples	% of whole fish	% dry matter	Na	K	Ca	Mg
Fillet	10	55	19,5	0,61	4,1	0,08	0,26
Gutted fish minus head	1	65	21,9	0,91	3,3	4,7	0,28
Tongue	5	0,6	18,6	1,6	3,0	0,13	0,12
Roe (juvenile)	1	0,3	18,3	0,9	3,9	0,08	0,20
Roe (mature)	1	5,3	30,5	1,3	2,1	0,11	0,08
Soft roe (milt)	1	5,3	15,9	0,92	2,8	0,10	0,19

Table 2. Major elements in non-edible parts of cod, g/kg wet weight.

Sample	No of samples	% of whole fish	% dry matter	Na	K	Ca	Mg
Head minus gills	5	6,7	25,8	2,9	1,7	22,1	0,42
Gills	4	3,2	19,1	2,5	1,9	6,8	0,26
Skin	1	2,6	18,8	0,73	0,63	5,0	0,12
Backbone	1	4,8	22,0	1,3	2,2	12,0	0,30
Intestines	1	4,8	24,4	1,5	2,8	1,3	0,36
Intestines minus stomach	3	3,0	23,1	1,5	2,3	1,6	0,39
Stomach, empty	4	1,8	20,1	1,9	1,9	0,23	0,18
Stomach content	2		13,4	2,2	1,4	1,5	0,39
Gall bladder	1	0,7	16,5	2,4	1,6	4,5	0,31

the other values were in the range 16 to 22%, averaging 19.6%. The second group of values (tables 2 and 6) comprise non-edible parts of cod, with an average content of dry matter of 20.8%, ranging from 13% in the stomach content to 26% in the heads. The third groups, tables 3 and 7, samples of different parts of saithe, had an average percentage of dry matter of 22.5%. Tables 4 and 8 give values from samples of haddock, tusk and redfish. Haddock and tusk are species of the cod family, and the dry matter contents were similar to those of the cod samples, whereas redfish had a higher content of dry matter, reflecting a higher fat content.

The preceding report gives a table of averages, low, main and high ranges for the 14 element found in fish species and products. These values were used as a basis for comparison in the present report.

Table 3. Major elements in different parts of saithe, g/kg wet weight.

Sample	No of samples	% of whole fish	% dry matter	Na	K	Ca	Mg
Gutted fish minus head .	2	71,5	24,1	0,58	2,8	7,5	0,34
Head with gills	1	12,4	22,4	2,4	1,8	17,6	0,28
Head minus gills.....	3	9,6	23,0	2,7	1,7	15,7	0,33
Gills	3	2,8	23,7	2,9	2,3	9,0	0,33
Intestines minus stomach	3	6,4	24,7	1,8	2,4	3,5	0,65
Stomach, empty	1	1,1	21,4	1,7	2,3	0,27	0,21
Stomach content	2	1,1	19,4	2,1	2,0	1,9	0,42

SODIUM AND POTASSIUM

Samples of gutted, headless fish, fillet and skin had sodium values in the low range, 0.5–1.0 g/kg, whereas the highest values were found in fish heads. Low values for potassium were seen in skin, heads and intestines, 0.6–2.0 g/kg, and the highest values were found in fillets and gutted, headless fish (2.8 to 4.1 g/kg). Correspondingly, the equivalent ratio between sodium and potassium ranged from 1:5 in fillets to 2.5:1 in heads. The distribution of sodium and potassium did not seem to differ among the species investigated.

CALCIUM AND MAGNESIUM

Very low values for calcium were found in samples of fillet, roe, tongue and stomach (0.1–0.4 g/kg), whereas samples of heads were high in all species investigated (12–22 g/kg).

Most of the magnesium values were in the main range 0.25–0.55 g/kg (see table 13, JULSHAMN et al. 1978), but low magnesium contents were found in samples of tongue, roe, skin and stomach (0.1–0.2 g/kg).

ESSENTIAL TRACE ELEMENTS (Mn, Fe, Co, Cu, Zn)

As found in the samples of fish species and products (preceding report) manganese was found in high levels in samples with high bone contents. Thus, values of 2 to 5 mg/kg were found in heads and gills of saithe and haddock. Fillets had low manganese levels, 0.1 to 0.5 mg/kg.

The values of iron varied widely with the different parts of the fish. The highest values were found in heads and gills, probably because of a high

Table 4. Major elements in different parts of haddock, tusk, redfish and catfish, g/kg wet weight.

