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Thawing of frozen fish in moist air.

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Numerous experiments have been carried out in different countries (1 to 19) in order to find out and develop more convenient methods of industrial thawing of frozen fish than the methods being applied at present. Experiments in Norway have comprised thawing in water and air, and recently the possibilities of obtaining a satisfactory thawing with the use of moist air blast has been investigated. The latter principle of thawing is known and described in earlier litterature (20). Recently suitable equipment (thawing plants) have also been developed for use in the industry and these plants are in operation commercially (21).

The thawing process mentioned can be arranged in different ways. The thawing may be carried out in a tunnel or a chamber, and the fish may be conveyed continuously through the apparatus in various ways as f.i. on waggons, conveyors etc.

The experiments in Norway were partly arranged in a small thawing tunnel in the laboratory and partly in a thawing tunnel built at a freezing plant in Northern Norway. In both instances the conditions, such as air temperature, velocities, etc., could be varied in order to find out the most suitable values, and obtain a satisfactory result as far as the quality of the fish is concerned.

The method has, however, not been adopted in industrial thawing of frozen fish in Norway, and it is difficult to say to what extent industrial thawing of frozen fish in connection with refreezing of fillets are going to be used, because frozen fillets from fresh unfrozen fish are preferred to those produced from frozen round fish stored and later thawed, and resulting in reduced quality. Some of the results obtained in our experiments, however, may be of interest and will be described in the following.

The experimental tunnel mentioned above is designed for thawing of individual fish or in blocks, weighing up to 40 kilos, and the thawing tunnel in Northern Norway has a capacity of about 2½ tons per load. It has doors in both ends where the fish is

taken in and out of the tunnel. The circulation and heating of the air is undertaken by a fan and an electrical heater. The air is blown over the fish blocks and through the tunnel longitudinally, and the fish blocks are sprayd with water to avoid drying out of the surface of the fish during the thawing in the warm air blast. The tunnel also is equipped with a steam and water supply to be used in experiments with steam or water to obtain high moisture contents in the air.

Frozen blocks of headed and eviscerated fish, single fish and blocks of fillets were used in the experiments. Part of the fish blocks were frozen in moulds on board a trawler and part of it in a freezing plant ashore. The blocks were about 20 kilos in some of the experiments and up to about 45 kilos in others.

The extent of the thawing time and fish quality obtainable under different thawing conditions of temperature and air velocity has been investigated. The yield obtained in thawing, filleting and refreezing of the fish was recorded, and the quality of the fish thawed in moist air blast was compared with the quality of other samples thawed in still air, fresh water and sea water. Further it was investigated if it was preferable to apply steam or water to obtain a high humidity in the air or if the fish blocks should be showered with a water spray during the thawing process.

Results and experiences.

According to the litterature on the subject of thawing of frozen fish it has been stated that the rate of thawing has little influence on the quality of the fish provided the thawing is carried out within a reasonable time (20, 22, 23, 24). In slow thawing on the other hand, it has been thought that the thawing time has a certain influence because it takes a longer time to increase the temperature of the fish in the zone between -1° and $-5^{\circ}C$, where the denaturation of the protein progresses more quickly, than at lower temperatures. Some results have also showed a greater decrease in "soluble protein" during slow thawing of fish than during quick thawing (22), and according to Canadian experiments (24) there was a greater difference in the values of "soluble protein" before and after thawing if the fish was stored before thawing than if it was newly frozen. Frozen, stored fish probably therefore may have a greater loss of quality during the thawing

period than newly frozen fish.

For reasons due both to quality and capacity it is therefore of interest to find a method which will enable us to carry out the thawing process as quickly as possible. Consequently, a good heat transfer is important, and this may be obtained by the use of an efficient air circulation and comparatively high air temperatures. However, a too high temperature will reduce the fish quality and result in greater loss of water from the fish fillets, and must be avoided.

