COMPARISON OF BINARY-ICE (FLO-ICE™) AND FLAKE ICE FOR CHILLING AND STORAGE OF YELLOW GURNARD *(TRIGLA LUCERNA)* ON A DUTCH COMMERCIAL TRAWLER

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Abstract

A comparison was made between binary ice (Flo-ice™), for chilling in the chute and storage, and flake ice (for storage only) of yellow gurnard *(Trigla lucerna)* caught during summer. The use of binary ice was evaluated with respect to time-temperature profiles and the quality of whole yellow gurnard and cooked fillets. It was observed that the time needed to chill yellow gurnard on board of the commercial trawler using Flo-ice™ for chilling in the chute is almost 10 times shorter, compared with storage in flake ice without pre-cooling. Using the Quality Index Method, no significant differences were detected between yellow gurnard chilled and stored in Flo-ice™ and stored in flake-ice without pre-cooling. The use of Flo-ice™ for chilling in the chute and storage of yellow gurnard as used in the described trials did not significantly affect the redness, the salt uptake ($p=0.05$) and taste of the cooked fillet of yellow gurnard. In conclusion it can be stated that Flo-ice™ is suitable for rapid chilling and storage of whole yellow gurnard on board of commercial trawlers.

1. Introduction

Quality assurance on board of commercial fishing vessels is important, and temperature control is one of the most important factors affecting the rate of deterioration of fish. Although there are several options to chill fish, conventional ice is still the major method to chill and maintain the temperature of melting ice for freshly caught fish (Prout, 1998). Therefore, the use of sufficient quantities of ice to achieve rapid chilling at an appropriate stage of handling on board is essential. The standard procedure on board of Dutch beam trawlers (storage in flake ice without

pre-chilling) may not be adequate for rapid chilling of fish, in particular during summer. Other possible disadvantages using conventional ice e.g. flake ice are the limited contact area between the ice and the fish; the sharp edges of flake ice which could damage the fish; flake ice must be stored on board during the fishing trip; and the use of excessive flake ice can form an insulating layer on top of the fish causing the so called «Igloo» effect, which slows down the chilling process, especially at temperatures in the fish hold below 0?C.

In recent years a new type of ice known either as binary ice or slurry ice, made from brine or seawater, has been developed. Binary ice exists out of ice crystals generated by chilling the inner surface of a stainless steel cylinder through which seawater is past. A scraper mechanism removes the ice crystals, which become suspended in the fluid and form a liquid pumpable ice. The amount of ice crystals proportionally to water can vary from 20 to 60%. When binary ice contains around 60% or more of ice its pumpability is lost. When binary ice is drained it becomes white as snow. During the so-called «snow» effect the ice percentage will rise to around 90%. The temperature of binary ice is lower than that of conventional fresh water ice and depends on the seawater salinity and the percentage of ice in binary ice. As the ice fraction increases the temperature will decrease due to an increase in salinity of the remaining seawater.

It is known that binary ice is suitable for rapid chilling of freshly caught fish (Prout, 1998; Lammers, 1997; Lammers, 1998). Therefore, the owner of a recently built Dutch trawler, equipped with Danish seining fishing gear, decided to install equipment to produce binary ice from seawater, which is designated as Flo-ice™ by the manufacturer. Though slurry ice is used already in the fish industry on large freezer trawlers for mackerel and few other pelagic fish species it is a novelty that it is used on smaller vessels for flatfish and round fish in the Netherlands (Lammers, 1997). The production and use of ice from seawater for the handling and storage on board has several advantages and disadvantages compared to freshwater ice. The advantage are considered to be that the ice is soft and flexible and there are no sharp edges which can damage the product; Flo-ice™ the machine produces ice constantly upon demand, eliminating the need for extensive back up storage areas and Flo-ice™ can be used for cooling the fish room using the existing cooling system to reduce the use of freons. Besides the advantages of using Flo-ice™ there are known problems that have to be solved. In practice problems can occur when Flo-ice™ is produced from seawater, because the salinity can vary with the area of fishing. For instance when the salinity is to low the ice, which is formed in the stainless steel cylinder, will be to hard for the scraper to remove and causes a safety stop of the machine. When to salt concentration is to high and the melting point of the Flo-ice™ becomes to low, the possibility exists of partial freezing of the fish and thereby damaging the skin and texture and negatively affect the shelf life. Also

the possible salt uptake by fish exposed to the brine can have a negative effect on the taste of the fish.

