Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins

Icelandic Fisheries Laboratories Report Summary

Titill / Title	**Tölvuvætt skynmat í fiskvinnslu**		
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Ágrip á íslensku:

Þessi skýrsla er lokaskýrsla Evrópusambandsverkefnisins: "Tölvuvætt skynmat í fiskvinnslu". Megin markmið verkefnisins var að aðlaga og tölvuvæða hlutlæga skynmatsaðferð, gæðastuðulsaðferðina (QIM) fyrir ýmsar fisktegundir, þróa frekari leiðbeiningar fyrir skynmat og taka myndir af fiskum til að sýna útlitsbreytingar sem verða með geymslu í ís. Niðurstöður er ætlaðar til notkunar á fiskmörkuðum, í fiskvinnslufyrirtækjum og til þjálfunar gæðaftirlitsfóks

Í verkefninum gerði Rf ítarlegar geymsluþolstilraunir á eftirfarandi fisktegundum: þorski, ýsu, karfa, ufsa, rækju og laxi þar sem þróaðir voru einkunnaskalar samkvæmt gæðastuðulsaðferð (QIM) fyrir hverja tegund. Samanburður var gerður við hefðbundnar aðferðir til mats á ferskeika fisks. Geymsluþolstilraunir voru gerðar á þorsk og ýsu á mismunandi árstímum. Leiðbeiningar hafa verið skrifaðar og ljósmyndir teknar af breytingum gæðaþátta sem verða við geymslu í ís. Línulegt samband með hárri fylgni fékkst milli geymslutíma í ís og gæðastuðuls fyrir allar tegundir. Lok geymsluþols var ákvarðað með skynmati á soðnum sýnum. Þessar upplýsingar gera það mögulegt að áætla liðinn geymslutíma og það sem eftir er af geymsluþoli með notkun gæðastuðulsaðferðarinnar.

Niðurstöður geymsluþolsathuganna benda til að lágmarks fjöldi fiska sem þarf að meta úr hverju safni sé þrír fiskar. Einnig er lögð áhersla á að matið ætti að framkvæma af fleirum en einum matsaðila.

Einkunnaskalarnir eru byggðir upp með mjög nákvæmum lýsingum á hverjum gæðaþætti. Auk þess má styðjast við ljósmyndir af breytingum þáttanna við matið. Þetta auðveldar mat á ferskleika og gefur mikilvægar og nákvæmar upplýsingar um ferskleika og gæði fisks sem geymdur er heill í ís. Hugbúnaður til notkunar fyrir skynmat með einkunnaskölum, leiðbeiningum, ljósmyndum og gögnum um samband milli geymslutíma í ís og gæðastuðuls var þróaður var af TölvuMyndum. Námskeið til þjálfunar í skynmati á fiski voru haldin fyrir starfsfólk allra þátttakenda frá fiskvinnslufyrirtækjum og fiskmörkuðum. Niðurstöður frá rafnefsmælingum bentu til að hægt væri að fylgjast með breytingum á þorski og ýsu yfir geymslutímann, en betri sýnatökutækni þarf fyrir FreshSense tækið fyrir heilan þorsk og ýsu. Niðurstöður mælinga með FreshSense tækinu gefa til kynna að not megi rafnef til ferskleikamats á rækju, bæði heilli og pillaði en sumir rafefnanemar tækisins gáfu svörun á fyrstu dögum geymslutímans. Kynning á gæðastuðulsaðferðinni og niðurstöðum verkefnisins fór fram á námskeiðum fyrir iðnaðinn og í háskólum, í fyrirlestrum og á veggspjöldum á ráðstefnum og sjávarútvegssýningum. Samvinna milli rannsóknastofnanna, hugbúnaðarfyrirtækis, fiskvinnslufyrirtækja og fiskmarkaða í þessu verkefni hefur skilað fiskiðnaðinn mjög gagnlegri aðferð til mats á ferskleika fisks auk þess sem hún er mjög hentug til rannsókna, þjálfunar og kennslu.

Lykilorð á íslensku: Gæðastuðulsaðferð, skynmat, ferskleiki fisks, geymsluþol

Summary in English:

This report is the annual final report of the EU-project: **Development and implementation of a computerised sensory system (QIM) for fish freshness** (CRAFT FAIR FA-S2-9063). The main objective of the project was to adapt and computerise an objective sensory method, the Quality Index Method (QIM) for various species of raw fish and develop further the instructions for sensory evaluation and generate photographs of fish showing changes in visual attributes during storage for direct inspection use in fish auctions, the fish processing plants and for training of quality managers and inspectors.

During the project period, IFL has done thorough studies of storage life of following fish species: cod, haddock, ocean perch, pollock, shrimp and salmon resulting in Quality Index schemes for each species. Comparison was made on traditional methods for evaluation of fish freshness. Storage life studies were done on cod and haddock during different seasons. Guidelines have been written and photographs taken of changes in sensory attributes during storage time in ice. Linear relationship with high correlation has been found between the storage time in ice and the Quality Index of all the species. The end of storage life has been found by sensory evaluation of cooked samples. This information makes prediction of past and remaining shelf life possible.

The results from the shelf life studies indicate that 3 fish are the minimum amount for assessment of each batch. Furthermore, it is emphasised that the freshness assessment should be carried out by more than one assessor.

The precise and descriptive QIM schemes for fish, supported by photographs showing visible changes occurring during storage in ice, makes it easy to assess the freshness of fish, giving valuable and reliable information about the freshness quality of whole fish kept in ice. The QIM schemes, guidelines, photographs and the data on the relationship between storage time in ice and Quality Index were implemented into the software package of TM Software. Extensive training sessions on sensory evaluation of fish were given to the staff of all the partners from the fish processing plants and auction during the project period. The results from the electronic nose measurements indicate that loss of freshness could be monitored but a better sampling technique is needed for the FreshSense instrument for whole cod and haddock. FreshSense is very promising to detect the early onset of spoilage formation in shrimp.

Dissemination of information on the Quality Index Method and the project results were given via courses for the industry and universities, in lectures and posters at workshops and conferences, seafood and fisheries exhibitions.

During this project a valuable cooperation between fish research institutes, a software company, fish processing plants and fish auctions has resulted in a effective tool for the fish industry for evaluation of fish freshness and a tool for research, training and teaching people.

English keywords: Quality Index Method, sensory evaluation, fish freshness, shelf life

CRAFT FAIR FA-S2-9063

Development and implementation of a computerised sensory system (QIM) for fish freshness

Individual Progress Report for the period 01.01.1999 -31.03.2000

Type of contract CRAFT

Total cost 848.000 **EC contribution:** 424.000 50%

Participant no 05 **Icelandic Fisheries Laboratories** total cost 119.000
EC contribution to partner 05, Icelandic Fisheries Laboratories 119.000
(28% of the total EU contribution)

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1. OBJECTIVES

The project has the following objectives:
1. To adapt an objective sensory Quality Index Method (QIM) for raw material of various species of fish and develop further the instructions for sensory evaluation and generate photographs of fish showing changes in visual attributes during storage

- for direct inspection use in fish auctions and the fish processing plants for evaluation of the raw material.
- for training of quality managers and inspectors and for quality control of the sensory evaluation system.

2. To optimise the use of sensory analysis in the fish sector by computerising information on sensory evaluation methods. This involves different sensory methods and in particular QIM, sampling plans and implementation of the information in the quality control / management systems and for use in statistical process management.

2. ACTIONS IN THE PROJECT

Following are the tasks that partner no. 05 has taken part in during the project period:

TASK 2. Controlled storage experiments of fish stored in ice

Subtask 2a. Adaptation of QIM to different species
Subtask 2b. Photographs
Subtask 2c. Comparison of QIM to traditional methods
Subtask 2d. Possibilities of using electronic nose

TASK 4. Application and testing of the QIM-method in companies.
TASK 5. Dissemination of the results.
Dissemination via exhibition in the second year and other dissemination during the project period.

3. Research activities

Research activities during 01.01.99 - 31.12.99 carried out by partner 05 IFL

TASK 2. Controlled storage experiments of fish stored in ice

Subtask 2a. Adaptation of QIM to different species. Adaptation of QIM schemes on ocean perch and pollock were performed. The main purpose was to make the QIM-schemes as reliable as possible. The schemes for ocean perch and pollock were implemented into the software

Subtask 2b. Photographs Standardisation of photographs have be given priority with respect to composition, light intensity, colour on the monitor of the displayed photos etc. to ensure reliable quality of photos. During the storage studies pictures are taken to follow the changes in appearance of the eyes, gills, skin and slime of the fish. During this period photographs have been taken of ocean perch, pollock and salmon. The Icelandic photographer Ragnar Th. Sigurðsson finalised the computer work on the pictures taken both in Iceland and the Netherlands. The aim was to harmonise the pictures and give as much information on the changes of the sensory attributes as possible.

Subtask 2c. Comparison of QIM to traditional methods.
This period storage experiments were done on salmon kept in ice. The storage studies were a part of a master thesis "Quality parameters and development of Quality Index Method (QIM) scheme for farmed salmon". The thesis was performed in collaboration of the University of Iceland / Icelandic Fisheries Laboratories and the Technical University of Denmark / Danish Institute for Fisheries Research, Department of Seafood Research. A part of the masters thesis dealing with the storage studies are shown in **Appendix 1.**
With regular intervals during the storage time fish were sampled and analysed. Icelandic farmed salmon was used in the experiment. The salmon was collected before pubescence and after slaughtering the salmon was gutted and the viscera removed. To monitor the spoilage pattern and find the end of storage life the results of the QIM-method were compared to microbial counts and sensory analysis on cooked fillets. The results of QIM- method were directly correlated with storage time in ice. Quantitative Descriptive Analysis (QDA) were used when evaluating the cooked fillets. The Torry-scheme on salmon was found to be unsatisfactory and profiling methods have already been tried on salmon in Denmark with good results. The results of the sensory evaluation of cooked samples were used to find out the end of storage life to be able to use the QIM-scheme for process management.
The correlation between QI scores and days in ice was high (R^2 = 0,9533). The linear relationship between the QI (y) and storage days in ice (x) is found by the formula: y = 0,6921x + 1,57.
The individual salmon appear to spoil at different rate. Based on that, it is concluded that minimum of 3 salmon should be included in the assessment of each batch of salmon. Using 5 salmon instead of 3 might reduce the prediction error, giving more reliable information about the storage time.
The panellists participating in the sensory evaluation with QIM for salmon performed differently, as some gave higher or lower scores throughout the storage time. The

assessors were trained for 1 or 2 days before the evaluation. More training might have reduced the difference of assessor performance. This implies that it is very difficult to have a sensory evaluation panel to perform in precisely the same way. There will always be some individual differences among people participating as sensory assessors. The descriptions given in the QIM scheme are very precise and describe the changes occurring in outer appearance, odour and texture of salmon very well, facilitating the freshness assessment of raw salmon, making the individual performance differences as small as possible. The photographs of salmon and guidelines for the assessment may support the assessment even further. All this makes it possible to evaluate the freshness of farmed salmon in a fast and a reliable way, providing reliable information about its quality and remaining shelf life in ice. However, the unavoidable chance of differences among assessors, as observed in this study, implies that the freshness assessment with the QIM scheme should preferably be based upon the assessment of more than one assessor. Furthermore, freshness assessment applying the QIM schemes is simple and easy to learn and more than 1-2 sessions of training for QIM assessment should not be necessary for further improvement of performance or harmonising of panellists.

Based upon the sensory evaluation of cooked salmon, the maximum storage life of salmon has been determined as 20 days in ice.

The total viable counts (TVC) were low at the beginning of the storage time (ca. 10^3 cfu/cm^2 on skin but ca. 10 cfu/g in flesh). However, at the end of the shelf life (20 days), TVC had reached ca. 10^8 cfu/cm^2 on skin but ca. 10^5 cfu/g in flesh. The H_2S producing bacterial counts were very low at the beginning of the storage time and hardly detectable in flesh samples until after 8 days of storage in ice. At the end of the shelf life of salmon the H_2S producing bacteria were dominating the bacterial flora of both skin and flesh. The bacterial growth in salmon correlated highly with QI scores, as deviation in bacterial counts were reflected in deviation in QIM scores.

Further statistical analysis on cod and haddock

Statistical analysis of the data on cod and haddock were performed at IFL during this period as shown in **Appendix 2**. The main purpose was to find out how many fish you need for each sampling. Also to use the QIM-scores to predict for storage times in ice and find the confidence limit. A significant difference was found between the slopes of the regression lines of cod and haddock in May and December. For cod the slopes were 1.20 for cod in May and 1.00 in December (intercept of 1,97) and for haddock 1.24 in May and 1.23 in December. However this difference will not have important influence in practical use of the slopes. The slope for the cod is chosen 1.20 because previous studies and the use in the industry has shown the same slope (Luten and Martinsdóttir (1997). An advantage of QIM data is that the QI is a sum of scores. Distribution of the sum of 10 to 12 attributes is close to normal even though the scores for each attribute (0-3) are not normally distributed. The data for cod and haddock indicate that samples taken at late post-catch times (after 8 to 10 days in storage) are more inhomogeneous in sensory quality because of different spoilage rate of individual fish. During early days of storage 3 fish is recommended as a sample size but greater sample size (5 fish) will give more accurate information at later stages of storage.

Reference: Luten J. B. and E. Martinsdóttir (1997). QIM- a European tool for fish freshness evaluation in the fishery chain. In: G. Olafsdottir *et al*. (eds.). *Methods to determine the freshness of fish*. Proceedings of the Final Meeting of the Concerted Action "Evaluation of Fish Freshness" AIR3CT94 2283. Nantes Nov 12-14, 1997. International Institute of Refrigeration. 287-296.)

Subtask 2d. Possibilities of using electronic nose. Simultaneous measurements were done during all the storage studies of salmon using a new rapid technique an electronic nose (FreshSense, Bodvaki, Iceland) to evaluate fish freshness. This technique has been used to evaluate freshness of fish in research with promising results. Some problems using the same samples for microbial counts occurred during the measurements as the CO_2 sensor responded to ethanol used for sampling for microbial. However the SO_2 and NH_3 sensors do not appear to be sensitive to ethanol the responses of these sensors towards salmon heads increases during storage. The response of the sensors to fillets is very low and no changes are observed during storage. Later a few samples of salmon were stored in ice to repeat the November study, mainly to study the characteristic responses of the CO sensor and to see if similar patterns were observed for the other sensors. The response of the CO sensor appears to increase with storage time, but changes in the response of the other sensors are minimal.

TASK 4. Application and testing of the QIM-method in companies.

Subtask 4. All the SME´s were visited by Icelandic Fisheries Laboratories this year for meetings with the personnel discussing the results of the project. Icelandic Fisheries Laboratories gave extensive training courses for all the Icelandic SME's. The aim was to train the personnel in the QIM method itself and also to use the software packages. Altogether twenty people attended the training courses with good results. Cod and ocean perch after various storage (from 1 to 16) days in ice were used for the training courses The results of each trainee were compared to the scores of the instructors from IFL and the average scores of the course participants and storage time in ice. the results were printed out and given to each of the participants.
After the fish processing plant HB had practical experience in using the software package in the daily routine of inspection of their raw material for some weeks a course was given in February 2000 for all the SME's. During the courses the training module of the software was used and the experience obtained during the courses used to revise features in the software. The training module of the software package was revised after the participants from the SME's had had their second training course. The revised training module was used for students from The Fisheries School in February 2000.
HB has started to use and test the computer program along with their existent quality control system. Learning and performing the QIM assessment has been very successful. However at first they found the computer program is rather slow, that is, it took too long time to enter the assessment into the program, despite a powerful computer. They conclude that the sensory evaluation (QIM) gives extremely valuable information that can be of use the daily quality control. The catch from their own boats is day-market. If it is was possible to implement registration for some important topics, the program could replace their existing system. The topics they have in mind are following: sorting, operation (i.e. bleeding, gutting), icing, temperature, gross weight, net weight.
For this processing plant it would be a big advantage if fish is bought unseen, as is most common when /trading at fish auctions, to have a quality index, giving a realistic estimation of the condition of the fish/fish product.

HB will use the information from the QIM assessment to inform the crew of the ships about the quality of the catch, so that they could take more care in handling the catch when needed. This is though dependent on that the topics here above are implemented in the computer program.

Information and results from IFL to TM-software

During the last months of the project period the finalised pictures of the sensory attributes of all fish species and the latest and revised QIM score sheets for the sensory evaluation have been delivered to TM-software and implemented into the software. All the schemes were translated with guidelines. Regression lines found in the controlled storage studies for the linear relationship between the sensory QIM score and storage time in ice used to predict storage time in ice given QI-score were used on the software. Guidelines for sensory evaluation of whole fish and information about storage life and how to predict storage life were written and delivered for implementation into the software package.

TASK 5. Dissemination of the results

The following presentations were given of the project on behalf of partner 05:

Date place	Dissemination activity
Introduction to EU funding of Craft-projects for the fish industry, Reykjavik March 23rd.	Lecture
Innovations for Seafood Gold Coast, QLD, Australia, April 21-23.	Lecture
Innovations in the fishing industry. Workshop, Vestmannaeyjar, Iceland - Nordic Network Fish Processing May 20-21th.	2 Posters
Workshop: Fish Quality Labelling and Monitoring FQLM, Reykjavík 28th May	Lecture
Evaluation of fish freshness - New Methods. Workshop for Nordic Fish Retailers, Reykjavik, Aug. 14-16,	Lecture
Icelandic Fisheries Exhibition 1999 , Kopavogur, Iceland Sept. 1-4 1999	Demonstration/ Poster
Sensory Evaluation and Quality, Nordic Workshop VIII, Reykjavik, Sept. 9-11 1999	Lecture/ Demonstration
CA-FQLM, QIM- Workshop, RIVO, IJmuiden, the Netherlands, 28/29 Febr. 2000	Lectures/ Demonstration
Fish International 2000, Bremen March 23-26th	Demonstrations

During QIM Workshop held within the EU-project FAIR PL98-4174 Fish Quality Labelling and Monitoring 28 to29 February 2000, IJmuiden the Netherlands lectures, demonstration and practical session on sensory evaluation of fish using the QIM-method and demonstration of the software QimIT were given by the IFL's staff.

In Bremen, Germany 25 to 28 of March at Fish International 2000 at the booth of WEFTA Industry Forum demonstration on sensory evaluation of salmon and cod were given and QIM and the software package introduced to the visitors.

The staff of IFL give regularly courses in sensory evaluation of fish and other food and have been using QIM in training and teaching during training courses for inspectors in the fishing industry. Also as a part of sensory courses in Food Science at the University of Iceland and Fisheries Science at University of Akureyri, Fish Technology School and Fisheries University of the United Nations.

A press conference was held on May 29th for Icelandic Ministry of Fisheries and Directorate of Fisheries and an introduction was given of the QIM method and the software package. This conference was covered by newspapers and television in Iceland the following days.

Appendix 1

Application of the Quality Index Method (QIM) in shelf life study of farmed salmon (*Salmo salar*)

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Icelandic Fisheries Laboratories

Abstract

This report is a part of the master thesis "Quality parameters and development of Quality Index Method (QIM) scheme for farmed salmon". The thesis is performed in collaboration of the University of Iceland / Icelandic Fisheries Laboratories and the Technical University of Denmark / Danish Institute for Fisheries Research, Department of Seafood Research.

This part of the thesis is about sensory evaluation and quality parameters of farmed salmon. It deals with the revision of a QIM scheme previously developed for farmed salmon (*Salmo salar*) used for the prediction of past and remaining storage time in ice. Sensory analysis of cooked salmon with Quantitative Descriptive Analysis (QDA) was carried out parallel to decide the maximum storage time in ice and to observe how the different quality attributes changed with storage time in ice. For the shelf life study, salmon was stored in ice for up to 24 days and analysed every second or third day. In order to gain further information about the salmon the following measurements were carried out: Total viable counts (TVC) and hydrogen sulphide (H_2S) producing bacteria counts were done both on skin and flesh samples. The fat content was determined by Soxhlet method.

The shelf life study of farmed salmon resulted in a slightly changed QIM scheme for farmed salmon, with linear relationship between QIM scores and storage time in ice (R^2 = 0,95) and a slope of 0,692. Assuming that three salmon are included in the QIM assessment of each batch, the storage time could be predicted with ± 2 days. The shelf life of salmon was determined as 20 days in ice, based on sensory evaluation of cooked salmon.

The microbial counts increased exponentially with the storage time and were ca. 10^8 cfu/cm^2 on skin and 10^5 cfu/cm^2 in flesh after 20 days of storage in ice (at the rejection time). The H_2S producing bacteria had become a dominating part of the total viable counts at that time. The average fat content of the salmon was 15,1 ± 2,1%. High fat content resulted in more rancid and tender samples than salmon of lower fat content as observed by the sensory panel of cooked samples.

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1. Introduction

Several quality parameters are responsible for consumer acceptance. In a marketing study on quality parameters of salmon (Koteng, 1992), freshness, texture and fat content were considered to be among the most important quality parameters. One of the most important aspects of fish and fish products is freshness and due to the consumer preferences there is a strong tendency to select very fresh fish (Luten and Martinsdóttir, 1997; Koteng, 1992). Sensory evaluation is the most important method for freshness and quality assessment in the fish sector and fish inspection services. The Quality Index Method (QIM) is a seafood freshness quality grading system that is a promising method to assess freshness in a rapid and reliable way. The method has to be developed for each fish species, and exists for several fish species today. Among those are fresh herring, saithe and cod (Larsen *et al*., 1992; Jónsdóttir, 1992), frozen cod (Warm *et al*., 1998), red fish, sardines and flounder (Nielsen, 1993), haddock and plaice (Martinsdóttir, 1995), Atlantic mackerel, horse mackerel and European sardine (Andrade *et al*., 1997). The author concluded from her pre-thesis report (Sveinsdottir, 1998) that the development of the method (QIM) would be of interest for the freshness assessment of salmon.