It is also a known fact that the thawing time is depending on the block thickness and that a quick falling apart of the blocks will reduce the thawing time. Any means of dividing the blocks into individual fishes f.i. by mechanical means, will therefore speed up the thawing process. Further it is obvious that uneven blocks having a comparatively greater surface can be thawed in a shorter time than even blocks with less surface.

The experiments in thawing of frozen fish carried out in Norway have confirmed the importance of the factors mentioned above. Thus both the temperature, the air velocity, the dividing of the blocks into single fishes, the condition of the surface of the blocks, and the moisture of the air, all have a great influence on the thawing time and the quality obtained in the thawing of frozen fish. The experiences also show that, it may be possible to obtain an acceptable product in thawing of frozen fish in moist air providing the conditions are ideal. Thawing of frozen fish in moist air blast also gave better results than thawing in fresh water or sea water, but the quality of refrozen fillets of cod produced from frozen and thawed fish was not quite as good as the quality of frozen fillets produced from fresh fish.

Further it was found that the fish blocks must not be thicker than 10 cm if the results of thawing in moist air should be satisfactory. Thicker blocks required long thawing time, and the quality of the fish in the blocks was consequently reduced more than in the thawing of thinner blocks thawed in shorter time.

It has been confirmed that the temperature of the air should not exceed +18° to +20°C, as stated earlier by Reay (4). If the temperature was higher, the fish became soft, some of the fillets were split when the fish was filleted and in some cases a peculiar unpleasant odour from the thawed fish was observed. To prevent

such results a careful control of the temperature is necessary.

A suitable air velocity seems to be about 5-6 m/sec. as mentioned in a previous publication by Waterman (17). Lower air velocity results in longer thawing time, and according to experiments carried out at the Norwegian Fisheries Research Institute, by Rolf Ruud, the influence of the air velocity was greater the lower the temperature. He found that the thawing time for a single fish was reduced 11 per cent by increasing the air velocity from about 1.5 m/sec. to about 2.5 m/sec., and reduced 22 per cent by increasing the velocity to 5 m/sec. at an air temperature of +20°C. In other experiments using blocks he found 35 per cent shorter thawing time by increasing the air velocity from about 1.5 m/sec. to 5 m/sec. The thawing time was reduced 30 per cent by increasing the temperature from +20° to +25°C, but for quality reasons the temperature should not be raised that high. Results also indicate that the fish preferably should not be kept in the warm air in the tunnel longer than 4-5 hours.

During the experiments a relative humidity in the air of 100 per cent could easely be obtained by using either sprays of warm water or steam. A saturated air is required to give a good heat transfer rate and avoid drying out of the fish surface, and according to the results it seemed immaterial whether steam or water was used. With the other factors such as temperature and air velocity alike the thawing time was the same in both instances. By the use of steam, however, precautions must be taken to prevent the temperature from exceeding +20°C.

As mentioned above the dividing of the blocks into single fishes during the thawing process also had a marked influence on the thawing time, and in ideal conditions the thawing time for a 10 cm thick block probably will not exceed about 4½ hours.

It further seems advantageous in order to maintain the quality, to interupt the thawing process before all the fish is thoroughly thawed and prevent the temperature in any parts of the fish to become too high (not higher than a few degrees centigrade above freezing). Alternately the temperature of the air should be lowered in the latter part of the thawing period.

In the experiments carried out with the thawing of frozen fish in moist air blast no loss in weight of any importance was observed, but a too great difference in the thawing of various

parts of the block (center and surface) caused a lower yield of fillets than could be obtained from fresh fish. It is presumed, however, that the yield could be improved with more experience.

It may also be mentioned that no water was pressed out of the fish during the packing and refreezing of the fillets from the fish thawed in moist air. This is of course and advantage. Such a loss is commonly encountered during packing and refreezing of fillets from fish thawed in water.

