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Shelf Life of Thawed Cod Fillets Kept in Ice

Wilfried Vyncke

Ministry of Agriculture, Fisheries Research Station, Ankerstraat 1, B-8400 Oostende, Belgium

Haltbarkeit aufgetauter und in Eis gelagerter Kabeljaufilets

Zusammenfassung. Kabeljaufilets (*Gadus morhua*) wurden vakuumverpackt, in einem Luftfroster tiefgefroren und bei −28 °C gelagert. Nach 1 Woche bzw. 3, 6 und 12 Monate wurden die Proben aufgetaut und in Eis gelagert.

Sensorische Analysen zeigten, daß der aufgetaute Fisch ca. 2 Tage (1 Woche Gefrierlagerung) bis 3–4 Tage (3 bis 12 Monate Lagerung) länger haltbar war als die frischen Filets.

Die Erhöhung der pH-Werte, des flüchtigen Basenstickstoffs, des Trimethylamins und der flüchtigen Säuren war in den aufgetauten Filets wesentlich verzögert. Jedoch korrelierten die drei letzten Befunde wenig mit den sensorischen.

Summary. Fillets of cod (*Gadus morhua*) were vacuum packed, frozen in an air-blast freezer and stored at −28 °C. After 1 week, 3, 6 and 12 months, samples were thawed and stored in ice. Fresh fillets from the same batch were taken for reference and iced immediately. Organoleptic tests showed an extension of shelf life for the thawed fish of 2 days (1 week frozen storage) to 3–4 days (3 to 12 months storage) compared to the fresh fillets. The increase of pH, total volatile bases, trimethylamine and volatile acids was significantly retarded in the thawed fish. Relationships of these last three determinations with sensory assessment, however, were poor.

Nowadays most frozen fishery products reach the consumer in their original state. For commercial reasons however (consumer preference) it is very often necessary to put thawed fish on the market and then treated as the fresh commodity. Furthermore, many lots of seafrozen fish have to be thawed for further treatment (e.g. filleting). Instead of being refrozen, which is practice in several countries, this fish can also be sold on the fresh market, e.g. in prepacked form.

Although sporadic reports on the quality of fish further stored after thawing have been published since the nineteen twenties [1] controversial opinions still exist on the spoilage rate of such fish in comparison to non-frozen fish.

Several early workers (cited by Luijpen [2]) were unable to establish any significant variations in the rate of deterioration between fresh fish and thawed frozen fish in general. The same conclusion was drawn by Lojkiewicz et al. [3] for herring (*Clupea harengus*). Rakow [4] and Hennings [5] reported a decreased shelf life for cod (*Gadus morhua*), while Luijpen [2] and more recently Simmonds [6] claimed a slower spoilage rate for cod and Cape hake (*Merluccius capensis*) respectively.

It can be safely assumed that the storage life of thawed fish will depend upon a large number of conditions (species, biological condition, freezing method, storage temperature and time, thawing method, storage conditions of the thawed product). These parameters were not always identical in the experiments carried out by the authors mentioned above, which could explain the discrepancies.

Hence, it was decided to carry out a series of tests with land-frozen cod fillets of standard quality (grade A of the EEC classificaion) in order to study the spoilage rate of the fish kept in ice after thawing. The second aim of the experiments was to investigate the usefulness of some commonly applied objective quality assessment methods for this type of product (see "Methods and materials").

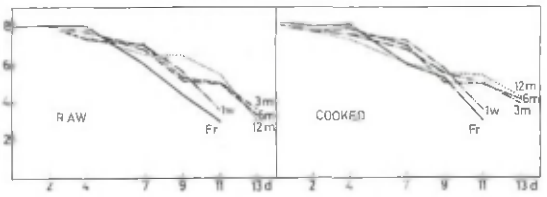

Fig. 1. Sensory scores of fresh (*Fr*) and thawed cod fillets stored in ice

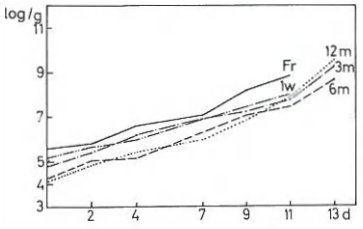

Fig. 2. Evolution of total viable counts in fresh (*Fr*) and thawed cod fillets

Methods and Materials

Fish. cod (*Gadus morhua*) of about 3 kg, caught in the Southern North Sea in October-November and about 6 days old at the start of the experiments.

Analyses

Organoleptic Judgment. was performed by a panel of 3–4 persons. Freshness was assessed on raw odour and cooked flavour [7]. Freezer storage deterioration was evaluated using scores for cold store flavour, firmness and dryness [8]. The fillets (~250 g) were cooked for 3 min in a microwave oven in a Pyrex dish with loose lid.

pH: with a combined glass-calomel electrode inserted into minced fish muscle.

Total Volatile Bases (TVN). according to Lücke and Geidel [9] but using an Antonacopoulos still [18].

Trimethylamine (TMA). according to Dyer [11] as modified by Hashimoto and Okaichi [12].

Total Volatile Acids Number (VAN). by the method of the AOAC [13] but with an Antonacopoulos still [10].

Total Viable Count. determined after incubation for three days at 20–22 °C after inoculation on trypton glucose extract agar in Petri dishes.