In Iceland, the production of farmed salmon between 1990 and 1998 has been 2000-3000 tons per year (according to Institute of Freshwater Fisheries). The worlds farmed salmon production has increased gradually and steadily between 1990 and 1997, going from 540.000 million tons to almost 1.400.000 million tons per year (FAO, 1999). Norway is the world's largest farmed salmon producer with 320 000 million ton in 1997. In 1997, 38% of the salmon produced in the world was made up of Atlantic salmon (*Salmo salar*). Between 1990 to 1997 the world fresh salmon imports increased from 165.000 million tons (US$ 1 billion) to 420.000 million tons (US$ 1,8 billion). In this period the import in European countries (Sweden, Germany, France and Denmark) has more than tripled (from ca. 75.000 million tons to ca. 250.000 million tons per year). This increase was brought about by the extraordinary growth in imports of all main buying countries. This applies especially to Denmark, the leading fresh salmon importer which increased its imports by 76 200 million tons, reaching 92 300 million tons in 1997. Denmark is the largest importer of fresh salmon in Europe, mainly for re-exports, the biggest fresh salmon supplier being Norway.

Because of gradual and steady increase in the trade of fresh salmon between countries, there is a need for a good grading system, such as QIM, for the quality assessment of salmon. The increase in unseen trades furthers this need and quality grating with QIM would provide a reliable estimation of the quality and freshness of the salmon.

Software for the QIM has been developed during the work of an European project (Quality Index Method and Information Technology - QimIT) (QimIT, 2000). Computerising QIM may further and facilitate quality assessment of fish. A QIM scheme was developed and evaluated for Norwegian farmed salmon at the Danish Institute for Fisheries Research during the summer of 1999 (Sveinsdóttir, 2000). The main aim of this project was to revise the scheme, by performing a shelf life study with farmed salmon at the Icelandic Fisheries Laboratories, and determine maximum storage time in ice by sensory analysis of cooked salmon. Salmon was collected over a month's period in several batches. It was stored iced in a cold store at 0-2°C until analysed by sensory evaluation, other analysis and photographing.

The salmon was evaluated raw using the QIM scheme and cooked samples were evaluated using Quantitative Descriptive Analysis (QDA) to observe how the quality changed with storage time and to determine the shelf life of salmon stored in ice. During this project photographs were taken of salmon at different freshness stages to include in the computerised QIM (QimIT). To get a better overview of the quality of the salmon, some other quality parameters were measured/estimated in addition to the sensory assessment, i.e. microbial counts, fat and water content.

1.1. Sensory evaluation of whole raw fish

Freshness is considered to be one of the most important factors in determining the overall quality of raw fish. The most common methods used to evaluate the freshness of fish, are sensory evaluation methods.

The first modern and detailed sensory method for the evaluation of raw fish was developed at the Torry Research Station (Shewan, *et al*. 1953). The basic idea was that each quality parameter was independent of other quality parameters. Then the quality attributes were grouped together and grades given for each group. Today, the most used methods for quality assessment of raw fish in Europe are the EU-scheme (Anon, 1996) and the Quality Index Method (QIM).

QIM is based upon a scheme originally developed by the Tasmanian Food Research Unit (Bremner, 1985). The QIM is based on characteristic changes that occur in raw fish. A score from 0 to 3 demerit (index) points is given for changes in outer appearance of eyes, skin, gills and changes that occur in odour and texture as well. No emphasis is put on one single feature within the QIM, and a sample can not be rejected on the basis of one single criterion (Botta, 1995; Hyldig and Nielsen, 1997; Nielsen, 1997; Martinsdóttir, 1995; Martinsdóttir, 1997). The scores for all the characteristics are summarised to give an overall sensory score, the so-called Quality Index. The aim when developing QIM for various species is to have the Quality Index to increase linearly with storage time in ice, which makes it possible to predict past and remaining storage time in ice.

The QIM has the advantage of being rapid, cheap to use, requires little training and is also non-destructive. QIM has some unique advantages over the EU-scheme according to Martinsdóttir (1995). The panellist must e.g. evaluate all the parameters involved in the scheme. It is also easy to make QIM an objective method compared to other sensory methods, since it includes instructions and good illustration material. In addition, the method can be used to predict the remaining storage time in ice, and the information can be used in production management. Furthermore, the method is well suited to train inexperienced people to evaluate fish to train and harmonise panellists. Good training, in combination with detailed descriptions of the methods, schemes, sampling plans and illustration materials, may facilitate the use of sensory evaluation in different parts in the fishery chain.

There has been an increasing interest in the Quality Index Method. During the last 3 years, the EU has been funding a CRAFT project called Quality Index Method and Information Technology (QimIT). The main aim of this project was to develop QIM schemes for fish species and combine it in a computer software system for assessment of fish freshness, with colour photographs of all the species demonstrating the different stages of freshness (Luten and Martinsdóttir, 1997). This project is a cooperation of The Netherlands and Iceland. Two research institutes; Icelandic Fisheries Laboratories and Netherlands Institute for Fisheries Research/RIVO-DLO are participating in the project and one software company; TM Software, Iceland. From the Icelandic fisheries industry; Haraldur Böðvarsson, Hólmadrangur, Fiskimarkaður Suðurnesja are participating and from The Netherlands, IJmuiden and Den Helder. At a later stage in the project, the Danish Institute for Fisheries Research (DIFRES) took part.

Computerising the QIM is considered to have several advantages, such as enhancement of implementation of sensory analysis, in particular QIM, access to photographs of specific quality parameters and calculation of the Quality Index. One of the main advantages of computerising the QIM is the method provides the user (producers, buyers, sellers, consumer etc.) with information stating in a reliable and standardised way the freshness of the products (Luten and Martinsdóttir, 1997).

QIM schemes have been developed for various species, and in the computerised version cod, haddock, red fish, saithe, shrimp, salmon (responsibility of Icelandic Fisheries Laboratories) brill, plaice, sole, turbot, dab (responsibility of Netherlands Institute for Fisheries Research/RIVO-DLO), herring and trout (responsibility of Danish Institute for Fisheries Research) will be included. It is possible to include more species in this programme when schemes for them have been developed and shelf life studies carried out to determine the slope and correlation between the QI score and storage time in ice and photographs taken. In addition to QIM schemes, photographs and guidelines for the assessment, the programme includes a set-up for training of assessors, and reports where it is possible to compare the assessments, e.g. over some defined periods, or customers. It is also possible to implement sensory methods for assessment of fillets, cooked, frozen and processed fish.

In this first version, the programme will be in Icelandic, Dutch, Danish and English, but it is possible to include more languages if desired.

1.2. Sensory assessment of cooked fish

The maximum shelf life of fish can be determined by sensory evaluation of cooked samples. A descriptive 10-point scale developed at the Torry Research Station is often used for this purpose. This scale is often referred to as the Torry scale. It has been developed for lean, medium fat and fat fish species and scores are given from 10 (very fresh in taste and odour) to 3 (spoiled). The Icelandic Fisheries Laboratories use the score 5,5 as the limit for consumption, based on the average score given by a sensory panel.

The Torry scale provides limited information about how the individual characteristics of the cooked fish change through the storage time, but by using Quantitative Descriptive Analysis (QDA) methods, much more detailed information can be gained. With QDA, all detectable aspects of a product are described. The panellists intended to participate in the sensory analysis of a product, make a list of concepts/words describing the product under guidance of a panel leader. The panellists are then trained in using an unstructured scale for each of the concepts, before participating in the sensory analysis of the product.

Care must be taken in the selection of individuals for the wordlist development. It should be avoided to choose people because of their proximity to the product, since knowing the product too well, e.g. the process or ingredients, increases the chance of people providing what is believed to be the expected response rather than what was perceived (Stone and Sidel, 1998). The panel leader does not participate directly in the development of the list of concepts/words. If one panel member is thought to have more knowledge about the subject, the others might observe his/her opinion and agree, even though they do not observe or detect the same sensation. Instead, the panel leader serves only as a facilitator of the process of the descriptive wordlist development, providing samples, recording what was discussed and keeping the dialogue focused on the tasks. The panel leader must ensure that all subjects have equal opportunity to participate and resolve any conflicts that may develop (Stone and Sidel, 1998).

Applications for the QDA methodology are very broad. Results can e.g. be used to relate to physical and chemical analysis, product formulations, preferences and other kinds of consumer measures of concepts. The methodology has been used successfully in identifying which specific sensory characteristics of products are the most important to consumer preferences (Sidel *et al*., 1994). Knowledge about which quality characteristics are important to consumers, provides a real use of sensory information within the quality control process (Stone and Sidel, 1998). Other applications include its use in measuring shelf life of products without dependence on standards or control products.

1.3. Microbial counts

Microorganisms are present on all outer surface and in the intestines of live and newly caught fish. Bacteria on fish caught in temperate waters will enter the exponential growth phase almost immediately after the fish is killed (Gram, 1995b). During ice storage the bacteria will grow with a doubling time of approximately one day and will after 2-3 weeks, reach numbers of 10^8-10^9 cfu (colony forming units)/g flesh or cm^2 skin (Gram, 1995b). The amount of bacteria on newly caught fish can vary enormously, and 10^2-10^7 cfu /cm^2 can be quite normal (Liston, 1980). According to Ólafsdóttir *et al*. (1997a), total viable counts of 10^2-10^6 cfu/g are common on whole fish, but at the point of sensory rejection the total viable count of fish products are typically 10^7-10^8 cfu/g.

Gram (1995b) emphasis that the terms spoilage flora and spoilage bacteria are not the same. The former describes the total bacteria flora on the fish when it spoils, but the latter is the specific group that produces the off-odours and flavours associated with spoilage. A large part of the bacteria present on spoiled fish do not play an important role in the spoilage. Comparison of the chemical compounds developing in naturally spoiling fish compared to sterile fish, has shown that most of the volatile compounds are produced by bacterial activity, including trimethylamine, volatile sulphur compounds, aldehydes, ketons, esters, hypoxanthine and other low molecular weight compounds (Shewan, 1962).

The flesh of healthy live or newly caught fish is sterile as the immune system of the fish prevents the bacteria from growing in the flesh. (Gram, 1995b). When the fish dies, the immune system collapses and bacteria are allowed to proliferate freely and during storage, bacteria invade the flesh by moving between the muscle fibres (Gram, 1995b).

The aim of microbiological examinations of seafood products is to evaluate the possible presence of bacteria or organisms of public health significance and to give an impression of the hygienic quality of the seafood including temperature abuse and hygiene during handling and processing according to Gram (1995a). The determination of bacterial numbers in seafood is widely used as an indicator of hygiene, and activity of microorganisms is the main factor limiting the shelf life of fresh fish (Ólafsdóttir *et al*. 1997a).

Unspecific plate counts are common for determining the bacteriological contamination of seafood, but are seldom considered to be a good indicator of the sensory quality or the remaining shelf life of the product (Huss *et al*. 1974). Plate count agar has been one of the most widely used agars for determination of total counts. Iron agar (Iron Agar, Lyngy, Oxoid) has though been found to give higher counts and also give higher counts of the number of H_2S producing bacteria which are specific spoilage bacteria in some seafood (Gram, 1990). The most important spoilage bacteria in seafood are characterised by their ability to produce H_2S and reduce TMAO, which has been used for their specific determination. Capell *et al*. (1997) found counts of hydrogen sulphide producing bacteria more closely associated with the rejection of several fish species, irrespective of the temperature and atmosphere, than the total viable count. To detect H_2S producing spoilage bacteria in seafood, peptone-rich substrate containing ferric citrate has been used. If present, black colonies are formed due to precipitation of FeS.

1.4. Electronic nose

Attempts have been made to develop various techniques for freshness evaluation of fish to replace or support sensory analysis. During the last decade progress has been made in the development of gas sensors, which respond to volatile compounds in food. Instruments equipped with gas sensors, so-called electronic noses are already on the market and there is much interest in using such instruments to rapidly evaluate the quality and freshness of fish in a non-destructible manner. Data is collected through many different sensors and data processing depends on complicated methodology. As their applications are supposed to be diverse they are not specific for compounds that are formed in fish. The fish industry needs an inexpensive, simple instrument that will give results similar to traditional freshness evaluation methods. IFL and Bodvaki have developed a measurement device with electrochemical gas sensors that has been used in research projects funded by the Icelandic Research Council. The instrument FreshSense has been used to evaluate the freshness of various fish species and has shown promising results for the fishmeal industry for production control in factories (Ólafsdóttir *et al*., 1997b,c; Olafsdóttir *et al*., 2000).

1.5. Chemical analysis

The fat content of salmon and the composition of fat are considered to be important quality parameters for salmon and can affect sensory properties, such as texture and flavour.

The total amount of fat can vary a lot between the individuals of the same fish species, and between e.g. season, sex and physiological status (Børresen, 1995). Farmed fish may also show variation in chemical composition, but in this case several factors are controlled, thus the chemical composition may be predicted (Børresen, 1995).

Salmon is considered to belong to fatty fish species (>10% fat). It is commonly accepted that the total lipid content of farmed fish is generally higher, often up to double the content found in wild salmon (Moe, 1990). There is also less seasonal variation, than in the free-living salmon (Sigurgisladóttir *et al*., 1997). It appears that the fat depot mainly occurs within special fat cells that are located in clearly defined areas, particularly in regions where different types of tissues adjoin (Mohr, 1979). Studies have also shown that the stability of the fat cells seems to be determined by the properties of the collagen fibres that surround the cells (Mohr, 1979).

A standard sampling technique is available for determining the average fat content of fillets from the Norwegian General Standardizing Body (1994). The slice recommended for fat analysis in the standard is a cut at the end of dorsal fin and backwards to the gut opening. It is though the section below the dorsal fin that is thought to resemble best the average fat content of the fillets. Salmon processing companies in Europe are not completely satisfied with this standard cut since they do not think it resembles the average fat content of the fillet (Sigurgisladóttir *et al*., 1997). This standard sample cut has also been reported to represent lower fat content of salmon compared to measuring the fat content of the whole fillet. Refsgaard *et al*. (1998) measured fat content using the standard cut, but also in whole fillets which resulted in ca. 13% fat using the standard cut, but ca. 15% fat content in the whole fillets. The variation between the individuals of farmed salmon (150) was also reported to be very large or 15 ± 3% (95% confidence interval) in the same study, which is surprisingly much considering that the salmon analysed was from the same batch (same farm, slaughtering time, size, feed).

The fat and water normally constitute around 80% of the fish fillet weight (Børresen, 1995). This can be used to estimate the fat content from analysis of water amount in fillets, and has been utilised with success in a fat analysing instrument called the Torry Fish Fat Meter, where it is actually the water content that is measured (Kent *et al*., 1992; Distell, 1999).

2. Materials and methods

2.1. Salmon

A total of 53 farmed Atlantic salmon (*Salmo salar*) from Silungur ehf eldi (Stóru-Vatnsleysu, 190 Vogar, Iceland) was used in this experiment. The salmon (Norwegian race) was 3-4 kg, and slaughtered before pubescence.

The salmon had been fed with various types of the feed blend "Gull" (Gull 3, 4, 6, 8, 10, 12, depending on the age of salmon) from Fóðurblandan hf (Korngörðum 12, 104 Reykjavik, Iceland). The blend contained 40% protein, 16% carbohydrates and 25% to 30%fat (the fat percent increased from 25 to 30% through the farming time). The salmon was starved for 2 weeks and then killed with carbonic acid. After slaughtering, the salmon was gutted and all viscera removed. The salmon was bled, gills cut through and the salmon rinsed in running water for 30 minutes. The salmon was then chilled to 0°C in slush ice (0 to -1°C) before iced in boxes.

The salmon arrived in 8 different batches. They were slaughtered in the period 11th of October 1999 to the 8th of November 1999. The salmon were iced after slaughtering and arrived iced in boxes the same day or the day after slaughtering. Thereafter the salmon were stored in a cold store (0-2°C), iced in boxes until taken out for sensory evaluation, photographing and other measurements. The boxes were labelled with the day of slaughtering. Holes were drilled on the bottom of the boxes to prevent water from accumulating in the boxes. The lids of the boxes were also partly opened to allow air exchange in the boxes.

2.1.1 Sampling plan for all measurements

The procedure of the experiments is shown in Figure 2 and sampling is shown in Figure 3. To limit amount of salmon used in the experiment, the sample collection from the salmon was carefully planned.

The sensory evaluation of raw (QIM) and cooked salmon (QDA) were carried out parallel for 5 adjoining days along with measurements of microbial counts, electronic nose and chemical analysis (fat analysis and dry material).

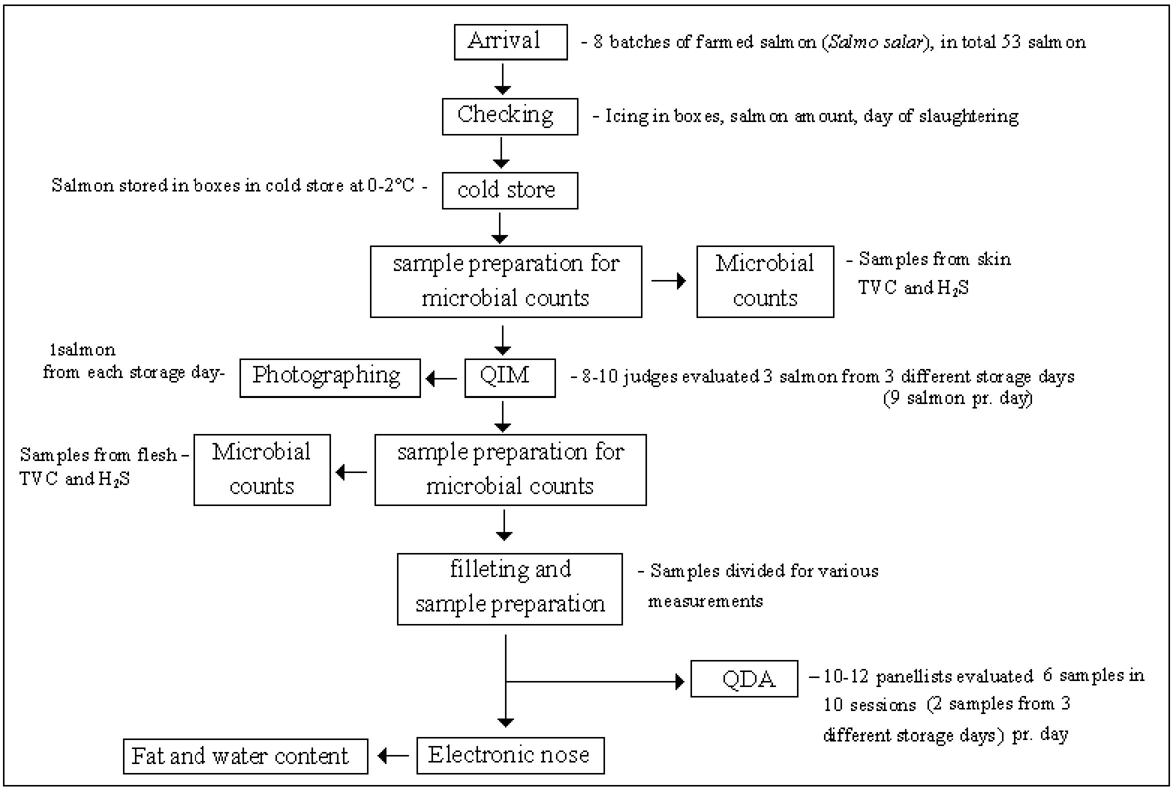

Figure 2. Flowchart over the procedure in the shelf life study of salmon at the Icelandic Fisheries Laboratories in Nov. 1999.

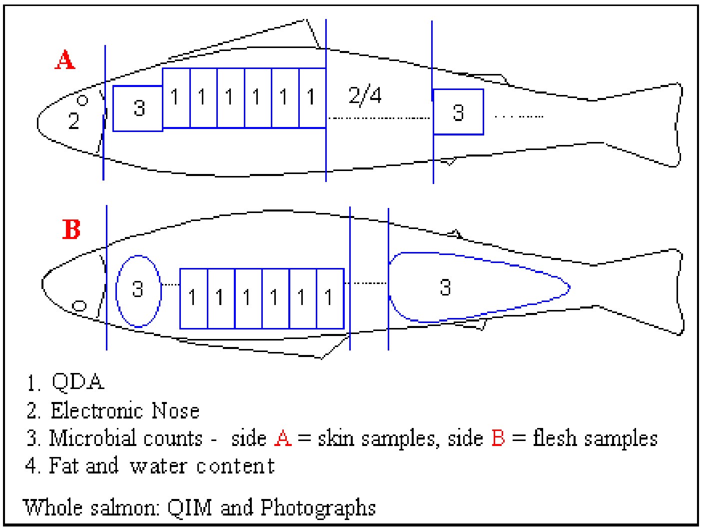

Figure 3. Sampling plan for all measurements carried out in the shelf life study of salmon at the Icelandic Fisheries Laboratories in Nov. 1999.

Each day of the experiment, nine salmon from 3 different storage days were collected from the cold store and skin samples taken for microbial counts. Next the salmon were analysed whole with QIM. Then, one salmon from each of the three storage day was removed for photographing. The two salmon remaining from each storage day, were filleted, after collection of flesh samples for microbial counts. The head and a fillet sample from one side were used for electronic nose measurements. The fillet samples were then used for analysis of fat and dry material. For the sensory analysis of cooked salmon, 6 samples from each fillet were taken from the loin part.