To evaluate the use of Flo-ice™ (binary ice) on a Dutch commercial trawler a comparison was made between binary-ice, for chilling in the chute and storage, and flake-ice (for storage only) of yellow gurnard *(Trigla lucerna)* caught during summer. The use of binary-ice and flake-ice was evaluated with respect to:

*Time-temperature profiles and minimum time needed to chill yellow gurnard to a core-temperature of 0?C.

*Quality of whole yellow gurnard and cooked fillets.

2. Materials and methods

Fish was caught in the area near Heligoland (51.10?N, 8?E) by a Dutch trawler equipped with Danish seining fishing gear and a Flo-ice™ (binary-ice) system installed by Inham refrigeration b.v. The catch and procedure of the fish on board consisted of eight steps:

1. Catch
2. Collect bin
3. Stripping and sorting with respect to weight and species.
4. Washing
5. Pre-chilling with Flo-ice™ (ice percentage 20% w/w) in the chute
6. Weighing
7. Icing with Flo-ice™ (ice percentage 40-60% w/w)
8. Storage in the fish hold.

The whole process from catch to storage in the fish hold took between 1.5 and 2 hours.

2.1. Determination of the minimum time needed to chill Yellow gurnard to 0°C.

Immediately after sorting the average core-temperature of five fishes of equal size was measured using thermocouples, and put in an excessive amount of ice (3 kg per fish) to determine the difference in cooling time between Flo-ice™ (-2.4?C) and flake ice. The time needed to chill the fish to a core-temperature of 0?C is designated as chilling time. The fish were placed in the ice as follows: two on the bottom, one in the middle and two on top. Temperature measurement took place every minute for the first half-hour and every 15 minutes for a maximum of two hours.

2.2. Determination of the temperature profile of yellow gurnard from catch up to and including storage on board.

Immediately after the catch the average core-temperature of five fishes of equal size was measured during the procedure and storage trials on board, using thermocouples. The fish were placed in the ice as follows: two on the bottom, one in the middle and two on top. Temperature measurement took place every 5 minute for the first two hours and every 30 minutes until the mean temperature was below zero degrees centigrade. The following storage trails were carried out:

- yellow gurnard without chilling in the chute and stored in flake-ice
- yellow gurnard chilled in the chute and stored, using Flo-ice™.

2.3. The quality assessment of yellow gurnard as measured by QIM

The Quality Index Method (QIM) is a rapid and objective quality-grading scheme for the grading of raw fish (Bremner, 1985; Luten en van de Vis, 1999; Luten and Martinsdottir, 1997). QIM is based on the significant well-defined changes of attributes (eyes, skin, gills and smell) for raw fish and a score system from 0 to 3 demerit (index) points. No due emphasis is placed upon one single feature within QIM. A sample cannot be rejected on the basis of a single criterion.

The demerit points for the attributes are summed to give an overall sensory score the so-called QIM score. There is a good linear relationship between the QIM score and the number of days of storage in ice. The scheme which was used for assessment of whole yellow gurnard (n= 10) is shown in Annex 1. Sensory analysis of the whole fish of both groups were carried out on day 2, 5, 6, 8, 12 and 16 during the storage trail using five assessors analysing 10 fishes. The mean QIM-score per group per day is an indication of the quality of yellow gurnard on that particular day.

2.4. Redness measurements

To assess a possible effect of using Flo-ice™ on the redness of yellow gurnard the Minolta tristimulus apparatus was used for the measurements. The Minolta was calibrated using a standard white plate. For each individual fish six measurements on both the dorsal and lateral side were performed. The values for the dorsal and lateral side were averaged. Samples were taken on day 2, 5, 6, 8, 12 and 16 during the storage trail using 10 fishes per group per day.

2.5. Salt uptake

The possible salt uptake was determined chemical (Kolthoff and Sandell, 1950) as well as sensory analysis of the cooked fillets using the paired comparison test (Nielsen and Jessen, 1997).