Further it was found that the blocks could be divided easier and quicker during the thawing process if the round fish before freezing was dipped in a solution of alginate with a lower melting point than ice. This method should therefore give an advantage depending on the cost of the alginate. Thawing frozen fillets dipped in this manner seemed, however, not to influence the thawing time appreciably.

In the thawing and refreezing of fish fillets some advantages may also be obtained by dipping the fillets in solutions of sodiumtripolyphosphate + NaCl before freezing. Both the "Fresh Lock" method, patented in USA (25) and the dipping of fish fillets in different solutions of tripolyphosphate and salt have been tried. In both cases some improvement of the quality was obtained. In particular the gloss of the fish was improved and the loss of drip during thawing of the fish was reduced.

Experiments in thawing of frozen blocks, having the same thickness, have showed that blocks containing smaller fishes thawed somewhat quicker than blocks containing bigger fishes, provided an efficient dividing of the blocks into single fishes during the thawing process could be obtained. Smaller fishes, however, will often be more sensitive to mechanical influence. In connection with the air thawing of fatty fish such as herring and sprat etc. one also will encounter the problem of rancidity, and so far the best results in thawing of sprat have been found to be thawing in a water spray. In Norway this method therefore has been adopted for the thawing of sprat and herring. The blocks are placed in racks with water sprays arranged above, and the individual fishes are loosened and removed from the blocks by the sprays during the thawing process. If desired the thawed fish may be collected on a conveyor below the racks.

Attempts in utilizing the same method with water sprays for

larger fish probably would also be worth trying out. An advantage with this method is that the fish blocks can be divided without mechanical help as would be necessary with air thawing and water thawing. The fish will also absorb less water when thawed under the water sprays than it will be when totally immersed in water.

Summary.

Experiments in thawing of frozen fish blocks in moist air blast have been carried out in order to gain experience and investigate the possibilities of this method for the industrial thawing of frozen fish. Blocks of headed and eviscerated fish, one or more single fishes, or blocks of fillets etc. were used in the experiments. The weight of the blocks were about 20 kilos in some of the experiments and about 45 kilos in others. Thawing time, yield and quality of the fish under different conditions (temperature, air velocity etc.) were recorded, and the quality obtained in thawing of fish in moist air blast was compared to the quality of fish obtained in thawing of other samples in still air, or immersed in fresh water or sea water.

The experiments show that acceptable results in thawing of frozen fish in moist air blast may be obtained with ideal conditions pertaining during the thawing process. The quality of the fish was better than that obtained in thawing of fish immersed in fresh water or sea water. On the other hand, however, the quality of refrozen fillets of cod produced from frozen and thawed fish was not quite on the same level as the quality of frozen fillets produced from fresh fish.

The experiments also confirm, in accordance with results published earlier, (4, 17), that the following conditions in thawing of frozen fish in moist air blast should be satisfied: the thickness of the blocks should not exceed 10 cm, the air temperature should not be higher than +18° to +20°C, the relative humidity of the air should be 100 per cent, the air velocity should be around 5-6 m/sec., and finally the fish should not be kept in the tunnel longer than about 4-5 hours. Under more unsatisfactory conditions the texture of the fish became soft, some of the fillets were split and the quality was reduced. When the air temperatue was higher than about +20°C and/or the fish was kept too long in the thawing tunnel a peculiar unpleasant odour from the

fish also was observed. To prevent this a careful control of the temperature is necessary.

No loss of weight of any importance was observed during the thawing process in moist air blast, but the yield from the filleting of thawed fish was a few per cent less than the yield obtained in the filleting of fresh fish. Further the blocks would fall apart more easily during the thawing process when the fish had been frozen in a solution of alginate, due to the solution having a lower melting point than ice. Dipping of the fish in a solution of sodiumtripolyphosphate + NaCl showed a marked improvement on the appearance (gloss) of the fish. For the thawing of fatty fish, (sprat, herring, etc.) which is sensitive towards mechanical influence, and easily become rancid exposed to air, the use of water sprays is preferred.

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