2.2. Quality Index Method (QIM)

2.2.1 Sample preparation for QIM

The salmon was collected from the iceboxes and placed on a clean table, 30 minutes before the evaluation started. The side where the gills had been cut through was facing down. Then skin samples (ca. 2 cm^2) were collected for microbial count. Each salmon was coded with a compose of three numbers that did not indicate the storage time of the salmon. Salmon from three different storage days were evaluated each time:

- For the training of QIM judges (2 sessions over 2 adjoining days), 6 salmon from 3 different storage days were evaluated, that is 2 salmon from each day.
- For the QIM evaluation (5 sessions over 5 adjoining days), 9 salmon from 3 different storage days were evaluated, that is 3 salmon from each day.

A total of 53 salmon were analysed with QIM during the training and evaluation period. For information about which storage days were taken out for evaluation each day of the QIM training and evaluation, se Appendix A1.

2.2.2 Procedure of QIM

All observations of the salmon were carried out under standardised conditions; always in the same room, with as little interruption or distraction as possible, at room temperature, under electric light.

Revision of descriptive words in the QIM scheme and training of QIM judges

The revision of descriptive words in the QIM scheme and training of 12 QIM judges was carried out in 2 sessions (over 2 adjoining days). The judges were all employees at the Icelandic Fisheries Laboratories and had experience in assessing fish with QIM.

The judges were introduced to the scheme developed earlier for farmed salmon (Appendix A2). Before introducing the scheme to the judges some changes were made in the scheme. The order of parameters was reorganised for convenience. "rigor" was included in the parameter "texture". One description was also added to "colour/appearance" for the parameter "skin". The judges observed salmon from 3 different storage days (the storage time in ice was given) and the scheme was explained to them at the same time. The judges suggested some changes to the scheme.

The procedure of the evaluation was trained and evaluation of each parameter was discussed. Here the storage time of each salmon was unknown to the judges until after the session.

Based upon the suggestions of the judges, some minor changes were made in the scheme. That scheme is the ultimate scheme developed for farmed salmon and was used in the evaluation of salmon in the shelf life study (Appendix A3).

QIM evaluation of farmed salmon

The QIM scheme modified under the training period (Appendix A3) was applied for the sensory analysis of the raw fish. The evaluation was carried out in 5 sessions over 5 adjoining days. Eight to ten QIM judges evaluated 9 salmon (composite of three storage days) each day individually, and registered their evaluation for each quality parameter in the scheme. (One of those days only 6 salmon were evaluated from 2 storage days). The judges had no information about the storage time in ice before the evaluation. Each day the evaluation took 10-30 minutes.

2.3. Quantitative Descriptive Analysis (QDA)

Sensory analysis of cooked salmon with the QDA method was carried out parallel to the QIM evaluation, using the same salmon. Two salmon from each storage day were used for the QDA part. A total of 39 salmon was used for training and the QDA of the salmon in this experiment.

2.3.1 Sample preparation for QDA

Samples for QDA were collected from the fillets as shown in Figure 3, located under the dorsal fin, ranging from the spine to 2 cm below the lateral line. From each salmon, 12 samples were collected and altogether, 72 samples were prepared for each session of QDA. The size of each sample was ca. 1-2 cm width, and 7-8 cm in length. The samples were placed in metal boxes (ca. 5 width x 8 length x 4 height cm^3) on a tray with plastic film. Neither skin nor bones were removed. Each sample was coded with a composite of 3 numbers that did not indicate the storage time. The boxes were stored in a cold store for ca. 15 minutes (first session) or 2-3 hours (second session) at 4°C until they were cooked at 95-100°C in a pre-warmed oven (Convostherm, Convostar, Germany) with air circulation and steam for 7 minutes. The boxes were closed with plastic covers and served for the QDA panel. Each panellist evaluated 3 samples from the 3 different storage days in duplicates. Each salmon in the shelf life study was evaluated by all panellists.

2.3.2 Procedure of QDA

The procedure of QDA was as described here below. All observations of the salmon were carried out according to International Standards (ISO 11035, 1994).

Wordlist development and training of QDA panel

Twelve trained panellist participated in the QDA of the farmed salmon. They were all employees at the Icelandic Fisheries Laboratories, and a part of them participated in the evaluation with QIM as well.

The panel was trained for the QDA of farmed salmon for 2 adjoining days prior to the evaluation, one session each of the days. In that period, the panel estimated the cooked salmon and came up with suggestions of attributes to describe odour, flavour, appearance and texture of the cooked salmon. To help the panellists, they were shown a list of words that was used in QDA of salmon in Denmark. The panellists had to agree on which words to use, and which words described positive and negative parameters. Positive words described fresh salmon and negative words described salmon at the end of the storage time.

The panel was then trained in using a 15-cm unstructured scale for each of the attributes describing odour, appearance, flavour and texture. The left end indicated that the sample was not or little described by the attribute, but the right end indicated that the attribute described the sample highly.

QDA of farmed salmon

A 15-cm unstructured scale for each of the words describing the quality parameters odour, appearance, flavour and texture (shown in Appendix B1) was applied for the sensory analysis of the cooked salmon.

Each panellist had to evaluate samples from 3 storage days in duplicates, served in random order in 2 sessions each day. For every sample, the panellists evaluated each attribute using a computer for data collection. The evaluation was carried out in 10 sessions over 5 adjoining days. The panellists had no information about the storage time of the samples.

2.4. Microbial counts

Both skin and flesh samples were collected from the 30 salmon. Total viable counts and black colonies were counted.

The skin samples were collected before all other analysis. The skin samples were collected by cutting 2 x 7,5 cm^2 skin strips from one side of the fish (as shown in Figure 3) and put into 50 ml Butterfield´s Buffer (Bufferstock, KH_2PO_2 + distilled water, pH 7,2).

The flesh samples were collected after the QIM evaluation from the other side of the salmon. First the skin was washed with alcohol in order to kill microorganisms on skin. Next, the skin was removed with sterilised scalpel, the flesh down under collected and minced. From the mince, 25g were weighed and put into 225ml of the Butterfield´s Buffer and minced again in a mincer (Stomacher). Dilutions were done using the Butterfield´s Buffer, with mincing in a mincer (Stomacher), followed by spread plating (in duplicates). Iron Agar was pored over, and again when the former had become solid. The spread was cultured at 22°C for 3 day. After culturing, total colonies and black colonies were counted.

2.5. Electronic nose

Both salmon fillet and heads were measured with the electronic nose, from 30 salmon altogether in the shelf life study in November 1999, but in March 2000, fillets from 2 salmon were measured. Approximately 700 g of salmon fillet or ca. 1100 g of heads were placed in the glass container and temperature was measured before the container was closed (10-12°C). Measurements were taken every 10 seconds for 10 minutes. The reported value (current) is the average of last three measurements of the 10 minutes measurement cycle minus the initial value which is calculated as the average of the values during 3 minutes before the measurement starts. The measurement technique with the gas sensors was reported earlier by Ólafsdóttir *et al.* (1997b,c).

Electronic nose measurements were performed using a gas sensor instrument called "FreshSense", developed by the Icelandic Fisheries Laboratories and Bodvaki (Artorg 1, 550 Saudarkrokur, Iceland). The instrument consists of a glass container (5,2L) closed with a lid with a sensor box and a PC computer running a measurement and data analysis program. The sensor box contains five different electrochemical gas sensors (Dräger, Germany: CO, H_2S, NO, and SO_2; City Technology, Britain: NH_3A7AM) and a temperature sensor. A fan is positioned in the glass container to facilitate the mixing of the headspace. The measurement technique for the analysis of volatile compounds with the gas sensor instrument is based on a static headspace sampling. The headspace of the fish sample is analysed directly at room temperature in a closed glass container. The sensors are particularly sensitive to three main groups of metabolites in fish. The CO sensor is sensitive to short chain alcohols and aldehydes. The H_2S and SO_2 sensors are sensitive to compounds containing sulphur like hydrogen sulphide (H2S) and other malodorous compounds. The NH_3 sensors are particularly sensitive to amines such as TMA and ammonia.

2.6. Chemical analysis

Average crude fat and dry weight of all salmon in the shelf life study (30 salmon) were determined.

The salmon was filleted and samples collected according to method recommended by Norwegian Standardised Body (1997), (Norwegian Quality Cut, NQC). The samples were vacuum packed, and stored at ÷20°C until analysed (storage time varied from 2 to 10 days).

The samples were minced in mixer and 5 g of samples were measured into porcelain jars in duplicates, mixed with sand and dried in an oven (102-105°C) for 4 hours. The samples were then cooled in desiccator and weighed for determination of dry material. The fat content was then determined with Soxhlet method by IFL´s method manual for chemical analysis (1999) based on A.O.C.S. Official Method Ba 3-38, using petroleum ether (boiling point 30-40°C).

2.7. Photographs

The salmon was photographed by a professional photographer, Ragnar Th. Sigurðsson. Selected photos were intended to be used as a helping material with the QIM scheme for farmed salmon.

After the salmon had been analysed with QIM, one salmon from each of the analysed storage days were iced in boxes, where they were stored until photographed (within 3 hours). Thus salmon stored from 1 to 24 days in ice were photographed. Photographs were taken of whole salmon, to try to catch the appearance of the whole salmon to show colour and mucus, eyes to try to catch the colour and form, gills were photographed to view the colour and mucus present and abdomen to show the colour of blood in abdomen.

2.8. Data analysis

The results from the QIM evaluation were analysed in the statistical programme Solo 6,0,4 (BMDP, 1995) with one-way analysis of variance (ANOVA), using Duncan´s Multiple comparison test to observe if a significant statistical difference of the Quality Index of samples existed, within and between storage days.

The data from QDA were treated in HyperSense, Version 1,6 (© 1993-1996 Icelandic Fisheries Laboratories, Reykjavík, Iceland). Interaction of judges and samples was assumed and statistical analysis was done using two-factor design with interaction in the analysis of variance (ANOVA) to observe if a significant statistical difference between samples for each quality attribute assessed existed. The programme calculates multiple comparison using Tukeys test.

The following data analysis was carried out in Microsoft Exel97: For analysis of expressible moisture, single factor ANOVA was used to test the hypothesis that means from two or more samples are equal (drawn from populations with the same mean).

For QI, total viable count and H_2S-producing microbes on salmon skin and flesh, instrumental texture parameters, expressible moisture, and storage time in ice, correlation coefficient was calculated to determine the relationship between two properties. The least squares fit for a line was calculated, represented by the equation: $y = mx + b$, where m is the slope and b is the intercept.

Multivariate comparison of the different attributes in QIM, QDA, texture measurements, chemical analysis and expressible moisture was carried out in the statistical programme Unscrambler ®, Version 6,1 (CAMO, Trondheim, Norway), with principal component analysis (PCA). Before the analysis, variables were scaled. Each element in the matrix was multiplied with the inverse of the standard deviation of the corresponding variable if the variables had different units. By doing this, each variable has the same variance.

Predictability of Quality Index (QI) scores from QIM data was analysed using partial least squares regression (PLS). PLS uses the structure in X to model Y. The QI scores were used as the X matrix and storage time in ice (days in ice) were used as the corresponding Y values, that is to predict future Y values (storage time) from given X values (QI scores). The average QI score for each storage day, including assessment of 3 salmon was used for this analysis. The validation method used was full cross validation since the number of samples was 14, providing the prediction error. Using full cross validation, the modelling is based upon as many sub-models as there are samples, where one of the samples is kept out of the calculation at a time and used for testing the sub-model. The squared difference between the predicted and real Y-values for each omitted sample is summarised and averaged, giving the validation of the Y-variance of the model. The root mean square error of prediction (RMSEP) is calculated for the model, which is the prediction error in original units. Bias is the averaged difference between predicted and measured Y-values for all samples in the validation set. The standard error of performance (SEP) is the precision of results, corrected for the bias. If a normal distribution can be expected of the samples, as in the case of QI scores as it is the sum of 11 attributes assessed in the QIM scheme for salmon (if values are subject to a lot of randomly varying factors the distribution will by close to normal according to O´Mahony (1986)), 2*SEP can be regarded as 95% confidence interval (Esbensen *et al.*, 1998). If not stated elsewhere, the significance level was set at 5%.

3. Results and Discussion

The results and discussion of the sensory analyses of raw and cooked salmon (QIM and QDA), microbial counts, texture, fat and expressible moisture measurements are presented in comparison to storage time in ice and the different quality parameters compared. Raw data is included in Appendices.

3.1. Quality Index Method (QIM)

Revision of descriptive words in the QIM scheme and training of QIM judges

The final QIM scheme for farmed Atlantic salmon (*Salmo salar*) is shown in Appendix A3 as it looks after revision.

During the training period, the parameter "colour/appearance" was thought to lack one description, as there was found difference between salmon that had less pearl-shining appearance and salmon that had become yellowish. Some changes in the choice of words were made in the description of most parameters, mainly to make each description more precise.

After the period of training the judges had become familiar with how the different parameters of salmon change during storage in ice and how to use the QIM scheme for farmed salmon.

The QIM evaluation of farmed salmon

The sum of scores from the QIM scheme is presented as the Quality Index (QI). The average QI score with days in ice is shown in Figure 4.

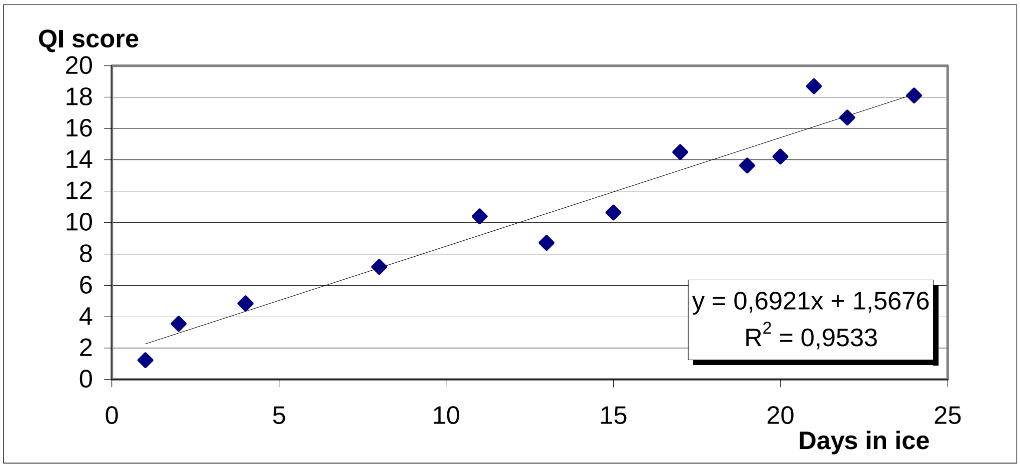

Figure 4. QI scores of salmon stored in ice. Averages over each day of storage analysed vs. days in ice.

A high correlation (R^2 = 0,953) between the average QI score and days in ice was obtained with a slope of 0,692. The aim when developing QIM scheme for fish is to have the regression line to start at the origo (0,0), which is not quite reached here, since the intercept is at 1,568. If the line is forced through the origo here, the correlation between the average

QI score and days in ice becomes slightly lower (R^2 = 0,933). It could also be argued if it is actually wrong to force the line through origo. Using the QIM scheme in estimating the freshness of fish gives the assessors the opportunity to choose between scores ranging from 0-1, 0-2 or 0-3 but never a negative number. They have therefore the chance to be either slightly below or above the average, the same when the fish is very fresh or less fresh. Forcing the correlation line through the origo would not give the assessors the chance to be below the correlation line. In fact, if one assessor misjudges the fish when very fresh/just caught, is it only a positive score that is possible, and therefore, the correlation line should be allowed to cut the y-axis slightly above zero.

Occasionally, rather large deviation from the correlation line is observed. Looking into the data, it appears that the individual salmon from the same storage day are somewhat different, obtaining different scores (see Figure 5) though stored in precisely the same way,- coming from the same box, slaughtered in the same way, at the same time. The difference in QI score could be partly caused by different position in boxes or different nutritional status/stress before slaughtering. That could explain the deviation of some storage days from the correlation line in Figure 4.

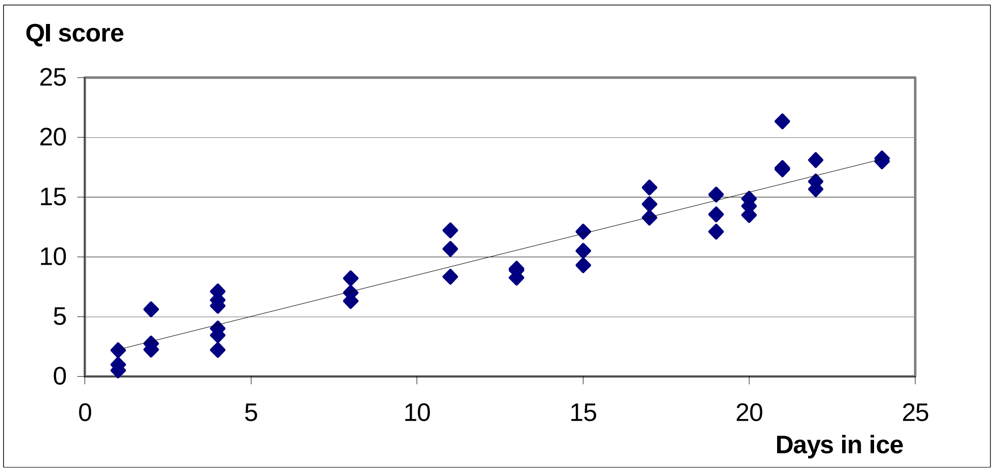

Figure 5. QI scores of salmon stored in ice. Average QI score of each salmon analysed vs. days in ice.

It is also of interest to know if there is a significant difference between the individual salmon stored equally long in ice and how able the assessors are to distinguish between storage days. The results were analysed statistically with one-way analysis of variance using Duncan´s Multiple comparison test. The Quality Index of each sample (salmon) was compared to all other samples (Table 1) and the Quality Index of each sample group from each storage day was compared to all other sample groups from other storage days assessed (Table 1).

Table 1. The Quality Index (QI) of each group analysed (salmon stored in ice). One-way analysis of variance with Duncan´s Multiple comparison test used to estimate if the groups were different within or if they were different from each other.

Group (storage time in ice)	mean (QI)	Statistical difference within the group*	Not statistically different from group/groups
1	1,2		
2	3,5	x	4
4	4,9	x	2
8	7,2		
11	10,4	x	15
13	8,7		
15	10,6		11
17	14,5		19,20
19	13,6		17,20
20	14,2		17,19
21	18,7	x	24
22	16,7		24
24	18,1		21,22

*** x = statistical difference exists**

The difference between salmon stored equally long in ice is in some cases significant. This emphasis that the assessment of the Quality Index with the QIM scheme should never be based upon only one salmon. In this study, each group included three salmon, and to make the assessment reliable three should be the minimum number for assessment of each batch.
It appears that it is rather difficult to distinguish between storage days in ice, especially at the end of the storage time. With longer storage time it becomes more difficult to discriminate between storage days, as the variation in sensory attributes between the individual salmon becomes larger. This indicates that the individual salmon spoil at somewhat different rates, that could be caused by different position in boxes, or size, post mortem pH or difference in fat content that are thought to influence the spoilage rate of fish (Gram, 1995a).

To examine better how the QI scores could predict the storage time in ice, the results were analysed using partial least squares regression (PLS). The average QI score for each storage day, including assessment of 3 salmon was used for this analysis. This was done as it was presumed that the assessment of each batch would include the average QI score based on the assessment of minimum 3 salmon later on (future use of QIM scheme for salmon). Figure 6 shows the resulting PLS plot.

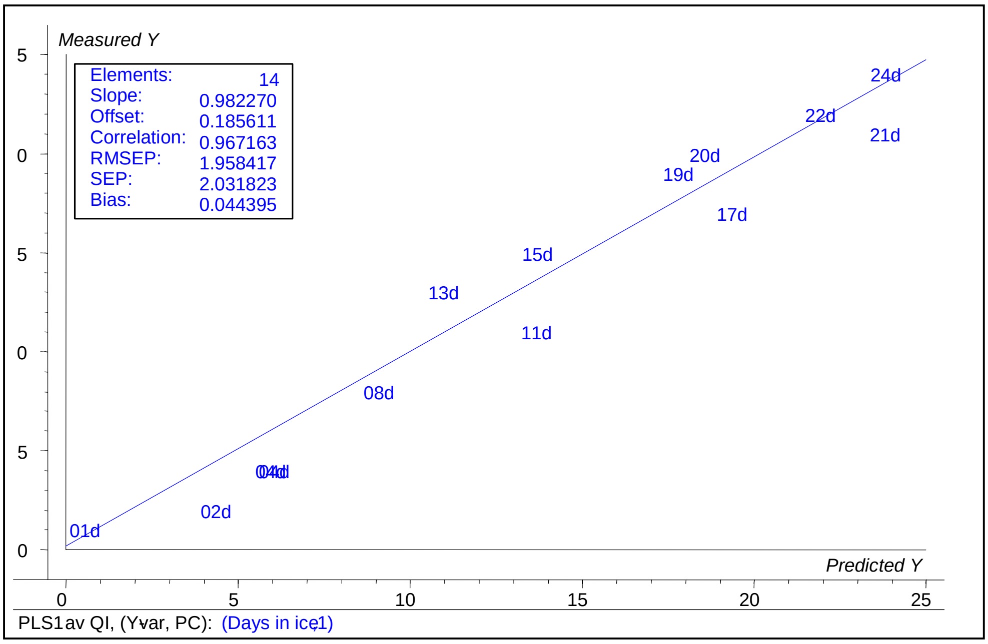

Figure 7. PLS1 modelling of QIM data from salmon stored in ice using full cross validation: Measured vs. predicted Y values. Average QI for each storage day based on assessment of 3 salmon used to predict storage time in days.