2.6. Statistical analysis

Two factor ANOVA (p= 0.05) was used for statistical analysis of the results obtained from sensory analysis of whole yellow gurnard using QIM, the color measurements using the Minolta and salt analysis. The paired comparison test was used to evaluate a difference between the samples stored in Flo-ice™ or flake ice using 48 samples. When more than 31 samples (p=0.05) are classified in one of the categories than the result is considered to be significantly different.

3. Results

3.1 Determination of the minimum time needed to chill yellow gurnard to 0?C.

The average time needed for yellow gurnard in Flo-ice™ and flake ice to reach a core-temperature of 0?C is shown in figure 1. The core-temperature of yellow gurnard chilled in Flo-ice™ decreased 2.5 faster than for flake ice. The use of Flo-ice™ will reduce the core temperature of the fish from 12?C-15?C to 0?C within 38 minutes, which is 50 minutes faster compared to flake ice. With the use of Flo-ice ™ as a pre-cooling agent in the chute it can be predicted that yellow gurnard will reach a core-temperature of 0?C in less than 1.5 hours after the catch.

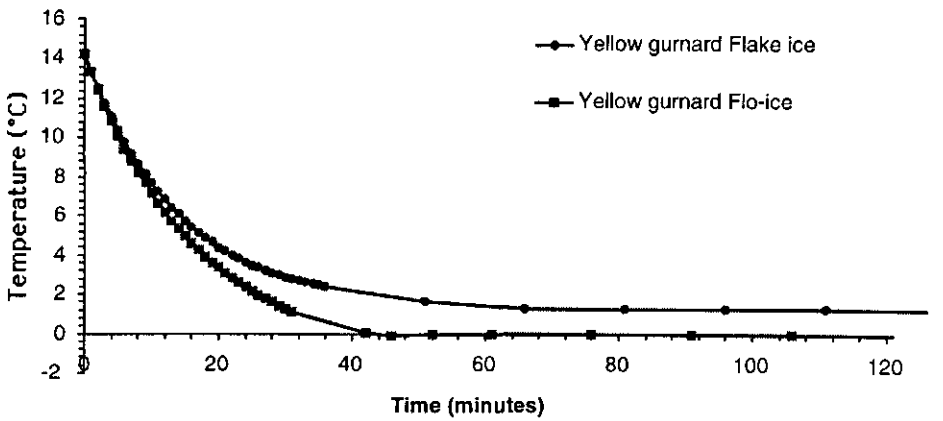

Figure 1: The temperature profile of the core of yellow gurnard stored in Flo-ice™ and flake-ice (3 kg ice/fish).

3.2 Temperature profile of yellow gurnard from catch up to and including storage on board

The average decrease in core-temperature of yellow gurnard from catch till storage on board is shown in figure 2. It was observed that the chilling time needed for yellow gurnard on board of the commercial trawler using Flo-ice™ for chilling in the chute is almost 10 times shorter, compared with storage in flake ice without pre-cooling. The core-temperature of yellow gurnard chilled in Flo-ice™ decrease from 16?C to 0?C in less than two hours. A core-temperature of 0?C could not be achieved when using flake ice. The rapid decrease in temperature using Flo-ice™ is obvious and was probably caused by the optimal contact between Flo-ice™ and the fish during the pre-chilling step. The slow decrease in temperature observed by the use of flake ice is probably due to the low temperature in the fish hold (-1?C-0.6?C). This hinders flake ice to melt, which should be prevented as the melt water and not the flake ice itself is needed to chill the fish. In this situation flake ice will function as an insulating layer and cause the so-called «Igloo» effect, which hinders lowering of the temperature quickly.