Procedure

The cod were filleted and skinned by hand at a wholesaler's premises. They were divided into two batches. A first batch was covered with a sheet of parchment paper, packed in ice and put into a cold store maintained at 1 °C. The second batch was vacuum-packed per in 2 kg portions, deep-frozen in an air-blast freezer at −40 °C and stored at −28 °C. After 1 week, 3, 6 and 12 months, samples were thawed in about two hours in a circulating water bath at 18 °C, removed from the package and stored in ice in the same way as the fresh batch. Every 2–3 days five fillets were removed for analysis. The experiment was repeated three times.

Results and Discussion

The average results are reported graphically in Figs. 1–3. Organoleptic tests (Fig. 1) showed a clear difference between the thawed fish samples and the fresh reference batch, which reached the limit of acceptability after about 8 (±1) days. The extension of shelf-life was 3–4 days after frozen storage for at least three months. For one week, the increase was about 2 days. There was no difference between 3, 6 and 12 months frozen storage.

Concerning the effects of freezing and cold storage on the organoleptic quality, a very slight increase in firmness (score 2.5–3) but not in dryness was noted after 6 months' storage. Cold-store flavour and odour were absent in all batches.

There was no discolouration.

It could be assumed that the freezing and thawing processes resulting in unavoidable mechanical damage to the cell structure would facilitate interaction between the muscle components liable to degradation and the muscle and bacterial enzymes present, which could enhance spoilage. On the other hand, spoilage bacteria are influenced by freezing and thawing. As many factors are involved (qualitative and quantitative composition of the flora, nature of the substrate, freezing and thawing methods, storage temperature) experimental results are sometimes contradictory. In general, however, there is a reduction in count, which will continue in most cases to fall during storage in the frozen state. Gram-negative bacteria seem to be more sensitive to freezing than gram-positive bacteria and bacterial spores are highly resistant [14, 15]. In recent years, attention was drawn to the importance of thawing itself. Han-Ching and Crépey [16, 17] working with sardine (*Sardina pilchardus*) and tuna (*Thunnus albacores*) established that there was an appreciable lag-phase after thawing, which retarded the spoilage phenomena. This was also reported for Cape hake (*Merluccius capensis*) [6].

A reduction in bacterial counts was also observed during the present experiments (Fig. 2). During storage, the total viable count gradually decreased from log 5,6 to 4,2 per g in 12 months. During further storage in ice after thawing, the numbers increased at more or less the same rate as in the unfrozen cod, but reached the same values only about two days later. The influence of freezing and thawing on the bacterial flora was apparently more important for the progress of spoilage in the chilled state than the mechanical damage, with its potential acceleration of enzymatic processes.

This change in spoilage pattern was reflected by the chemical analyses (Fig. 3). The increases in pH, TVN, TMA and VAN were significantly retarded in thawed cod. Although no further bacterial differentiation was examined, these laboratory tests also show that, besides a quantitative reduction qualitative, changes in the flora must have occurred. Indeed, the amounts of TVN, TMA and VAN, which are essentially bacterial

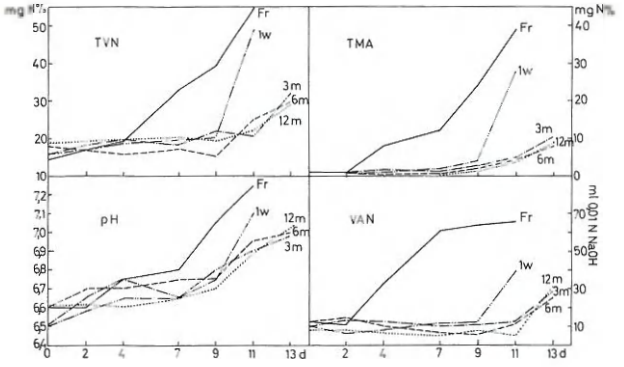

Fig. 3. Evolution of *TVN*, *TMA*, *pH* and *VAN* in fresh (*Fr*) and thawed cod fillets

degradation products, were markedly lower at the limit of acceptability in the 3, 6 and 12 months samples than in the 1 week and fresh batches: about 25 mg of TVN, 7 mg of TMA and 20 ml of VAN instead of about 35, 15 and 60, respectively. Thus a short storage at -28 °C (1 week in this case) did not seem to alter the spoilage pattern. It should further be noticed that the pH values of the frozen samples were quite normal at the end of the acceptable storage life (6.9–7.0), notwithstanding the lower amounts of bases formed. During spoilage some changes must therefore have accurred in the buffering capacity of the fish. The poor relationship between methods such as TMA and VAN determinations and sensory assessment was also noticed by Luijpen [2] using cod fillets. Rakow [4] on the other hand found no difference for TVN in whole cod.

Conclusions

Fillets of cod that are correctly frozen, stored and thawed give a product with a somewhat longer shelf life than the corresponding fresh fillets when the limit of acceptability is taken into consideration. This however is only of limited usefulness, firstly because the extension of storage life concerns fish with a rather low degree of freshness (scores around 5–6) and secondly because in commercial practice a further storage life of 5–6 days is sufficient in most cases. In this period the thawed fillets have about the same quality as the fresh ones.

From another point of view, this is an important conclusion and indicates that thawed cod fillets can be at least of equal, very acceptable quality. The view expressed by some authors [5, 14, 19] that thawed fish in general spoils more rapidly, and hence can be of inferior quality cannot be supported. From the point of view of objective quality assessment, the results of TVN, TMA and VAN determinations should be evaluated with caution, lower amounts being formed in thawed cod fillets; pH on the other hand seemed to behave rather normally.

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