Since a normal distribution can be expected for QI scores, 2*SEP can be regarded as 95% confidence interval (Esbensen *et al.*, 1998). The SEP value for the QI scores is 2,0. Based on this, it can be assumed that the QI score of a batch (if 3 salmon are assessed) can be used to predict the storage time in days with ± 2 days. This is a rather wide interval. It can though be assumed that including more salmon in the assessment of each batch might reduce this interval.

Performance of individual judge

Some variation was observed in QI scores given by different judges as shown in Figure 7.

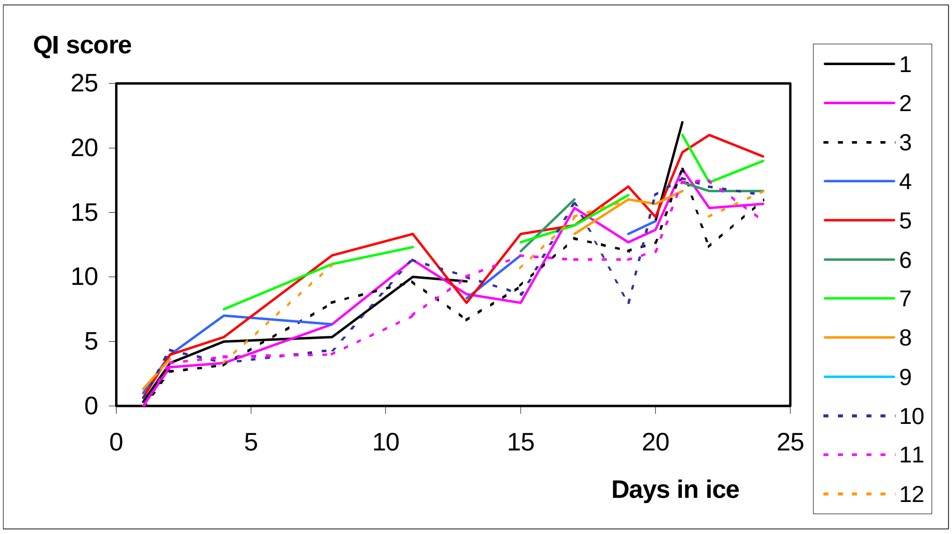

Figure 7. Average QI score of salmon stored in ice each day of analysis, as given by each judge.

The difference in the QI scores given by each judge appears to increase with storage time in ice, indicating that the judges are more sure and agreeing in analysing very fresh salmon with the QIM scheme. Looking at Figure 7, it can bee seen that the same judges are usually scoring either higher or lower than the generality of the judges.
This could indicate that the judges could have used more training before the evaluation, emphasising the importance of training and good helping material, e.g. in the form of photographs and guidelines.

Changes occurring in individual sensory attributes of salmon with storage time in ice
The Quality Index Method assumes the scores for all quality attributes to increase with storage time in ice. To observe how the scores for different quality attributes increase with storage time, the scores were plotted vs. days in ice as Figures 8 - 11 demonstrate.

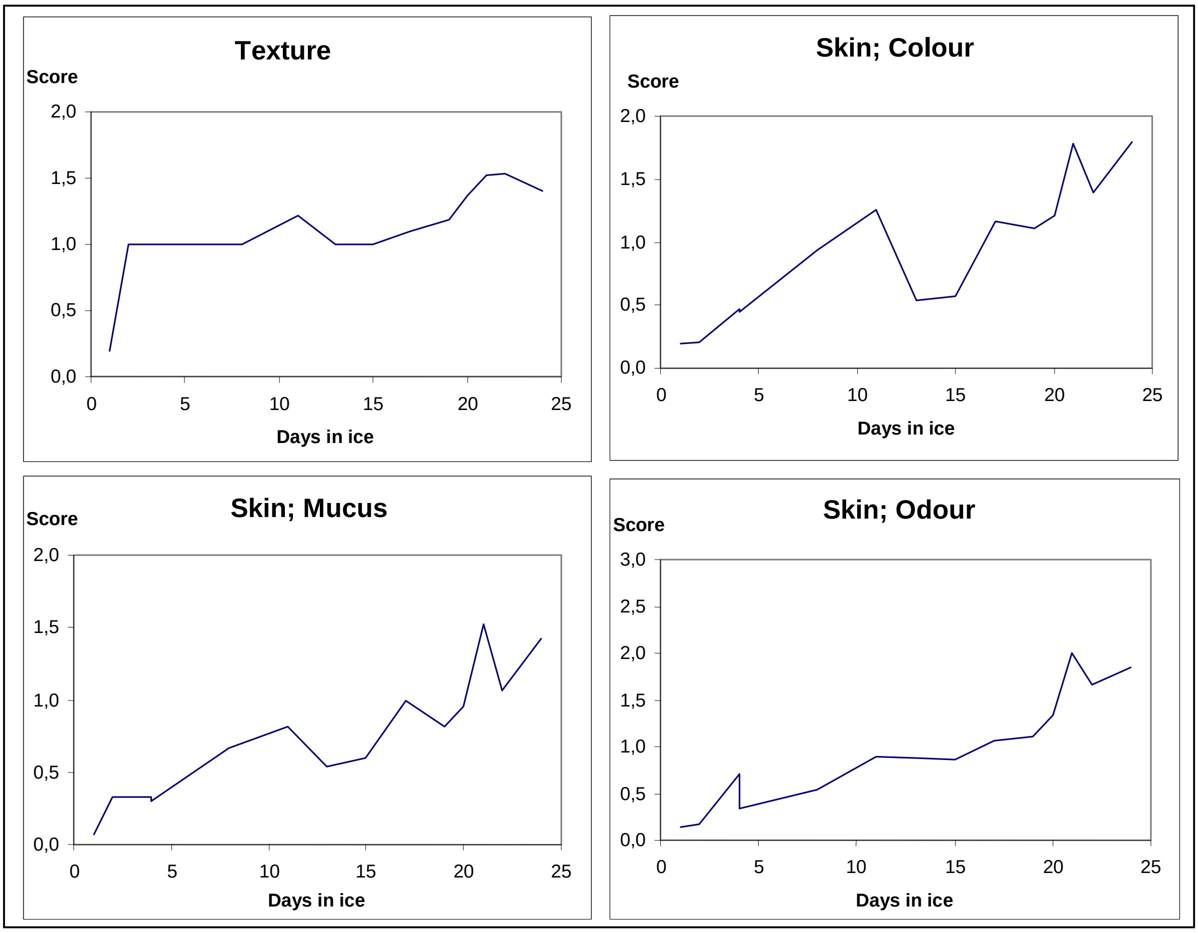

Figure 8. Average scores of quality attributes of skin (attributes assessed with QIM scheme for salmon stored in ice) vs. days in ice.

The scores of all attributes for skin increase with storage time in ice. The score for texture are around zero at storage day 1, as the salmon is in rigor at that point. The resolution of *rigor* causes the muscle to relax again and through storage in ice, the flesh becomes soft due to autolysis influenced by both fish muscle enzymes and microbial enzymes (Nielsen, 1995; Gill, 1995). The skin does not appear to become soft or less springy until after 17-20 days of storage in ice, where the score increases from 1 to 1,5. The score 2 is therefore used frequently for salmon stored longer than 15 days in ice.

The estimation of skin colour appears to be rather difficult as Figure 8 indicates, since salmon stored 13 to 15 days in ice receive much lower scores than salmon stored 11 and 17 days in ice. This could be due to individual differences between salmon as only 3 salmon were evaluated each day of analysis. The average score is however close to the maximum score (2) after the 20 days, but minimum score (0) after 1 and 2 days of storage in ice.

The scores for skin mucus increase rather constantly through the storage time in ice, from zero to close to maximum score.

The scores for skin odour appear to have the same trend as skin mucus, but the average score reaches only 2 at the end of the storage time. The odour of salmon skin is therefore not frequently described as rotten. At the beginning of the storage time when the salmon was very fresh, the odour was described as fresh seaweed or neutral. This is probably because newly caught fish contains low levels of volatile compounds which contribute fresh like odours (Ólafsdóttir and Fleurence, 1997). During the first days of storage, a cucumber like odour dominated the odour of the salmon skin. This could be caused by the compound 2,6 nonadienal, which has a very characteristic cucumber odour and a low odour threshold (0,001 ppb) (Ólafsdóttir and Fleurence, 1997). The sour and later rotten odour of the salmon is probably caused by microbial activity, e.g. short chain acids, alcohols, sulphur compounds and amines (Ólafsdóttir and Fleurence, 1997).

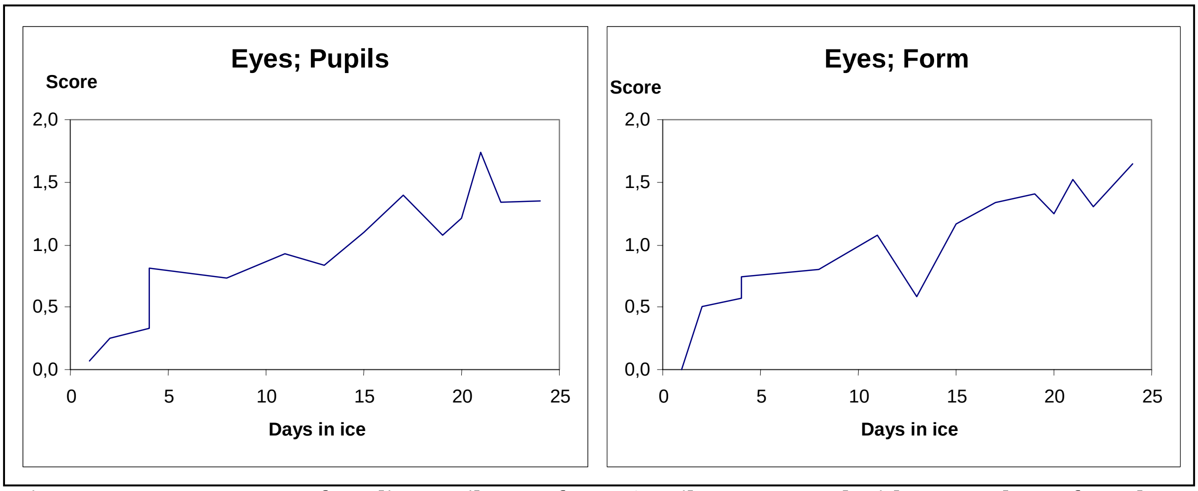

Figure 9. Average scores of quality attributes of eyes (attributes assessed with QIM scheme for salmon stored in ice) vs. days in ice.

The scores for the quality attributes of eyes increase constantly throughout the storage time in ice from zero though the scores vary somewhat with the storage time.

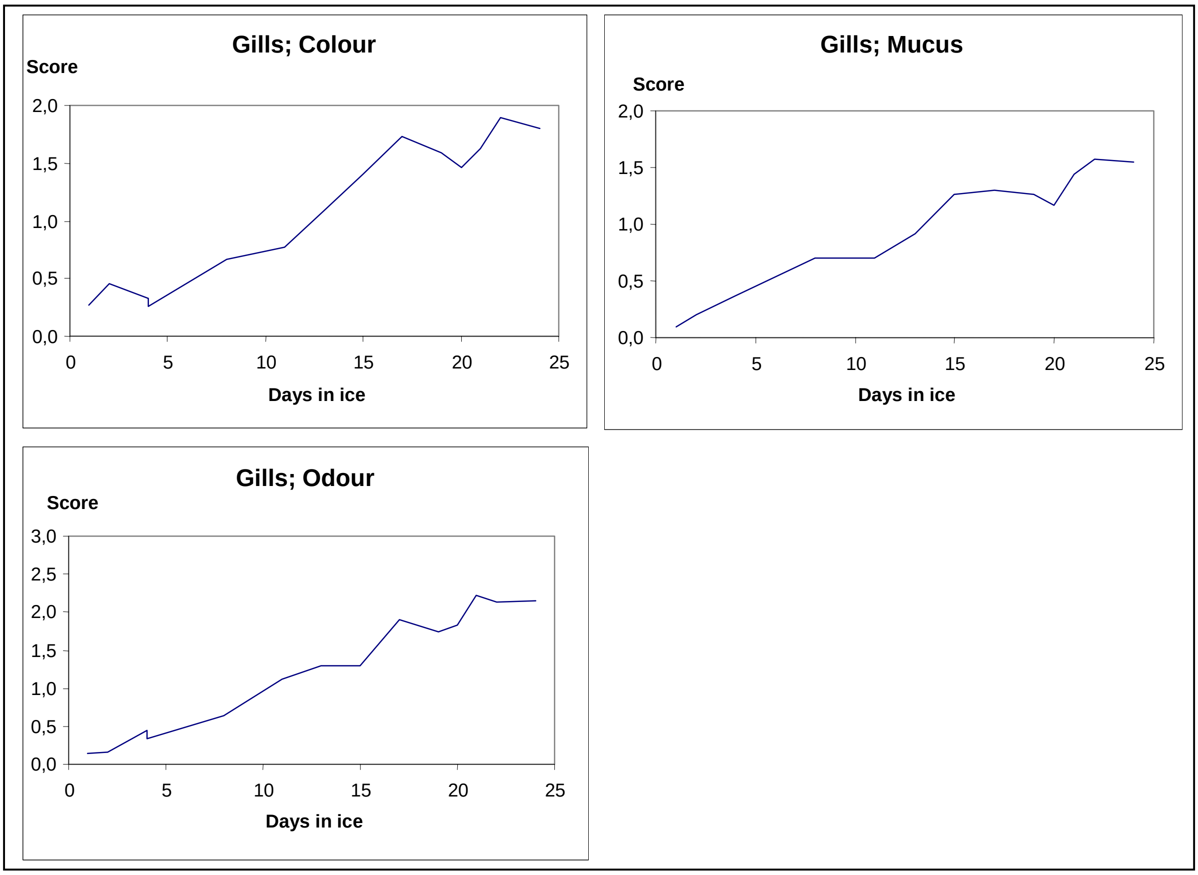

Figure 10. Average scores of quality attributes of gills (attributes assessed with QIM scheme for salmon stored in ice) vs. days in ice.

The scores of the quality attributes of gills increase with storage time in ice from zero. The colour approaches maximum score after ca. 15 days of storage in ice. The scores for mucus have similar trend, but the score is not as high as for the colour of gills. The odour of gills is not often described by the maximum score of 3, but after 20 days of storage in ice the average score is above 2.

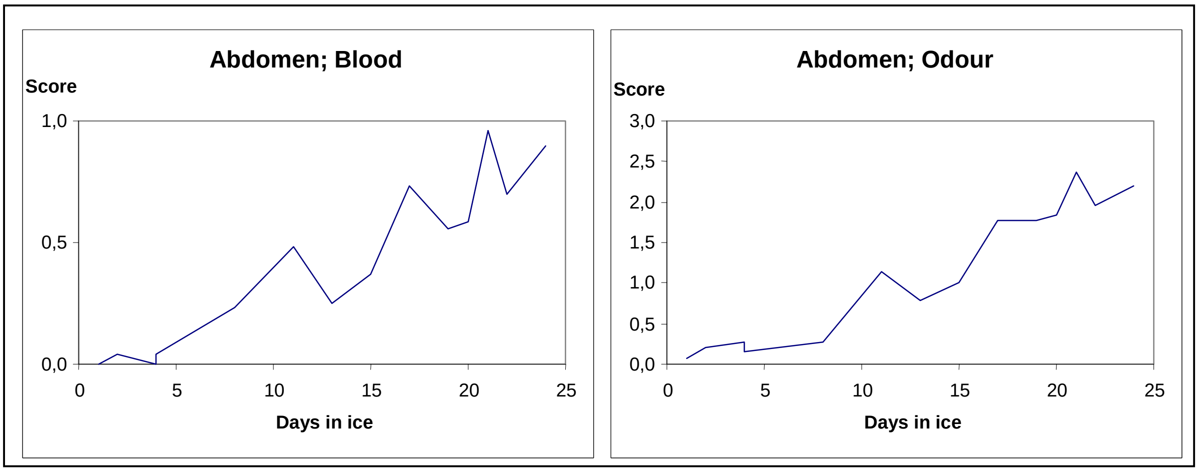

Figure 11. Average scores of quality attributes of abdomen (attributes assessed with QIM scheme for salmon stored in ice) vs. days in ice.

The scores for quality attributes of abdomen increase with storage time in ice, though not very constantly. The scores for blood in abdomen are close to zero until after 4 days of storage in ice. The blood in the abdomen is blood red at first, but later on it becomes brownish. Similarly, the scores for odour in abdomen are close to zero the first 8 days of storage in ice, then they increase with the storage time.

In order to obtain a better overview of how the different quality parameters of salmon change with the storage time, the results were analysed with principal component analysis (PCA) in the statistical programme Unscrambler.

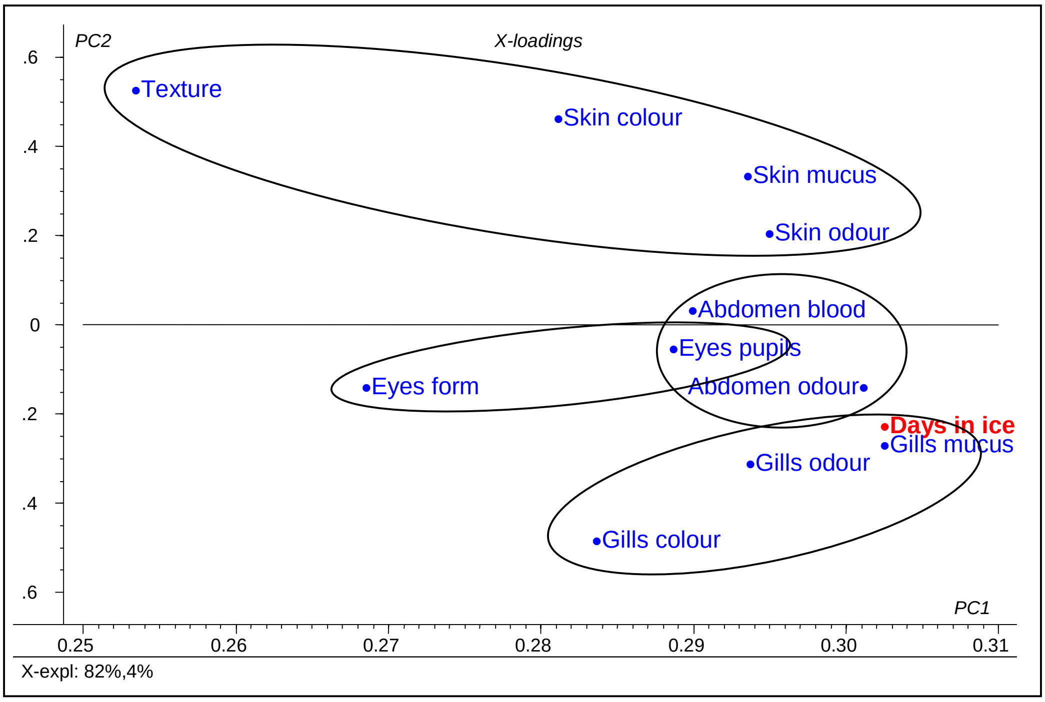

Figure 12. Loadings in PCA of salmon data including all quality parameters assessed in the QIM scheme for salmon and storage time in ice. All variables are weighed (1/SD).

Figure 12 illustrates how the quality parameters of salmon are connected to storage time in ice. The first Principle Component (PC1) axis spans clearly the variation between samples observed with storage time in ice. The parameter days in ice is located at the right end of the PC-axis that explains 82% of the variation between the samples. The entire variables in the QIM scheme receive higher scores with storage time in ice and are therefore located at the right side of PC1 as it spans the variation between samples with storage time.

The quality parameters for each group assessed (skin, eyes, gills and abdomen), show a certain grouping in the figure, and therefore it appears that the spoilage rate of the quality parameters within each group is somehow connected.

Gills mucus almost adjoins the variable days in ice. This does though not indicate that assessing the gill mucus is enough to give an estimation of the storage time in ice, even though it might give the closest correlation to storage time in ice. The scores possible to give for the gill mucus are only in the range from 0 to 2 (three possible scores) which could

never give nearly as good estimation of the storage time as all the parameters added together with a possible score ranging from 0 to 24 (25 possible scores).
The variable texture is located furthest away from days in ice. However, the variation in texture explains some of the variation between the samples, as it is located to the right side of the PC1-axis. Though it appears not to give as good indication of storage time in ice as the other variables, it should not be excluded from the QIM scheme for salmon. The texture is important parameter that changes with storage time, involving the stiffness in rigor and softening of the fish flesh during storage.

3.2. Quantitative Descriptive Analysis (QDA)

Wordlist development and training of QDA panel

The descriptions developed under wordlist development and training for the quality parameters odour, appearance, flavour and texture of the QDA, are given in Appendix B1.
It was noted that the panel had some trouble in finding words that could be used to describe the sensory attributes of salmon. The appearance did not change much through the storage time, it was mainly the colour that appeared to become more heterogeneous with time. The odour and flavour of salmon at the beginning of the storage time could best be described as characteristic salmon odour and flavour, but also with seaweed or seaside odour, oily or fresh liver odour, metallic and sweet flavour. Along the storage time the odour and flavour appeared to become more sour, musty and rancid. The texture did not appear to change much through the storage time, but despite of that, it was decided to include juiciness (dry/juicy) and tenderness (tough/tender).
After the 2 days used for wordlist development and training, the panel had become familiar with the quality attributes of cooked salmon, but perhaps not trained enough in using the scale since 2 days are rather short time for training for the QDA of salmon. On the other hand, the panel was already trained in assessing fish (including salmon) with sensory evaluation. They were also familiar with the QDA method and most attributes used in describing the cooked salmon.