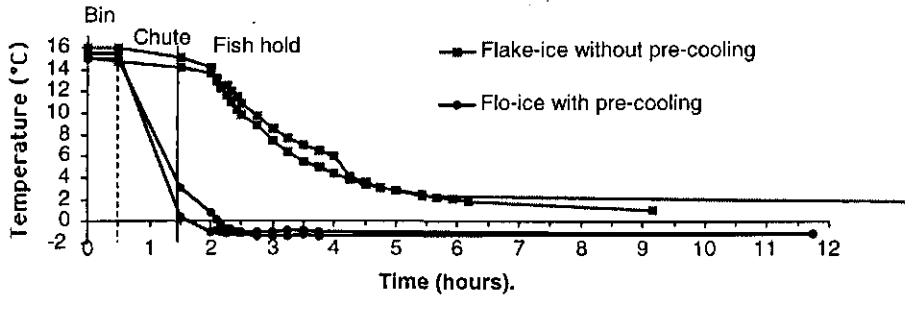

Figure 2: The decrease in core temperature of yellow gurnard on board.

3.3 The quality assessment of yellow gurnard as measured by QIM

The effect of chilling in the chute and storage in Flo-ice™ on the quality of whole yellow gurnard is depicted in figure 3. Using the Quality Index Method, no significant (ANOVA, P=0.05) differences, were detected between yellow gurnard chilled and stored in Flo-ice™ and stored in flake-ice without pre-cooling. It was

expected that the shelf life and quality of yellow gurnard pre-cooled and stored in Flo-ice™ would be better, compared to the yellow gurnard stored in flake ice. Apparently the good manufacture process on board the commercial trawler and their fishing gear used (Danish seining method) masked the expected advantages of using Flo-ice™. Another explanation could be that the Flo-ice™ used was very cold (-2.3?C to –2.9?C) and caused some damage due to partial freezing of the skin during the pre-cooling step in the process. This may have a negative effect on the shelf life and quality aspects measured using QIM.

3.4 Salt uptake

The use of Flo-ice™ for chilling in the chute and storage of yellow gurnard as used in the described trials did not significantly affect the salt uptake (p=0.05) and taste of the cooked fillet of yellow gurnard. The salt content of the edible parts of yellow gurnard chilled in Flo-ice™ was 0.12% and approximately the same as the salt content of yellow gurnard chilled in flake ice (0.10%).

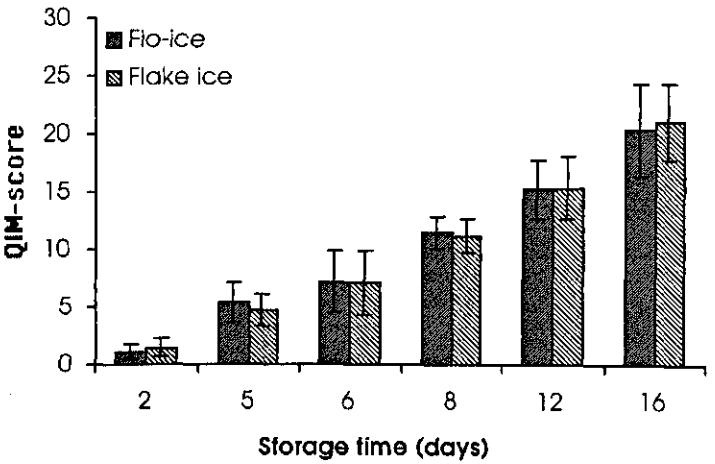

Figure 3: The effect of chilling in the chute and storage in Flo-ice™ on the quality of whole yellow gurnard measured by QIM.

3.5. Redness of yellow gurnard

The effect of Flo-ice™ compared with flake ice on the redness of yellow gurnard is presented in figure 4. The use of Flo-ice™ did not significantly affect

(p=0.05) the redness of yellow gurnard, compared with the standard procedure. The storage time has a negative effect on the redness of the dorsal side of the fish. The redness of the lateral side is not significantly affected by the storage time, which is an unexpected phenomenon. This is probably due to the mottled character of the lateral side colour. A mottled character cause variation between the different measurements, which may mask difference, related to storage time.