Sample	No of samples	% of whole fish	% dry matter	Na	K	Ca	Mg
Haddock, gutted minus head	2	71,5	23,6	0,86	3,4	11,4	0,40
» fillet	1	52	20,6	0,56	3,3	0,41	0,26
» head minus gills	2	11,6	20,3	2,5	1,5	18,0	0,33
» gills	1	2,6	19,7	2,1	2,0	n.d.	0,33
» skin	1	n.e.	20,4	0,45	0,57	7,4	0,11
» guts minus							
» stomach	2	5,1	17,9	1,5	1,7	1,1	1,09
» stomach, empty	2	0,8	20,8	1,9	2,2	0,62	0,26
Tusk gills	1	2,0	24,6	2,5	1,7	5,9	0,15
» guts minus							
stomach	1	3,2	22,6	2,3	2,5	2,4	0,50
» stomach, empty	1	1,4	22,1	2,5	1,9	0,26	0,12
Redfish, whole	1	100	34,5	1,4	3,1	9,5	0,26
» gutted minus head	1	67,9	36,3	0,84	2,9	9,0	0,36
» fillet	1	n.e.	30.4	0,57	3,7	0,17	0,28
» head with gills	1	20,9	35,9	2,6	2,0	22,7	0,30
» head minus gills	3	16,7	36,5	2,6	1,7	20,2	0,39
» gills	1	4,2	28,7	2,1	2,2	n.d.	0,28
» guts minus stomach	2	6,7	50,6	1,6	1,9	0,44	0,49

Table 5. Minor elements in edible parts of cod, mg/kg wet weight.

Sample	Mn	Fe	Co	Cu	Zn	Se	As	Cd	Hg	Pb
Fillet	0,12	2,1	<0,005	0,27	3,1	0,22	3,2	0,002	0,03	0,04
Gutted fish minus head	0,71	20,0	<0,002	0,51	9,8	0,43	1.2–6.2	<0,001	0,08	0,08
Tongue	0,53	4,0	0,003	0,72	9,0	0,25	2,6	0,08	0,01	0,15
Roe (juvenile)	0,82	17,0	0,008	1,27	132	0,74	0,9	0,008	0,03	0,08
Roe (mature)	0,78	9,0	0,005	0,63	45	0,76	0,8	0,001	0,02	0,05
Soft roe (milt)	0,40	4,0	0,002	1,60	5,0	0,24	5,4	0,008	0,01	0,08

Table 6. Minor elements in non-edible parts of cod, mg/kg wet weight.

Sample	Mn	Fe	Co	Cu	Zn	Se	As	Cd	Hg	Pb
Head minus gills	1,4	23	0,003	0,98	18,3	0,56	2,6	0,08	0,04	0,12
Gills	1,2	25	0,005	0,59	16,6	1,0	1,4	0,18	0,04	0,11
Skin	1,0	13	0,004	0,64	10,0	0,29	0,4	0,01	0,01	0,08
Backbone	1,2	16	0,005	0,36	12,1	0,58	2,9	0,02	0,08	0,03
Intestines	0,61	19	0,24	2,5	29,0	1,2	1,1	0,03	0,02	0,03
Intestines minus stomach	0,71	26	0,15	2,4	25,6	1,2	5,5	0,05	0,05	0,11
Stomach, empty	1,1	11	0,004	1,6	17,8	1,4	1,4	0,04	0,06	0,12
Stomach content	1,5	23	0,004	2,7	15,4	1,4	1,1	0,05	0,08	0,06
Gall bladder	2,3	36	n.d.	2,4	29,8	0,76	3,9	n.d.	0,11	n.d.

Table 7. Minor elements in different parts of saithe, mg/kg wet weight.

Sample	Mn	Fe	Co	Cu	Zn	Se	As	Cd	Hg	Pb
Gutted fish minus head	1,6	16	0,005	0,65	14,0	0,39	2,2	0,001	0,07	0,10
Head with gills	2,0	15	0,002	2,2	18,0	0,64	0,3	0,014	0,02	0,02
Head minus gills	2,2	48	0,004	0,79	19,4	0,47	1,0	0,027	0,09	0,06
Gills	2,7	34	0,006	1,4	19,8	1,3	1,0	0,020	0,03	0,14
Guts minus stomach ..	1,5	19	0,19	4,2	51	1,9	2,3	0,12	0,07	0,06
Stomach, empty	0,50	8	0,003	3,0	19,2	0,95	0,7	0,005	0,09	0,06
Stomach content	1,4	10	0,004	3,9	20,0	1,0	1,0	0,035	0,02	0,09

content of hemoglobine. The fillet samples were low in iron, with 2.1, 2.6 and 5.0 mg/kg in cod, haddock and redfish, respectively.

All values for cobalt were below 8 microgram/kg (average 3.5 μg/kg), except in the samples of guts (intestines) without stomach were the values ranged between 0.09 and 0.24 mg/kg.

The major contribution to the cobalt content in guts comes from the liver. The normal low levels of cobalt relate to the content of vitamin B_{12} (Cobalamin) in the tissues.