QDA of farmed salmon

When the salmon had been stored for 21 days in ice, a part of the panel refused to taste the salmon. This strongly indicates that after 20 days of storage in ice, salmon is, according to sensory evaluation, no longer fit for human consumption. This is in agreement with previous studies. The author concluded that 20-21 days was the maximum storage time for salmon stored in ice (Sveinsdóttir, 2000). Others have come to similar conclusions, according to Magnussen *et al*. (1996), the maximum storage time of salmon is assumed to be 21 days (at best storage conditions).

To observe better how the quality of the cooked salmon changed with storage time in ice, the evaluated parameters were plotted vs. days in ice as shown in Figures 13 - 16.

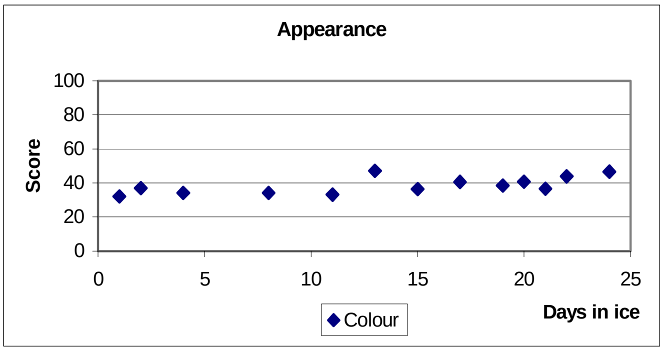

Figure 13. Changes in appearance of cooked salmon vs. storage of the raw salmon in ice observed by a trained panel by the QDA method.

The scores for colour appear to increase slightly along the storage time. The increase in scores (more heterogeneous colour) is though seldom statistically different (see Table 3), and no clear trend with storage time is seen.

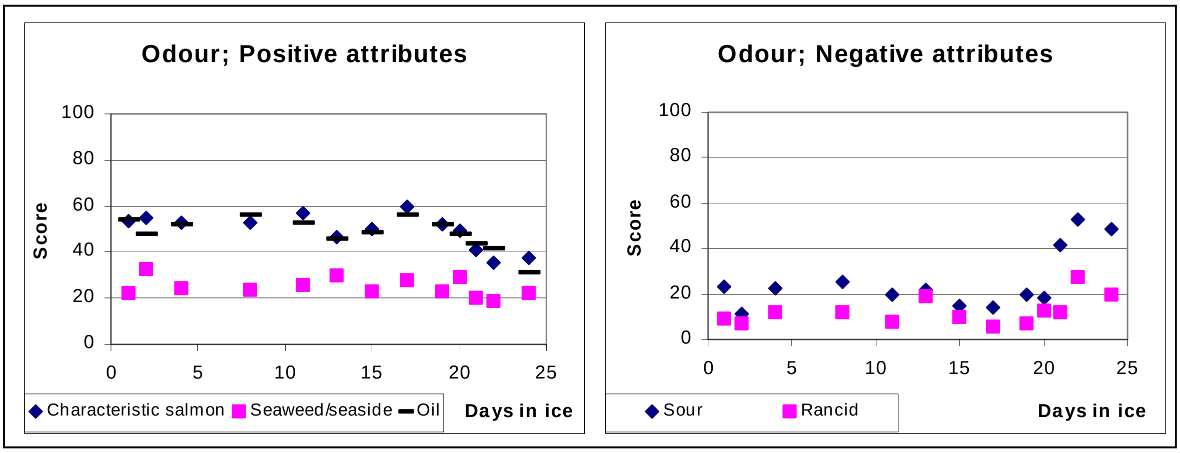

Figure 14. Changes in odour of cooked salmon vs. storage of the raw salmon in ice observed by a trained panel by the QDA method.

The positive attributes for odour appear not to change much along the storage time, but after ca. 19 days in ice, the scores decrease. This appears to be mostly true for characteristic salmon odour and oil odour, but less for seaweed/seaside odour, but for all attributes is found significant difference between salmon along the storage time in ice (see Table 3). The same trend is seen for the negative attributes as minor changes are observed with storage time until after day 20-21, when the scores increase significantly.

According to Figure 15, the positive attributes for flavour seem to be rather unchanged the first 17-19 days of storage in ice, but fade fast thereafter. This is especially true for characteristic salmon flavour, but also metallic and oily flavour, though less. Sweet flavour appears to be the least stable through the storage time, and its average score ranges between 20 and 40 through the storage time, and drops only below 20 for salmon stored 21 day in ice.

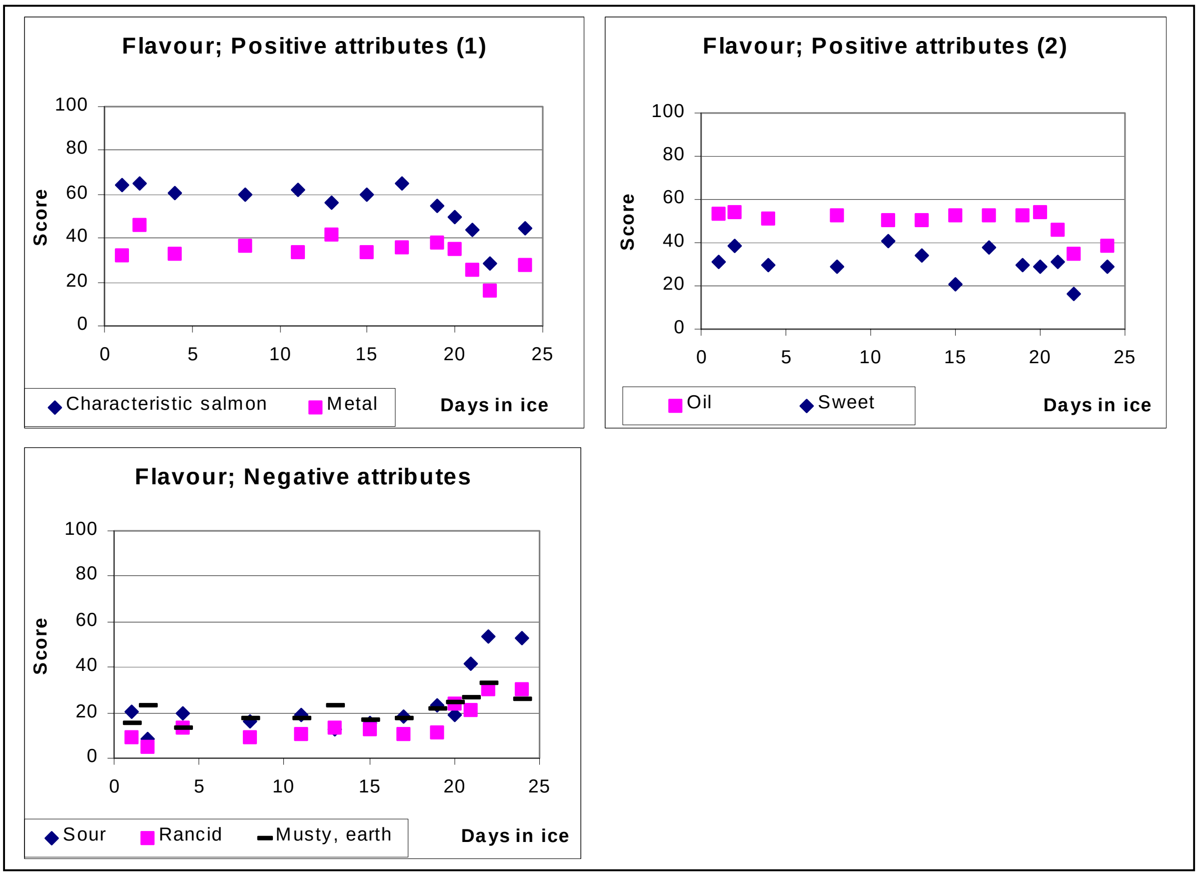

Figure 15. Changes in flavour of cooked salmon vs. storage of the raw salmon in ice observed by a trained panel by the QDA method.

Milo and Grosch (1996) analysed various odourants in salmon of different freshness (stored for 26 weeks at -60°C (fresh) and -13°C (not fresh). They found propionaldehyde and (Z)-1,5-octadien-3-one as the most potent high volatile odourants in cooked fresh salmon samples. The odour of those compounds is described as sweet and metallic (respectively). Food odour is a part of the overall flavour and those compounds may therefore be responsible for the sweet and metallic flavour of the cooked salmon in this study. Which chemical compounds could be responsible for the characteristic salmon flavour is not clear, but it could be a mixture of odourants in the cooked salmon. Milo and Grosch (1996) detected various odourants from cooked salmon (fresh), and the characteristic salmon odour and flavour were attributed to acetaldehyde (sweet), hexanal and (Z)-3-hexanal (green), methional (boiled potato-like), dimethyl trisulfide (cabbage-like) and 1-octan-3-one (mushroom-like). The oily flavour and odour might also be due to (Z,Z)-3,6-nonadienal as it is described as fatty, green and was threefold higher in the fresher samples.

The scores for the negative attributes sour, rancid and musty/earthy shown in Figure 15 are low and appear not to change the first 17-20 days of the storage time, but thereafter, the scores increase, and especially the scores for sour flavour. The scores for musty, earthy flavour are around the same as for sour flavour the first 20 days, but thereafter, the increase is much less than for sour. The scores for rancid flavour are very low, around 10 and increase first after 19 days of storage in ice. The increase in rancid flavour is not large and reaches only the score of ca. 30 for salmon stored 22 and 24 days in ice. This is rather strange for a fat fish species such as salmon but can be explained partly by that the feed of farmed salmon often contains carotenoids (Moe, 1990). Carotenoids are though to play an important role in protecting lipid tissues from oxidation (Burton and Ingold, 1984). Another reason can be that some panellists are unable to detect rancidity, and that may lower the average score.

Milo and Grosch (1996) found their less fresh cooked salmon samples to be fatty and train-oily smelling. The train-oily odour might correspond to the rancid odour, which increased in the last days of storage. According to their findings, the rancid flavour in salmon is caused by formation of volatile oxidation products such as aldehydes and ketons. They did however, not observe sour or musty/earthy as observed in this study. However, their samples were stored at -13°C for 26 weeks, but here the samples were stored in ice up to 24 days so the results are not directly comparable.

The flavour quality of cooked salmon decreased significantly for all attributes with days in ice (see Table 3). The average scores for positive flavour attributes decrease with the storage time but negative attributes increase. The change is generally noted after ca. 17-19 days in ice.

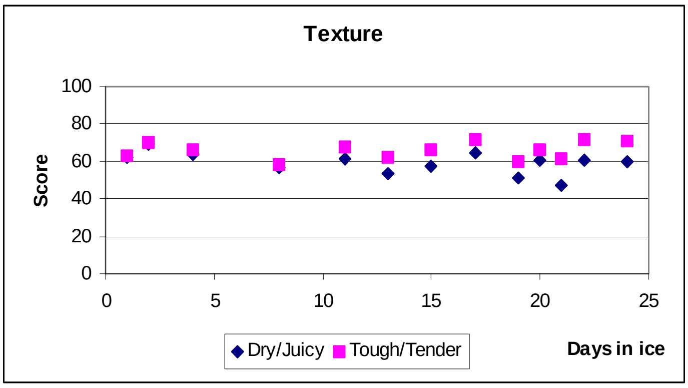

Figure 16. Changes in texture of cooked salmon vs. storage of the raw salmon in ice observed by a trained panel by the QDA method.

The storage in ice does not appear to affect the texture of the salmon, neither juiciness nor tenderness. The scores are between ca. 50 and 70 for juiciness and ca. 60 and 70 for tenderness throughout the storage time. Though, significant difference between some storage days is observed, especially juiciness. Salmon stored 21 day in ice is less juicy than more fresh salmon (see Table 3).

In Figure 14 and Figure 15 here above, it can be seen that salmon stored 24 days in ice is evaluated of better quality than salmon stored 22 (and sometimes also salmon stored 21) days in ice. The most likely reason for this is that one of the salmon analysed after 24 days in ice was of unusually "good quality" compared to the others. Unusually low QI scores given and low microbial counts for this individual salmon appeared to be reflected in the sensory assessment of the salmon cooked.

The results were treated statistically in HyperSence, the interaction between panellists and samples and difference between storage days was analysed with Tukeys test. The programme was not able to analyse the whole data set because of its size. However, reducing the sample size of two samples made the analysis possible. The samples that were excluded, were samples from storage day 4 and 24, to minimise the effect on the statistical analysis. Storage day 4 was analysed twice contrary to all other samples that were analysed once. Storage day 24 was kept out of the analysis, as the salmon was way past the limits of acceptance (20 days in ice).

Table 3. Statistical analysis of QDA scores of cooked salmon (previously stored for different time in ice). Two-factor design with interaction ANOVA using Tukeys test for multiple comparison showing the storage day when difference is significant.

		Odour					Flavour							Texture	
Days in ice	Colour	Characteristic salmon	Seaweed/seaside	Sour	Oil	Rancid	Characteristic salmon	Metallic	Sweet	Sour	Musty/earth	Oil	Rancid	Dry/Juicy	Tough/Tender
1		22		22		22	21,22	22		22	22	22	20,22	21	
2		22	22	21,22		22	20,21,22	21,22	15,22	21,22		22	20,22	19,21	21
4	13,22	22		22		22	21,22	22	22	22	20,22	22	22	21	
8		22		22	22	22	21,22	22		21,22	22	22	22	21	
11		21,22		21,22		22	21,22	22	15,22	22	22		22	21	21
13	4			21,22			21,22	21,22	22	21,22					
15				21,22		22	21,22	22	2,11	21,22	22	22	22	21	
17		21,22		21,22	22	22	21,22	22	22	22	22	22	22	21	21
19		22		21,22		22	21,22	22		22		22	22	2	
20				21,22		22	2,22	22		22	4	22	2	21	
21						22									
22						21									

From the results in Table 3, it appears that for most attributes a statistical difference is generally first noted at the rejection limits (after 20 days in ice). This is not surprising if Figures 13 - 16 are observed. The attributes appear to show no tendency of changes with storage time until at the rejection limits.

Similar trends for changes of cooked salmon are seen in the literature. Lande and Rørå (1999) performed a shelf life study with salmon where the flavour, odour and overall effects were analysed in cooked salmon. Minor changes were observed with storage time in ice up to 18 days of storage in ice. Magnussen *et al*. (1997) also observed sensory changes in fresh and cooked salmon stored 7, 14 and 21 days after good and poor icing. The changes were observed much sooner in raw fish, but sensory changes in cooked salmon which had been stored at best conditions became first evident when the salmon had been stored 21 days in ice.

If data is missing from the "two factor with interaction" model, HyperSence will automatically substitute the corresponding average for the missing data and reduce the number of degrees of freedom accordingly. It can be argued if this is allowable, as the panellist that is not present might have given quite different scores than the average score indicates. However, the assessment was carried out for several days and very few panellists were present in all sessions, making it impossible to discard all data from panellists that were not present in all the sessions.

For each attribute in the QDA, significant difference was observed between panellists. This is a well know phenomenon in sensory evaluation. The main types of differences among assessors may be caused by confusion about attributes, individual differences in sensitivity to certain sensations, individual differences in the use of the scale or individual differences in precision (Næs *et al.*, 1993). Various ways have been discussed to detect and handle such differences among assessors (Næs *et al.*, 1994; Næs, 1990; Næs and Solheim, 1991). In our study the panellists assessed quite differently and were differently able to assess the different attributes.

In order to obtain a better overview of how the different quality parameters of cooked salmon change with the storage time, the results were analysed with principal component analysis (PCA) in the statistical programme Unscrambler.

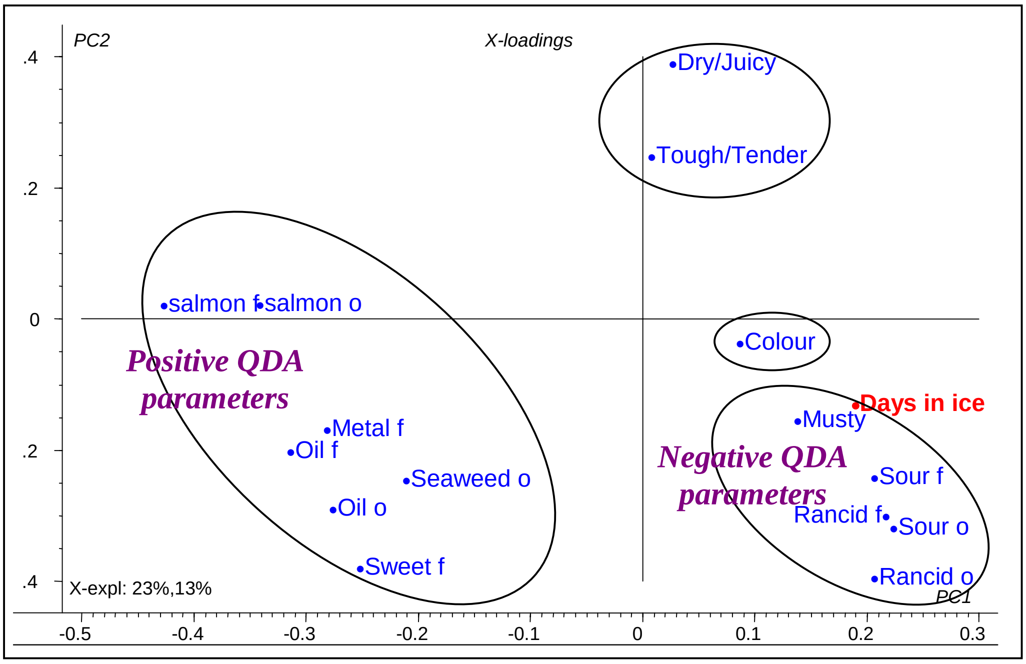

Figure 17. Loadings in PCA of salmon data including all quality parameters assessed in QDA of cooked salmon and storage time in ice. f = flavour, o = odour.

Figure 17 illustrates how the quality parameters of salmon are connected to storage time in ice. The Principle Component (PC) axis appears to span the variation between samples with storage time in ice. The parameter days in ice is located at the right end of the PC-axis that explains 23% of the variation between the samples. There is a clear grouping between positive and negative flavour and odour parameters along the PC1-axis. The negative parameters become more evident in salmon stored longer in ice, while the positive

parameters become less evident. The negative words used to describe the quality changes occurring in cooked salmon appear to be similarly able of describing salmon at the end of the storage time. Likewise, the positive words appear to be similarly able of describing more fresh cooked salmon, though, somewhat less.
Discolouration appears to become slightly more evident along the storage time. The texture parameters dry/juicy and tough/tender are grouped together on the PC2-axis. The texture of cooked salmon does not appear to change with storage time, counter to texture of raw salmon.

3.3. Microbial counts

In Figure 18 the results of total viable count and H_2S-producing microbes on salmon skin and in salmon flesh during storage time in ice are presented.

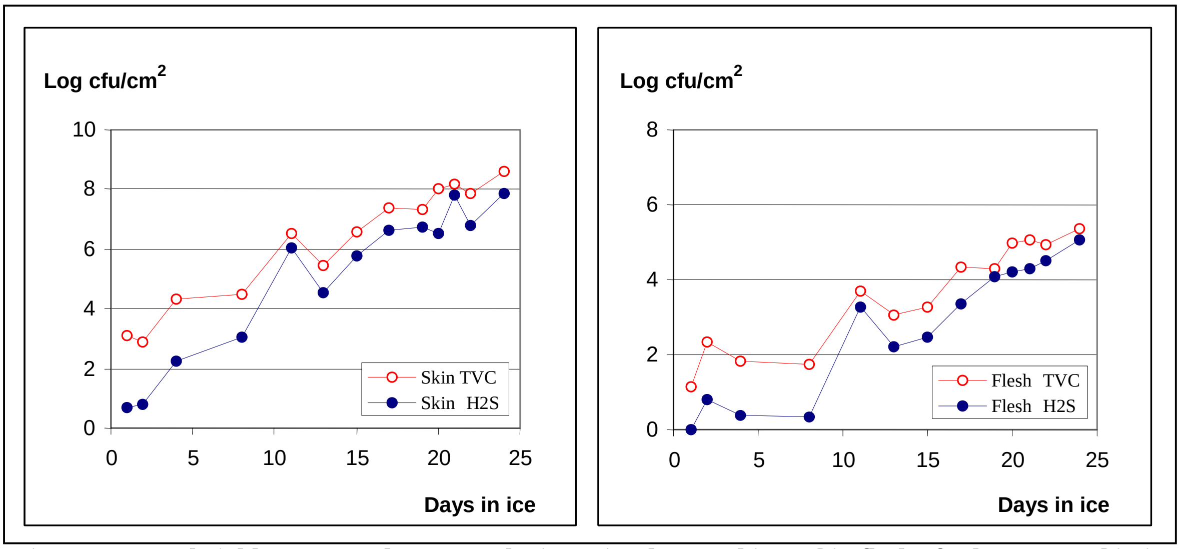

Figure 18. Total viable count and H_2S- producing microbes on skin and in flesh of salmon stored in ice.

The total viable count (TVC) on the salmon skin and in the flesh increases exponentially with the storage time in ice. The salmon stored 11 days in ice appears to have unusually high bacterial counts compared to salmon stored 8 and 13 days in ice. The high bacterial counts are in agreement with high QI scores given for salmon stored 11 days in ice in the QIM assessment. This indicates that the salmon stored 11 days in ice was of unusually bad quality, the fish may e.g. have been stored non-iced at too high temperatures before arrival. A similar pattern is noted for bacterial counts on skin and QI scores with storage time in ice, as salmon containing unusually low bacterial counts also receives unusually low scores in QIM. The TVC is in good agreement with the QIM assessment as a whole as shown in Figure 19. A high correlation is found between QI scores and TVC. The same is seen for H_2S producing bacteria, which are higher proportion of the TVC at the later stages of storage.