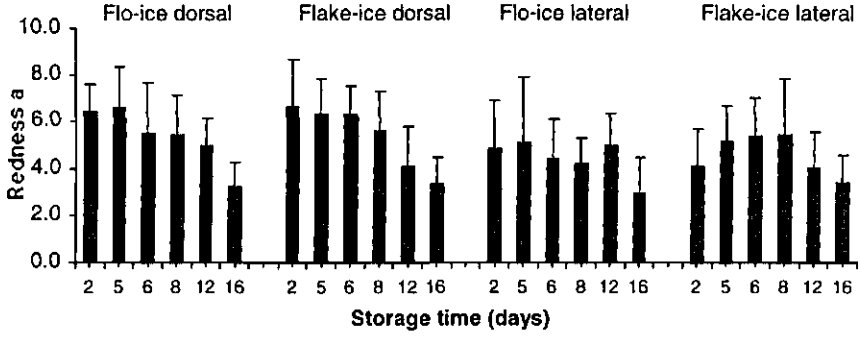

Figure 4: Effects of Flo-ice™ compared with flake ice on the redness of yellow gurnard

4. Conclusions

In conclusion it can be stated that:

- Flo-ice™ is suitable for rapid chilling and storage of whole yellow gurnard on board of commercial trawlers.
- The use of Flo-ice™ does not negatively affect the quality of the ungutted yellow gurnard.

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References

1. Bremner, H.A. (1985): A convenient easy to use system for estimating the quality of chilled seafood. *Fish Processing Bulletin*, 7, 59-70.
2. Lammers, C (1997). Chilling and storage on board, a comparison between Flo-ice and flake ice. RIVO-DLO rapport C060/97(In Dutch).
3. Lammers, C (1999). The use of Flo-ice for fishery products II. RIVO-DLO rapport C027/99 (In Dutch).
4. Luten, J.B., van de Vis, J.W. (1999). The Quality Index Method inevitable by quality assessment of fresh fish. In: Working chains, management, quality, logistics and ICT in the agricultural industrial sector (In Dutch).
5. Kolthoff, I.M., and Sandell, E.B. (1950). Textbook of quantitative inorganic analysis. London McMillan & Co Ltd. pp 471-478.
6. Nielsen, J. and Jessen, K. (1997). New developments in sensory analysis for fish and fishery products. In: Seafood from producer to Consumer, Integrated approach to quality.
7. Luten, J.B., BØrresen, and Oehlenschläger, J. Editors. Elsevier Science b.v. pp 537-547.
8. Luten, J.B. and Martinsdóttir, E. (1997) Qim: a European tool for fish freshness evaluation in the fishery chain. In: Methods to determine the freshness of fish in research and industry. Proceedings of the Final Meeting of the Concerted Action «Evaluation of Fish Freshness» AIR3CT942283. pp287-297.
9. Prout, P (1998). Initial Trails of the Binary Icing of Fish. Seafish report No. SR518.

Annex I QIM scheme for yellow gurnard

Attribute		Description	Index points
Skin	appearance	bright red/orange colour, iridescent, creamy white abdomen	0
		slightly greyish, less bright, abdomen slightly yellowish	1
		rather dull, the head also becomes greyish	2
		dull, greenish and bluish discoloration	3
	slime	clear, not clotted	0
		slightly clotted, milky	1
		clotted, greyish	2
		yellowish/brownish, clotted	3
Eyes	form	convex	0
		slightly flat	1
		sunken, concave	2
	brightness	black shining pupil, golden rim around the pupil, translucent cornea	0
		slightly greyish cornea , slightly greyish pupil	1
		greyish pupil, greyish cornea	2
		grey pupil, grey cornea, brown/red discoloration around pupil	3
Gills	Odour	fresh. seaweedy, metallic, cutted grass, fruity	0
		neutral, slightly sour, dry seaweed	1
		sour, slightly rotten, metallic	2
		very sour, musty, rotten, faecal	3
	Colour	bright, Bordeaux red, trace of grey	0
		Bored, slightly brownish	1
		yellowish/brownish, pale colour	2
		yellow/brown and green/blue discoloration	3
	Mucus	no mucus, filaments do not stick	0
		milky and somewhat ropy mucus, filaments do not stick	1
		cloudy mucus, filaments stick	2
		yellowish ropy mucus, filaments cannot be distinguished	3
Texture		in rigor or firm, slightly soft and elastic	0
		less elastic, slightly soft	1
		not elastic, soft, abdomen muddy	2
		very soft	3
Quality index			0-23