The copper contents were low in fillets samples ($\sim$ 0.3 mg/kg) and high in samples of intestines, again pointing to high levels in the liver. There was a 1:10 range between fillet and intestines for copper in the species of fish analyzed, compared to a 1:100 range for cobalt. The samples of saithe had the highest copper values.

Low zinc contents (3–10 mg/kg) were found in the cod samples with the exception of roe. Very low values were also found in the fillets of haddock and redfish (2, resp. 5 mg/kg). High values were found in the intestines of saithe and in mature cod roe, whereas the juvenile cod roe gave the exceptional value of 132 mg/kg.

Table 8. Minor elements in different parts of haddock, tusk, redfish and catfish, mg/kg wet weight.

Sample	Mn	Fe	Cu	Co	Zn	Se	As	Cd	Hg	Pb
Haddock,										
gutted minus head	2,6	35	0,38	0,004	15,1	0,24	8,1	0,004	0,06	0,08
fillet	0,20	2,6	0,27	<0,002	2,2	0,39	15,2	0,003	0,05	0,04
head minus gills	4,8	35	0,64	0,005	15,3	0,58	0,5	0,045	0,03	0,15
gills	2,6	27	0,41	0,003	15,1	1,5	0,5	0,030	0,01	0,09
skin	1,8	7,0	2,1	0,005	14,2	0,36	0,4	0,042	0,05	0,13
guts minus stomach	1.0	16	2,5	0,22	23,5	1,6	2,3	0,21	0,06	0,12
stomach, empty	1,9	22	0,78	0,003	19,1	1,9	0,7	0,020	0,05	0,30
Tusk,										
gills	1,1	21	0,57	0,002	14,8	0,66	1,3	0,040	0,03	0,12
guts minus stomach	0,65	37	1,8	0,092	20,0	1,3	0,6	0,022	0,002	0,19
stomach, empty	0,55	14	1,1	0,002	11,7	1,3	0,4	0,031	0,02	0,19
Redfish,										
whole	0,45	13	0,50	0,002	13,1	0,43	1,2	0,040	0,04	0,03
gutted minus head	0,49	30	0,50	0,002	13,9	0,54	3,8	0,020	0,04	0,17
fillet	0,41	5,0	0,35	0,002	5,3	0,37	3,5	0,008	0,07	0,06
head with gills	0,51	23	0,87	0,002	16,0	0,79	0,6	0,041	0,01	0,06
head minus gills	1,8	39	1,5	0,005	19,4	0,65	1,1	0,19	0,04	0,14
gills	1,1	58	1,39	0,004	19,8	1,3	1,2	0,010	0,01	0,02
guts minus stomach	0,7	26	1,1	0,23	26,0	n.d.	n.d.	0,080	n.d.	0,17

SELENIUM AND ARSENIC

The lowest values of selenium were found in the samples of fillet, skin, tongue and softroe, 0.2–0.4 mg/kg. Samples of gills and intestines showed the highest values, 1–2 mg/kg. The values fell within a 1:10 range, and no differences were found between the species. No positive correlation could be observed between the selenium and mercury contents. The fillet samples showed high values of arsenic, 3.2, 15.2 and 5.3 mg/kg in cod, haddock and redfish, respectively. Particularly, the samples of fillet and of gutted, headless haddock were surprisingly high. The samples of roe, stomach, skin, gills and heads showed the lowest value, less than 1 mg/kg.

CADMIUM, MERCURY AND LEAD

Excepting cod tongue, the edible parts of the fish samples showed low values of cadmium (<0.01 mg/kg). Most samples of non edible parts of the fish species were in the main range (0.01–0.05 mg/kg) given in the preceding report. A few high values were found in gills of cod, intestines of saithe and haddock and in heads of redfish (0.1 to 0.2 mg/kg). Fish fillets do not contribute much to the maximal weekly intake recommended by FAO/WHO of 0.4–0.5 mg per week. FAO/WHO have suggested a range of 0.01 to 0.04 mg in foodstuffs.

The mercury values ranges from 0.01 to 0.1 mg/kg. The highest mercury content was found in a sample of cod gall bladder, 0.11 mg/kg.

Many of the values found for lead were near the detection limit of the methods. All samples were below 0.3 mg/kg. The weekly intake through foods in the U.K. was estimated to 1.2 mg and FAO/WHO assessed a lead intake at 3 mg per week. The average content of lead in the diet in the U.K. was found to be 0.09 mg/kg.

Of the 14 elements analyzed, all except 5, K, Mg, Se, As and Hg, were found in the lower range in the fillet samples of cod, haddock and redfish. The trace metals were generally found in low concentrations in fillets, and in higher concentrations in the intestines. Generally low levels of the contaminating elements, cadmium mercury and lead were found, and this reflects the low levels of industrial pollution off the northern coast of Norway and in the Barents Sea.