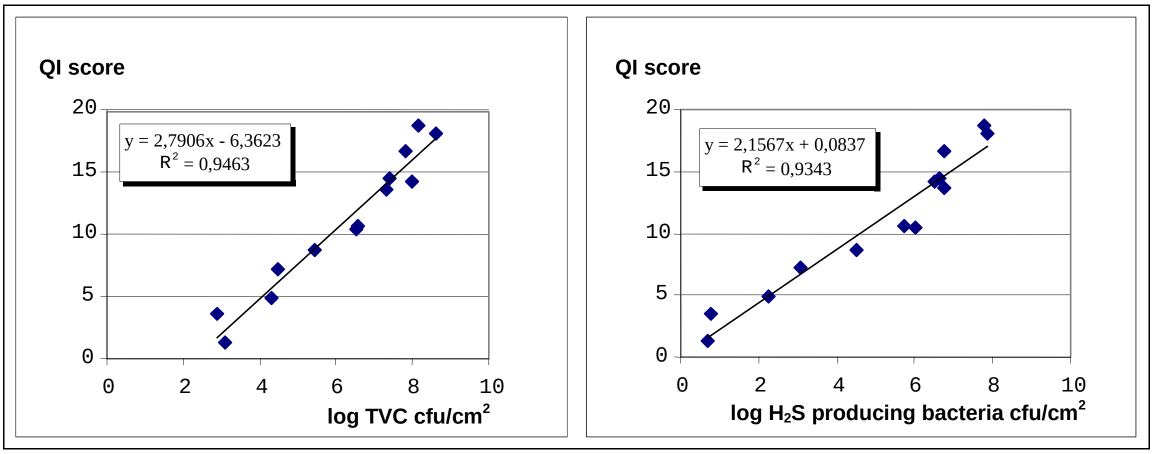

Figure 19. Correlation between bacterial counts on skin and QIM assessment of salmon stored in ice.

At the beginning of the storage time of salmon, the total viable count on skin was around 10^3 cfu/cm^2. This can be considered normal for newly caught fish (Liston, 1980). Very few H_2S producing microbes were a part of the microflora at the beginning (<10 cfu/ cm^2), but they increase their share of the total viable count along the storage time. The total viable counts (mainly H_2S producing microbes) on the salmon skin is around 10^8 cfu/cm^2 after about 20 days of storage in ice.

The bacterial counts in salmon flesh are lower than for skin. Newly slaughtered salmon contained TVC around 10 cfu/g. This is in agreement with Gram (1995b). After 20 days of storage in ice, the total viable count had only reached 10^5 cfu/g, which is considerably lower compared to the 10^8 cfu/cm^2 for skin. As for the microbial growth on salmon skin, the H_2S producing bacteria dominated the bacterial flora at the end of the storage time. Counts of H_2S producing bacteria were very low (below 10 cfu/g) until after 8 days in ice. Similar results very noted by Lande and Rørå (1999). Magnússon (1987) counted TVC and H_2S producing bacteria in farmed salmon, where the total viable count reached ca. 10^8 cfu/cm^2 after 19 days in ice on the skin, but ca. 10^5 cfu/g in the flesh after the same storage time. This is in agreement with the results obtained in this study.
The total viable count in salmon flesh at the rejection limits observed in this study are considerably lower than what is usual at the rejection limits (Ólafsdóttir *et al.*, 1997a). This could be caused by the high counts of H_2S producing bacteria at the end of the storage time, as they are probably responsible for spoilage (Capell *et al.*, 1997). This supports the rejection of the cooked salmon samples after 20 days of storage, as the TVC were dominated by H_2S producing bacteria.

3.4. Electronic nose

Samples in the experiment in November 1999 were contamined. Ethanol was used when taking samples for microbial analysis which were taken from the same fish as the samples for electronic nose measurements. Therefore, very high responses of the CO sensor were observed and this data can not be used. Moreover the NO and H_2S sensors also responded to the ethanol contamination. However the SO_2 and NH_3 sensors do not appear to be sensitive to ethanol and Figure 20 shows that the responses of these sensors towards salmon heads increases during storage. The response of the sensors to fillets is very low and no changes are observed during storage. In March 2000 a few samples of salmon were stored in ice to repeat the Novemeber study, mainly to study the characteristic responses of the CO sensor and to see if similar patterns were observed for the other sensors. Figure 21 shows that the response of the CO sensor appears to increase with storage time, but changes in the response of the other sensors are minimal.

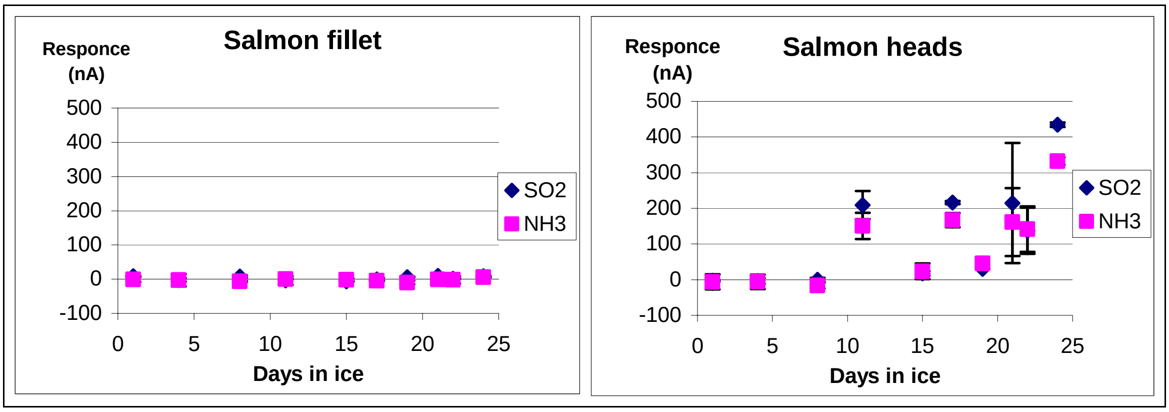

Figure 20. Response of SO_2 and NH_3 sensors to repeated measurements of salmon fillets and heads from salmon stored whole in ice for 25 days (Nov. 1999)

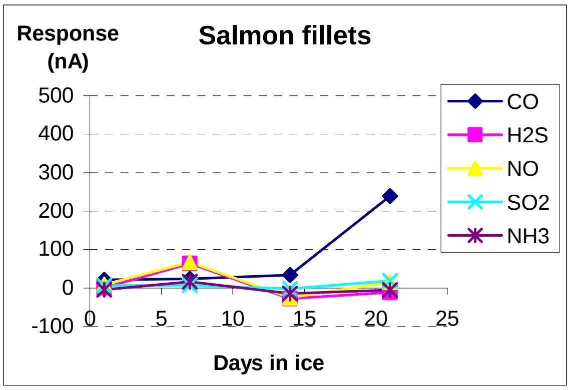

Figure 21. Responce of sensors to measurements of salmon fillets stored in ice for 21 days (March 2000).

3.5. Chemical analysis

Fat content

The average fat content of the salmon was 15,1 ± 2,1% (95% confidence interval) and is highest around 19%, but lowest around 10%. The fat content of all salmon can be seen here below in Figure 22.

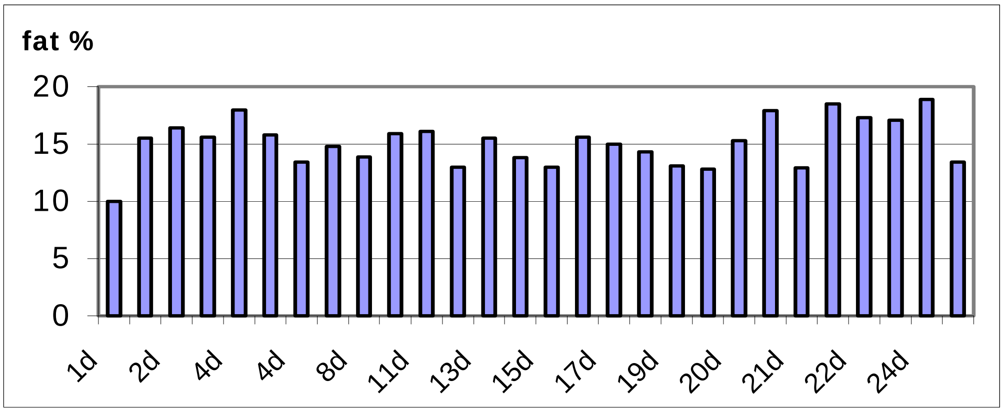

Figure 22. Fat content of salmon stored in ice.

The average fat content of the farmed salmon in this shelf life study is comparable to previously reported fat content of farmed salmon (Hafsteinsson *et al*.,1998a; Refsgaard *et al*.,1998). Refsgaard et al. (1998) also reported a considerably large variation between the individual farmed salmon (150) or 15 ± 3% (95% confidence interval) in the same study, which is surprisingly much considering that the salmon analysed was from the same batch (same farm, slaughtering time, size, feed).

Water content

The water content of the salmon in the salmon study was 64,8 ± 1,9% (95% confidence interval) but the highest value was around 70%, but lowest around 61%. The water content of all salmon is shown in Figure 23.

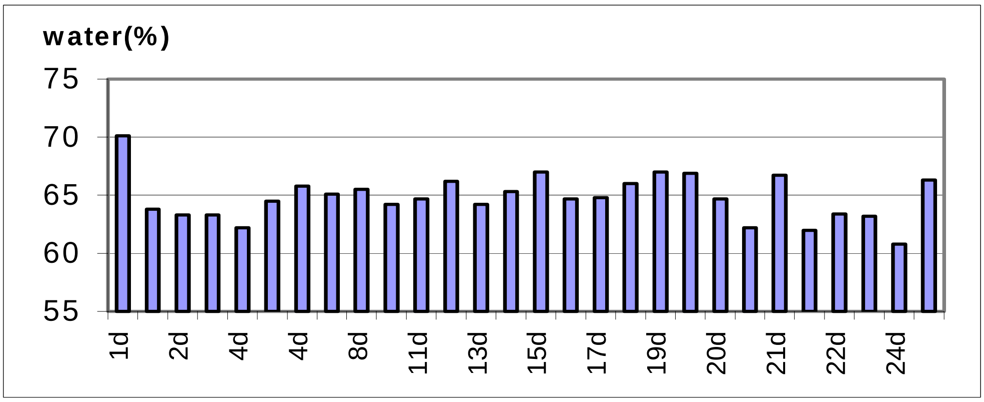

Figure 23. Water content of salmon stored in ice.

The fat content was negatively correlated to the water content as is demonstrated in Figure 24, and together fat and water add up 79,9% which is in agreement with the statement of Børresen (1995).

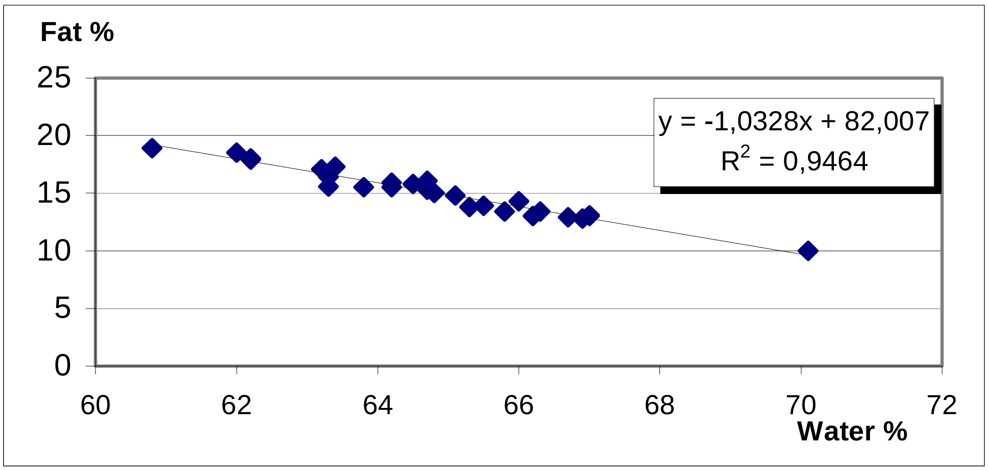

Figure 24. Fat content vs. water content of salmon stored in ice.

Fat content and sensory evaluation

In order to observe if the fat or water content of the samples affected the sensory evaluation related to those factors, the results were treated in the statistical programme Unscrambler and are viewed in Figure 25.

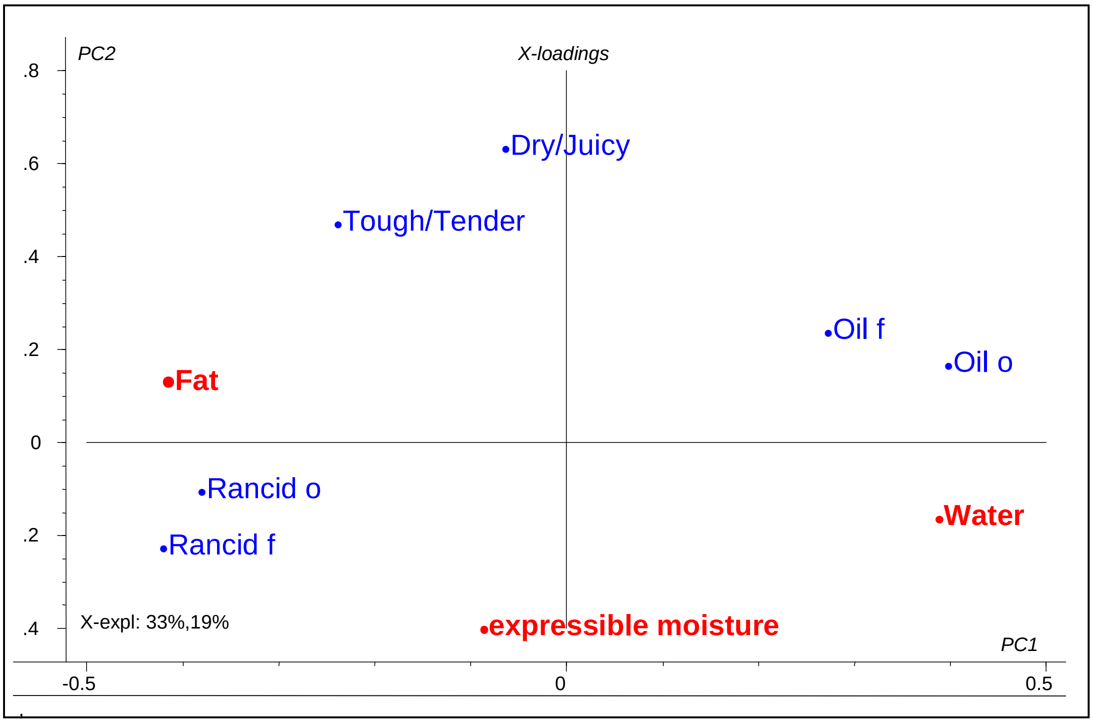

Figure 25. Loadings in PCA of salmon data including fat related sensory attributes, texture parameters assessed by sensory evaluation (QDA method), expressible moisture, fat and water content All variable weighed (1/SD). f = flavour, o = odour.

Water and fat are located opposite on the PC1-axis, but the same is observed for rancidity and oily odour and flavour. Therefore, PC1 might expand the variation between samples with storage time in ice rather than fat content. However, significant correlation is observed between fat content and the sensory attributes rancid odour and flavour (Table 7) and fat salmon appears therefore to become more rancid. Strangely, the fat content is negatively correlated to oily odour and flavour. However, the correlation is not significant.

Table 7. Correlation (R) between measured fat, water, expressible moisture and some sensory attributes (QDA method) of salmon stored in ice. Comparisons of significance according to O´Mahony (1986)*.

	Fat	Water	Expressible moisture
Oil odour	**-0,3814**	0,3777	-0,1931
Rancid odour	**0,4444**	-0,4253	0,0106
Oil flavour	-0,2220	0,1771	-0,1539
Rancid flavour	**0,5374**	-0,4893	0,3166
Dry/Juicy	0,2229	-0,1976	-0,3494
Tough/Tender	**0,3791**	-0,3066	-0,1114
Days in ice	0,1961	-0,1297	**0,7275**
Expressible moisture	0,1170	0,0699	-

*** Bold indicate significance (p < 0,05)**

The fat content appears to influence tenderness and the correlation between the two is significant. Therefore, cooked salmon of higher fat content appears to result in increased tenderness. This in agreement with what has been reported earlier (Andersen *et al*, 1994; Howgate, 1977; Andersen *et al* 1995b).

Juiciness did not have significant correlation to fat content (Table 7), but previously it has been reported that salmon with higher fat content are more juicy (Einen and Thomassen, 1998).

3.6. Photographs

During the shelf life study, photographs were taken of the various attributes that change with storage time in ice in salmon. This includes the colour/appearance of skin, effects on the skin by assessment of the texture, skin mucus, form and colour of eyes, colour/appearance and mucus of gills and the colour of blood in abdomen after various storage time in ice. The photographs that were found to fit best each description of the quality parameters assessed by the QIM scheme for salmon were picked out and imported into the WiseFresh program. There the photographs will be used for guidance for assessors that will use the programme to assess salmon by the QIM scheme.

Here below are some examples given of photographs in Figure 26, demonstrating different freshness stages.

Salmon stored 1 day in ice

Colour/Appearance: Pearl-shiny all over the skin
Eyes: Colour clear and black, form convex
Gills: Red, Mucus transparent

Salmon stored 20 days in ice

Colour/Appearance: The skin is yellowish, mainly near the abdomen
Eyes: Colour dark grey, form sunken
Gills: Colour grey-brown, brown, green, Mucus brown, clotted

Figure 26. Photographs of salmon at two different freshness stages, at the beginning of storage in ice (1 day in ice), and at the rejection limits (20 days in ice).

The changes occurring in the outer appearance of salmon with storage time in ice are clearly demonstrated in Figure 26. The appearance of the skin changes from being pearl-shiny to yellowish, the eyes change from being black and convex to grey and sunken. The gills change from being red with clear mucus to brownish with clotted, brown mucus. All those changes and more are listed in the QIM scheme for salmon, with photographs when possible, making it easier to assess the freshness stage of farmed salmon.

4. Conclusions

In this second part of the project, the QIM scheme for farmed Atlantic salmon (*Salmo salar*) has been revised. The scores for quality attributes included in the QIM scheme increased somewhat differently with storage time in ice, but added all together (QI), they give a linear relationship between QI and storage time in ice. The correlation between QI scores and days in ice is high (R^2 = 0,9533). The linear relationship between the QI (y) and storage days in ice (x) is found by the formula: y = 0,6921x + 1,57

The salmon used in this shelf life study was of the same stock as the salmon used in Part One of this master thesis, Atlantic salmon (*Salmo salar*) of Norwegian stock. However, the evaluation of the QIM scheme resulted in a linear relationship with a line of different slope compared to the first shelf life study of salmon in Part One. This is presumably because the scheme was revised, including addition of two scores. Therefore, it is recommended to repeat the shelf life study using the new scheme to observe if a similar slope is obtained, as it is the basis of calculating the storage time. If not, the predictability of past and remaining storage time is less reliable. Furthermore, the salmon in Part One received more frequently maximum scores. This might be due to different storage conditions, as the salmon in Part One was stored in closed boxes, but the lids of the boxes in Part Two had been partly opened, allowing air exchange. This implies that the quality attributes of whole raw salmon are negatively affected by storing the salmon in closed boxes, as it appeared to accelerate the spoilage characteristics presumably caused by a different bacterial flora. This should be taken into account when using the scheme.

The individual salmon appear to spoil at different rate. Based on that, it is concluded that minimum of 3 salmon should be included in the assessment of each batch of salmon. Partial least square regression (PLS) analysis of the predictability of storage time in ice from QI scores resulted in a standard error of performance (SEP) of 2,0 days. The SEP value indicates that the QIM scheme developed may be used to predict the storage time of salmon with ± 2,0 days at the 95% significance level assuming that three salmon are included in the assessment of each batch. This is a rather large interval, compared to the significance level observed in Part One. There however, five salmon were included in the calculations. This implies that including 5 salmon instead of 3 might reduce the prediction error, giving more reliable information about the storage time.

The panellists participating in the sensory evaluation with QIM for salmon performed differently, as some gave higher or lower scores throughout the storage time. The assessors were trained for 1 or 2 days before the evaluation. More training might have reduced the difference of assessor performance. However, the same trend was observed in Part One despite they had 6 days of training prior to the evaluation. This implies that it is very difficult to have a sensory evaluation panel to perform in precisely the same way. There will always be some individual differences among people participating as sensory assessors. The descriptions given in the QIM scheme are very precise and describe the changes occurring in outer appearance, odour and texture of salmon very well, facilitating the freshness assessment of raw salmon, making the individual performance differences as small as possible. The photographs of salmon and guidelines for the assessment may support the assessment even further. All this makes it possible to evaluate the freshness of farmed salmon in a fast and a reliable way, providing reliable information about its quality and remaining shelf life in ice. However, the unavoidable chance of differences among assessors, as observed in this study, implies that the freshness assessment with the QIM scheme should preferably be based upon the assessment of more than one assessor. Furthermore, freshness assessment applying the QIM schemes is simple and easy to learn and more than 1-2 sessions of training for QIM assessment should not be necessary for further improvement of performance or harmonising of panellists.

Based upon the sensory evaluation of cooked salmon, the maximum storage life of salmon has been determined as 20 days in ice. The quality of the cooked salmon did not change much through the storage time until day 17-20. Then the changes in odour and flavour became evident, and the positive attributes decreased while the negative attributes increased significantly. Similar results were observed in Part One, as the maximum storage time was determined as 20-21 day, despite the different storage conditions of the salmon in ice.
Differences among panellists were evident for all evaluated attributes. This might be reduced with more and longer efficient training aiming at more harmonised assessment. This could minimise the effect of different use of the scale and confusion of attributes.

The total viable counts (TVC) were low at the beginning of the storage time (ca. 10^3 cfu/cm^2 on skin but ca. 10 cfu/g in flesh). However, at the end of the shelf life (20 days), TVC had reached ca. 10^8 cfu/cm^2 on skin but ca. 10^5 cfu/g in flesh. The H_2S producing bacterial counts were very low at the beginning of the storage time and hardly detectable in flesh samples until after 8 days of storage in ice. At the end of the shelf life of salmon the H_2S producing bacteria were dominating the bacterial flora of both skin and flesh.
The bacterial growth in salmon correlated highly with QI scores, as deviation in bacterial counts were reflected in deviation in QIM scores.

The average fat content of the salmon was 15,1 ± 2,1%. This is considerably higher than what was obtained in Part One. However, the sample preparation was not completely the same and the method of analysis was different, and therefore not directly comparable. Different distribution of fat in salmon was observed in Part One and therefore it is very important to standardise how samples are collected from the flesh.
The fat and water content contributed to approximately 80% of the total sample weight and a high correlation (R^2 = 0,95) between the two was observed.
Correlation observed between fat content and attributes assessed by sensory evaluation of cooked salmon was higher than in Part One. As the panellists used the scale applied for the sensory assessment differently, this could be because each salmon was evaluated by all panellist here, but only a small part of the panel in Part One. Here, the fat content appeared to influence the sense of rancidity observed by the sensory panel as salmon with higher fat content resulted in more rancid samples. Therefore, salmon of lower fat content might be

more desirable. On the other hand, lower fat content resulted in increased toughness as observed by the sensory panel, which could be considered less desirable than more tender salmon.

Main conclusion and future work

The main conclusion of this project is the revised QIM scheme developed for farmed Atlantic salmon (*Salmo salar*). The results from the shelf life study indicate that 3 salmon are the minimum amount for assessment of each batch. Furthermore, it is emphasised that the freshness assessment should be carried out by more than one assessor.

The high correlation between QI scores and storage time in ice, makes it possible to predict the past storage time in ice. As the maximum storage time of salmon in ice has been determined as 20 days, this information can be utilised directly for assessment with the QIM for farmed salmon, to determine the remaining storage time in ice.

The precise and descriptive QIM scheme for farmed salmon, supported by photographs showing visible changes occurring during storage in ice, makes it easy to assess the freshness of salmon. Furthermore, it gives valuable and reliable information about the freshness quality of farmed salmon. Therefore, the QIM scheme for salmon may become very useful as the production of salmon has increased steadily the past decade. Moreover, trades using electronic commerce where fish is sold unseen is becoming more common and accurate information about quality and freshness is very important.

In continuation of this project it is of importance to repeat the shelf life study of salmon. This should be done mainly to observe if the same slope is obtained, as the slope is the basis of calculating the storage time. The different slopes obtained in this project, depending on if the salmon was stored in closed or open boxes give reason to examine this further regarding the use of the QIM scheme. Two different slopes might be necessary for calculations of the storage time, depending on the storage conditions for more reliable interpretation of the Quality Index. Furthermore, during long distance transport, salmon may undergo some temperature fluctuations. Therefore, it would be of interest to examine how salmon that has undergone temperature fluctuations during some part of the storage time would fit to the QIM scheme and calculations of remaining storage time.

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Appendix 2

Application of the Quality Index Method (QIM) in shelf life study of cod and haddock

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ABSTRACT
Storage studies have been done where fish was kept in ice under standardised conditions. The experiments were done on fish caught under best fishing conditions (i.e. longline) at two different seasons of the year. Two species, cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) were stored in ice for up to two weeks. At regular intervals during the storage time the fish was sampled and analysed. To monitor the changes and find the end of storage life the results of the QIM-method and electronic nose were compared to measurements of traditional methods, chemical analysis, microbial counts and storage time in ice. During the storage studies pictures were taken under standardised conditions to follow the changes in appearance of the eyes, gills, skin and slime of the fish. Simultaneous measurements were done during all the storage studies using a new rapid technique,an electronic nose (FreshSense, Element Sensor Systems, Iceland) to evaluate fish freshness. The storage life of cod and haddock was estimated to be 11 to 14 days from catch. The Quality Index correlates very well with days in iced storage and a high correlation was also found between QI and Torry sensory scores. The remaining shelf life and the Torry-score can be predicted if the Quality Index is known. . During early days of storage 3 fish is recommended as a sample size but greater sample size (5 fish) will give more accurate information at later stages of storage. The results from the electronic nose measurements indicate loss of freshness could be monitored but a better sampling technique is needed for the FreshSense instrument for whole cod and haddock.

CONTENTS

1. INTRODUCTION

The Torry scale is the first detailed scheme developed for evaluating the freshness of cod (Shewan et al., 1953) and the schemes used for sensory evaluation of cooked fillets by a trained panel are based on this original work with some modifications. These schemes are both used in the fish industry, where sensory evaluation of fillets is needed, and in research. The buyers of Icelandic fish require the use of sensory evaluation according to the Torry-scheme on cooked fillets. It is of importance for the industry to compensate this sensory method could by the use of a sensory evaluation of whole raw fish with the same result. This would be beneficial as this evaluation is more rapid and performed much sooner in the production chain. It is also of great importance to have a method that can show a linear relationship with storage time in ice as the results can be used for product management when remaining shelf life can be predicted.
Controlled storage studies of selected fish species will be undertaken to develop and adapt the QIM to different species. The main purpose is to make the QIM-schemes as reliable as possible. Also to find out the end of storage life to be able to use the QIM-scheme for process management as the quality index is linear during storage of the fish in ice. To monitor the changes and find the end of storage life the results of the QIM-method will be compared to other traditional methods, trimethylamin (TMA) and total volatile bases (TVB) chemical indicators of spoilage and microbial counts. Simultaneous measurements will be done during the storage studies using a new rapid technique an electronic nose (FreshSense, Element Sensor Systems, Iceland) to evaluate fish freshness (Ólafsdóttir et al., 1997).

2. MATERIALS & METHODS

IFL has carried out two storage studies on cod and haddock kept in ice. The fish was caught in May and June and in December. The storage studies were done during different seasons of the year, May/June and November/December.

2.1. Experiments

a) Experiment in May and June

Cod and haddock were caught on longline southwest of Iceland, bled, gutted and iced into 90 L boxes on board and brought ashore a few hours after catch. The fish was kept for storage trial at 0 to 1°C.

b) Experiment in December

The cod was caught on longline southwest of Iceland and brought ungutted ashore, stored in a cooled warehouse during the night, gutted and iced within 12 hours from catch.
The haddock was caught with longline southwest of Iceland. It was brought bled and gutted gutted and iced into 90 L boxes on board and brought ashore a few hours after catch. The fish was kept for storage trial at 0 to 1°C.
Samples were taken at 3 to 4 days interval during the storage period. On each day of sampling 5 fish were examined.

2.2. Sensory evaluation

On each sampling day the fish was evaluated by 10-12 members of the internal panel of IFL. Each panel member evaluated 5 fish according to the QIM-method and 3 cooked samples were evaluated according to Torry scale.

2.3. Microbial counts

Total viable counts (TVC) of fish samples were evaluated for both the skin and the flesh. An area of the skin (50 cm^2) was aseptically swabbed from one side of the fish, the swab diluted with 10 ml Butterfield's buffer (Vanderzant & Splittstoesser, 1992) and well shaken. Successive 10-fold dilutions were done as required. Spread-plating of aliquots was done on Iron Agar (1% NaCl; Gram *et al*., 1987) and CFC medium (Pseudomonas Agar base supplemented with CFC supplement (Oxoid)). The fish was aseptically skinned, pieces of flesh removed and minced. Twenty-five grams of minced flesh were mixed with 225 ml buffer in a stomacher (Stomacher Lab Blender 400, A.-J. Seward Laboratories, London, UK) for 1 minute. The dilution and spread-plating procedures were done as described above. The Iron agar (IA) plates were incubated aerobically at 15°C for 5 days as opposed to 22°C (3 days) for the CFC medium. After incubation, evaluation of total viable counts was done in a Darkfield Quebec Colony Counter (Spencer). H_2S-producers (black colonies on IA) were counted from all plates. It should be mentioned that the fish used for microbiological analyses (usually 2 per sampling) was first swabbed as described above, then assessed by sensory evaluation as whole, raw fish, which was followed by headspace analysis of volatile compounds by the electronic nose (May-June fish only) before it was brought to the microbiological laboratory for the flesh analyses.

2.4. Chemical analysis

Chemical analysis was performed on the remains of the flesh mince from the microbial analysis. The pH was measured in 5 grams of mince moistened with 5 ml of deionised water. TMA and TVB-N content were determined. TVB-N is measured using Billon and Tao (1979) where 25 ml of TCA extract with 10 ml of 10% NaOH is distilled in 10 ml of 4% boric acid. TMA was measured with the same method with modifications suggested by Malle and Tao (1987). TMA was measured in TCA extract by adding, beside the base, 20 ml of 35% formaldehyde, which binds the primary and secondary amines so TMA becomes the only volatile and measurable amine.

2.5. Electronic nose measurements

Measurements were carried out in an electronic nose that was developed at IFL and consists of a plastic container (22,6 L), closed with a plastic lid, an aluminium box attached to the lid and a PC computer running a measurement program. Nine electrochemical sensors are in the aluminium box (Dräger: CO, H_2S, NO, NO_2, SO_2; City Technology: SO_2, H_2S, NH_3 and NH_3 A7AM) and a temperature sensor. The box also contains electronics, A/D converter and a microprocessor to record measurements and send them to the PC. A fan is positioned in the container to ensure air distribution.

Measuring takes 20 minutes and the program records data (nA) every 10 seconds. The response of each sensor is calculated by subtracting the average response of three minutes before measurement begins (base-value) from the average of the final three measurements.

The sensors are particularly sensitive to three main groups of metabolites in fish. The CO sensor is sensitive to short chain alcohols and aldehydes. The H2S and SO2 sensors are sensitive to compounds containing sulphur like hydrogen sulphide (H2S) and other malodorous compounds. The NH3 sensors are particularly sensitive to amines such as TMA and ammonia.
Two whole fish were weighed and placed in the container each day of sampling. They were arranged head to tail , belly up, the gills opened up as much as possible. The weight of the two fish varied from 2,5 to 6,4 kg.

2.6. Statistical treatment of data

The data from QDA were treated in HyperSense, Version 1,6 (© 1993-1996 Icelandic Fisheries Laboratories, Reykjavík, Iceland). Interaction of judges and samples was assumed and statistical analysis was done using two-factor design with interaction in the analysis of variance (ANOVA) to observe if a significant statistical difference between samples for each quality attribute assessed existed. The programme calculates multiple comparison using Tukeys test. The regression analysis was carried out in Microsoft Exel97:

2.7. Photography

The photographer Ragnar Th. Sigurðsson photographed the whole fish and parts of the fish on each sampling day under standardised conditions.

3. RESULTS

3.1. Sensory evaluation

The results from the sensory evaluation according to QIM on raw whole haddock and cod and Torry-scale on cooked fillets are shown in Figures 1 and 2 for the experiments in December and May.

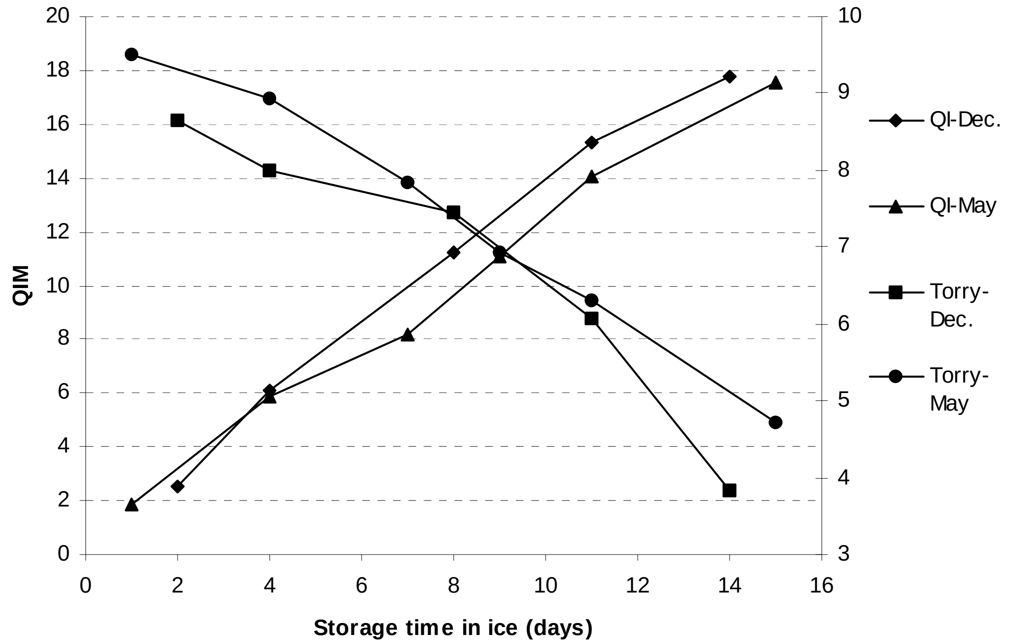

Figure 1. Sensory evaluation of raw (QI) and cooked (Torry) haddock

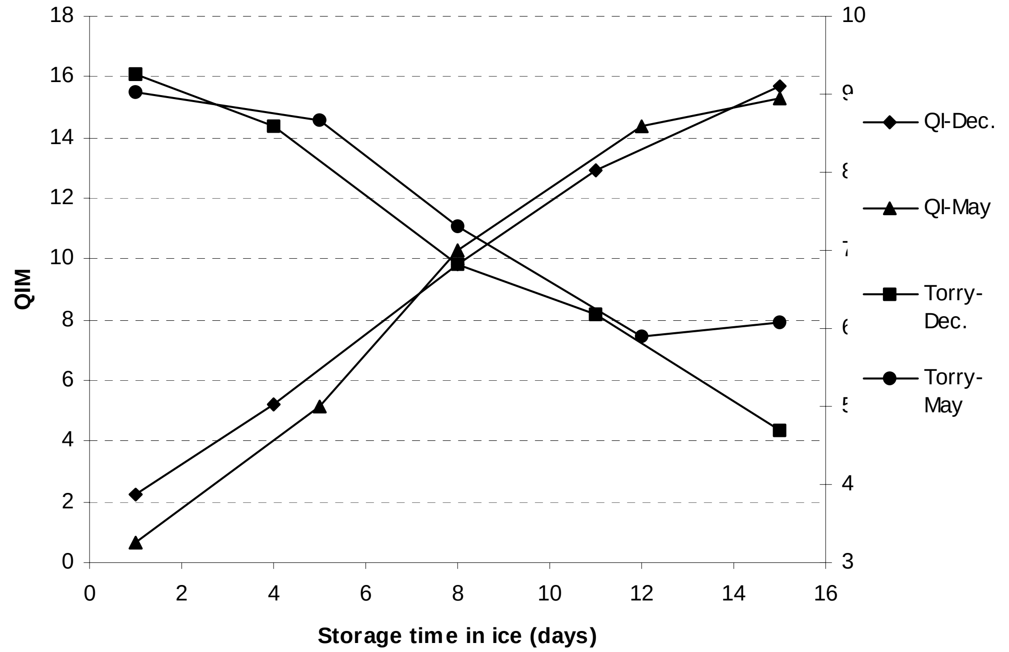

Figure 2. Sensory evaluation of raw (QI) and cooked (Torry) cod

Table 1 shows the coefficients of the best linear fit of the Quality Index versus storage time in ice for both haddock and cod. =days in ice   y = Quality index

Table 1. Coefficients of the best linear fit between Quality index and storage time in ice

	Intercept	Slope	R^2
Haddock, May	0,933	1,127	0,992
Haddock, Dec.	0,598	1,280	0,990
Cod, May	-0,04	1,2	0,966
Cod, Dec.	1,97	1,00	0,992

y = Quality index   x = days in ice

For the haddock a best fit of a model was found with the intercept =0. Then the slopes were found 1,23 and 1,24 for May and December respectively.
Table 2 shows the coefficients of the best linear fit of the Quality Index versus Torry-score for both haddock and cod.

Table 2. Coefficients of the best linear fit between Quality index and Torry-score

	Intercept	Slope	R^2
Haddock, May	10,40	-0,310	0,978
Haddock, Dec.	9,76	-0,280	0,858
Cod, May	9,46	-0,227	0,956
Cod, Dec.	10,34	-0,348	0,988

x = Quality index   y = Torry-score

Table 3 shows the coefficients of the best linear fit of Torry-score versus storage time in ice for both haddock and cod.

Table 3. Coefficients of the best linear fit between Torry-score and storage time in ice

	Intercept	Slope	R^2
Haddock, May	10,13	-0,353	0,989
Haddock, Dec.	9,69	-0,371	0,911
Cod, May	9,43	-0,248	0,912
Cod, May*	9,46	-0,300	0,934
Cod, Dec.	9,68	-0,331	0,991

x = days in ice y = Torry-score

*In Figure 2. it can be seen that the average Torry-score is higher on the last sampling day than the day before. The explanation can be individual variation in the fish. The best fit was also calculated leaving data from the last sampling day out.

3.2. Microbial analysis

The results from the microbial counts are shown in Figures 3-6. Total psycrotrophic counts (TVC, 15°C) of the skin was found to be lower for both species during the winter period when compared to the spring trial. This could be due to lower initial bacterial load on the fish at that time of the year and little temperature abuse during handling on board because of low environmental temperatures compared to the spring period. Nevertheless, TVC of the skin was close to log 7 CFU/cm^2 at sensory rejection during all trials. Interestingly, the *Pseudomonas* counts were higher than H_2S-producer counts during the winter trials while the contrary was observed during the spring experiments.

The flesh analysis indicated that bacterial invasion into the flesh took few days to occur, but was apparently slightly faster for haddock than for cod. At sensory rejection, TVC of the flesh was generally about log 4 CFU/g, except for cod caught during the spring period which had not reached that bacterial level after 15 days of storage on ice. Similarly to the findings reported for the skin analysis, the *Pseudomonas* counts of the flesh were found to be higher than H_2S-producer counts during the winter trials while the contrary was observed during the spring experiment with haddock. This variation could be due to the temperature abuse known to occur during the spring trials (because the samples were kept at room temperature for 30 minutes while headspace analyses of volatile compounds by the electronic nose was performed). H_2S-producers and *Pseudomonas* spp. are generally considered to be fish spoilage bacteria, but were found to occur at rather low levels in the flesh of the spoiled fish assessed, i.e. making up 0.5 to 19% of the final bacterial load.

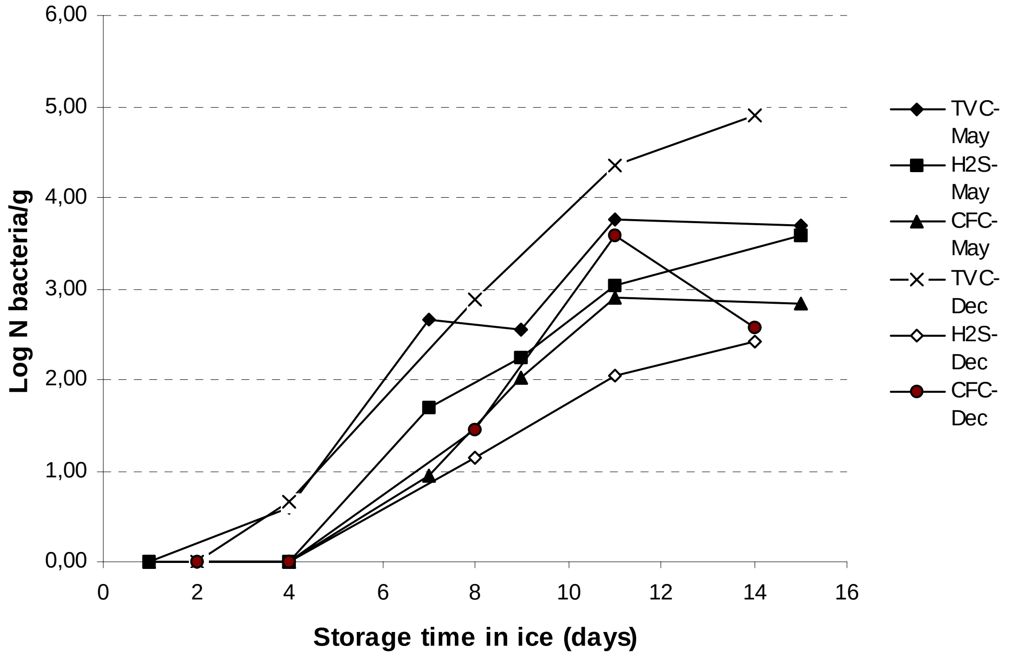

Figure 3. Growth of baceria from flesh on plate count agar (TVC), iron agar (H2S) and CFC medium during iced storage of haddock.

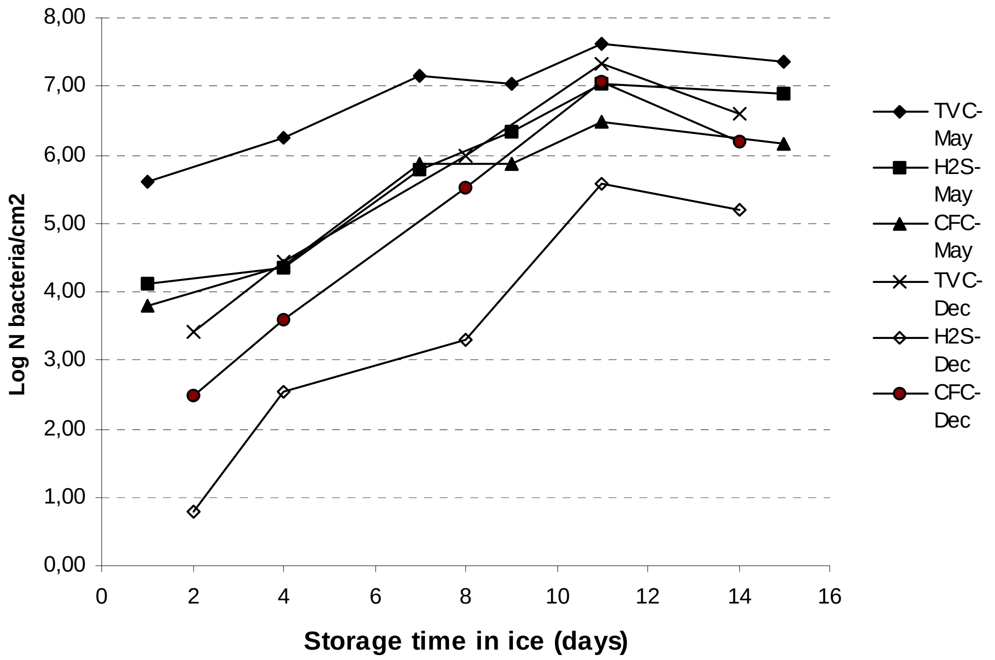

Figure 4. Growth of baceria from skin on plate count agar (TVC), iron agar (H2S) and CFC medium during iced storage of haddock.

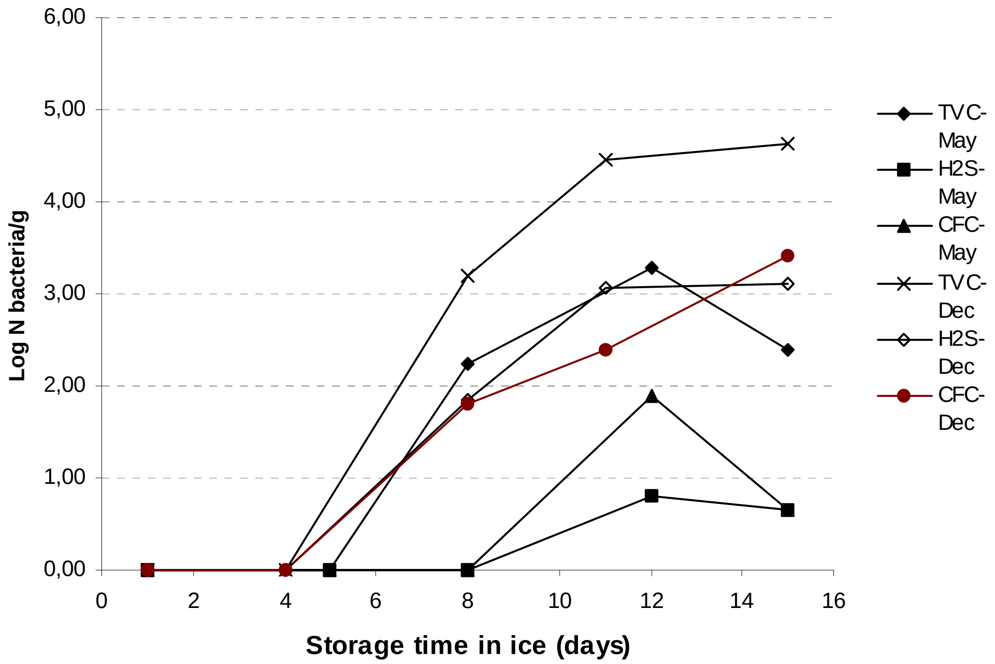

Figure 5. Growth of baceria from flesh on plate count agar (TVC), iron agar (H2S) and CFC medium during iced storage of cod.

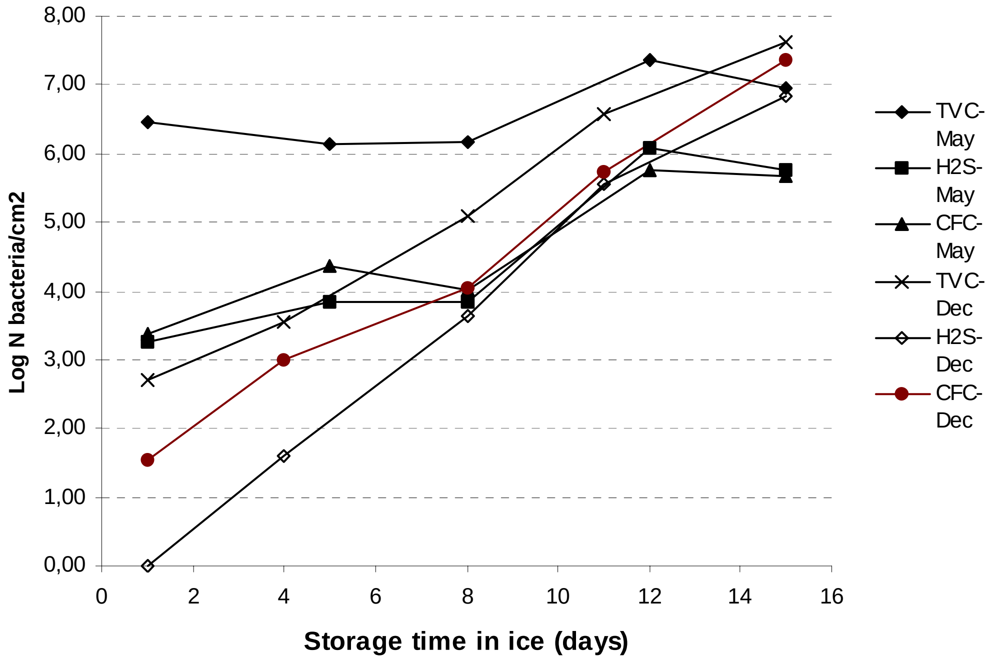

Figure 6. Growth of bacteria on skin on plate count agar (TVC), iron agar (H2S) and CFC medium during iced storage of cod.

3.3. Chemical analysis

Figures 7 and 8 show the results of the chemical measurements of TMA and TVB in haddock and cod.

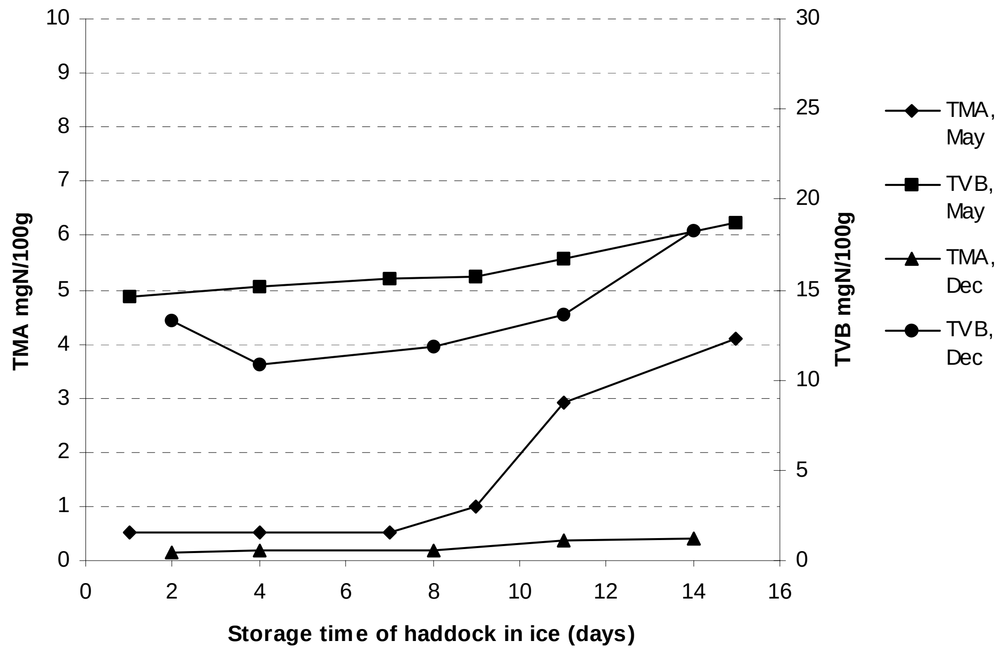

Figure 7. Changes in TMA and TVB during iced storage of haddock

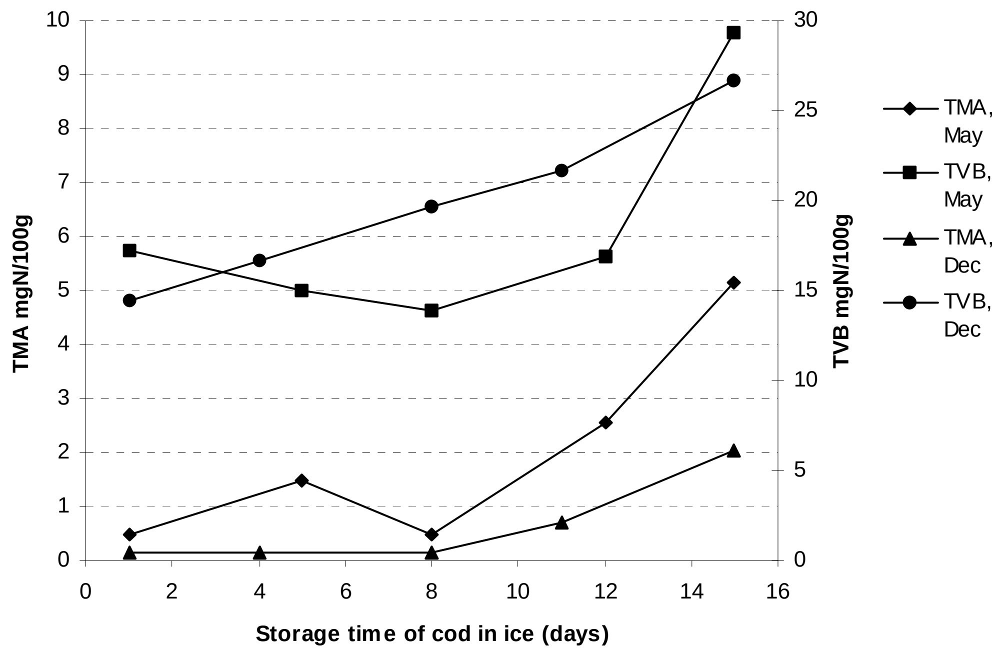

Figure 8. Changes in TMA and TVB during iced storage of cod

Analysis of TVB showed reduction during storage until the last sampling day for haddock in December and cod in May. There was a slight increase in TVB for haddock in May and a steady increase for cod in December from 14 mgN/100 g to 27 mgN/100g. There was no increase in TMA in haddock during storage in December but in May on the 9th day the TMA exceeded 1 mgN/100g. In cod there was a slight increase in December until the last day of sampling but in May the increase started after 8 days of storage. Fish containing more than 10 mgN/100g is usually regarded as unfit for further production (Connell, 1990). The fish in these storage experiments never reached 10 mgN/100g even though the sensory panel had judged the fish unfit for consumption.

3.4. Electronic nose measurements

Figures 9 and 10 show the results of electronic nose measurements of whole cod and haddock in May.

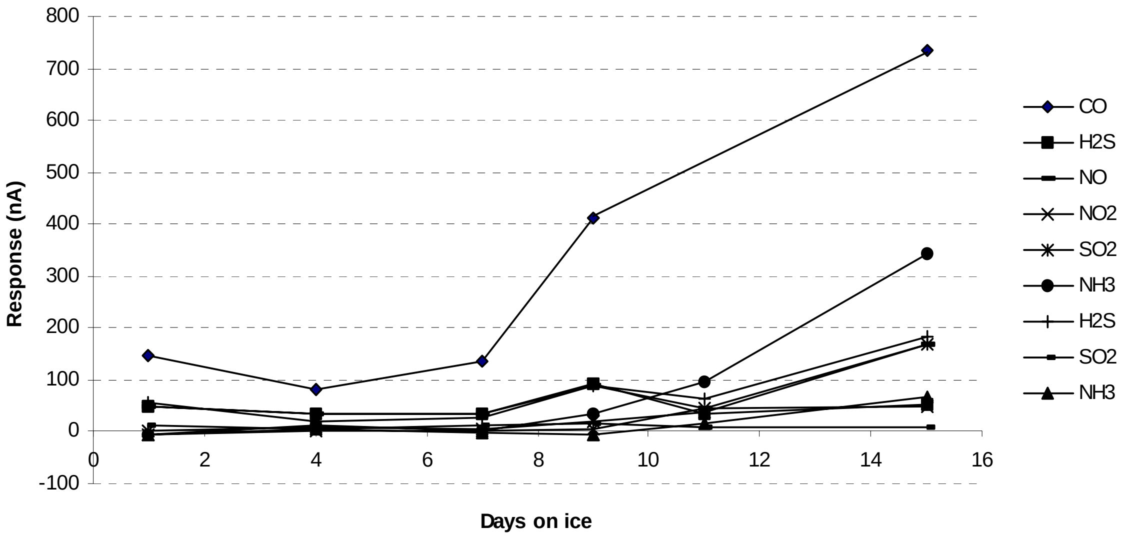

Figure 9. Electronic nose measurements of whole haddock, kept on ice

The haddock was measured whole, in a large plastic box, two fish at a time. The fish were weighed each time and as the total weight of them was different the results have been normalised by dividing the response by the ratio of weights, using the largest fish as 1,0. The CO response after 11 days was abnormal and has been kept out of the calculations. As can be seen from Figure 9 the CO sensor shows a significant increase after 9 days in storage. After 11 and 15 days in storage the other sensors start to respond.

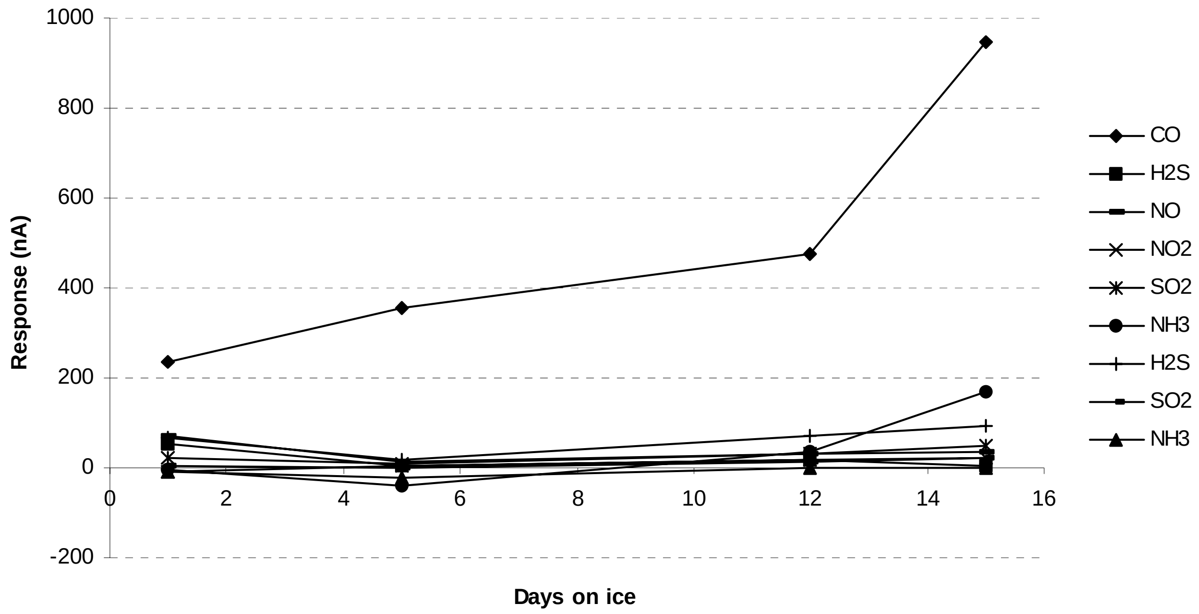

Figure 10. Electronic nose measurements of whole cod, kept on ice

The cod was measured in the same way as the haddock and the data handled similarly. Here a marked difference is seen in CO sensor response between 2 and 5 days in ice and from 12 to 15 days the increase is large. That is also when the other sensors start to respond (NH_3 , SO_2, H_2S). These preliminary experiments on measuring cod and haddock in the electronic nose indicate that it can be used to evaluate freshness of whole fish, particularly in the later stages of storage. A possible application at this stage would be to classify the fish into 3 categories: Good fish (all sensors have low responses, fair fish (only CO-sensor respond) and unfit fish all sensors respond). The sampling procedure is being optimised, as using the large plastic box and very different weights of fish is inconvenient and the results cannot be compared directly. Since the gills usually have the strongest smell it has been proposed to measure only the heads of the fish, perhaps 3-6 together in a smaller container. This method and others are currently being explored.

3.5 Storage life of cod and haddock

The storage life of fish is defined as coming to an end when the average sensory scores have reached 5.5 on the Torry scheme. Assuming linear regression and this limit,the storage life can be calculated using the equations in table 3. The storage life for haddock is then estimated as 13 days in May and 11 days in December. The storage life for cod is estimated as 13 days in May and 14 days in December leaving the last sampling day out in the equation. Assuming linear regression and the Torry limit 5.5 the Quality Index can be calculated using the equations in table 2 and is found to be 15-16 for the haddock and 14 - 17 for the cod. Further statistical treatment is needed and will be undertaken in the next period of the project. The different storage pattern of the fish in the different seasons can not be explained by the results of the chemical measurements since a very slight increase was measured in TMA and TVB in haddock in December but the scores from the sensory panel both for raw and cooked fish showed more rapid loss of freshness and a shorter storage life. The low production of TMA might be explained by the low proportion of H_2S-producing bacteria in the flesh as these bacteria are known to be TMA producers.

3.6. Further statistical treatment of data

In order to get replicates of the sensory evaluation several fish items are used for the quality judgment at each post catch time. The fish used is assumed to be of the same quality given a post catch time which equals days in ice. However the individual fish kept under standardised storage conditions spoil at somewhat different rates, that could be caused by different position in boxes, or size, post mortem pH or some biological differences which are thought to influence the spoilage rate of fish.

A question that rises is how many fish individuals are needed from a lot. A lot is defined as fish caught at the same day. .In particular, the interest might be if 3 fishes give good enough data for the analysis of the decline in fish quality with time. If the fish items are approximately of the same quality, the scores, QIM, from *n* panelists on each item would be a random sample from the same distribution. It is assumed that the sequence of evaluation of *k* fish is random.

In order to test this we ask if the variance in scores at each time point is due to differences between panelists alone or if there is reason to believe that some fishes reveal better or worse (low or high value respectively) scores than the others. Therefore the *n* scores on each fish are ranked. If the fishes are of the same quality the expected score value would be the same for all fish items. The test-statistics used are the sum of ranks, Z_i for i= 1,...,k where k is the number of fishes at a given post catch time. Under the H_o hypothesis of equal quality (random ranking of *k* fish items by *n* panelists) this statistic is quite well approximated by the Normal distribution with the parameters $\mu = n\ E(X)$ and $\sigma = n$ Var(X) where X is discrete uniformly distributed on the interval [1, 1.5, ...,k].

At each post catch time y Z_i for i=1,...,k. are tested. simultaneously. Therefore, a significance level of α/k is used for the individual tests, where α is the significance level of the combined test. The H_o hypothesis is rejected for high or low values of Z.

The results are shown in table 4.

Table 4. The results from testing for differences between the fishes used in a sensory test. Z_i, i = 1,…, k, are the test-statistic used. k gives the number of tests run simultaneously. Significance levels for individuals tests are α/k. The significance probabilities revealee ≤ 0.01/k. (*) indicates significance probability $\alpha \leq 0.025/k$

Species		Days in ice	no. of panelists [n]	no. of fishes [k]	Results	Significance probability
Haddock	May	1	15	4	Z_1 = 50.5	0.0004
		4	10	5	NS	
		7	13	5	NS	
		9	12	5	Z_3 = 60.0	4.0 10^{-8}
		11	10	5	Z_4 = 15.5	0.0002
		14	9	3	NS	
	Dec.	2	11	5	NS	
		4	12	5	NS	
		8	12	5	NS	
		11	12	5	NS	
		14	10	5	Z_5 = 42.0	0.0016
Cod	May	1	12	3	NS	
		5	14	5	NS	
		8	10	5	Z_3 = 42.5, Z_1 = 18.5*	0.0011 (0.0024)
		12	10	5	Z_4 = 44.0	0.0003
		15	7	5	Z_2 = 11.0	0.0017
	Dec.	1	10	5	NS	
		4	12	5	NS	
		8	12	5	Z_4 = 51.0	0.0004
		11	13	5	NS	
		15	13	5	Z_5 = 42.0	0.0004

The data indicate that the samples taken at a particular post-catch time consist partly of fish of different quality. Especially, this indication seems to concern late post-catch times, with haddock in May at post-catch time 1 day as an exception (see table 1). In three cases the panelists give significantly lower (better) scores for a particular fish item, relative to the other fish items, than expected under the H_0 hypothesis. For the rest of the significant cases (seven) a particular fish item is, relative to the other items, the least good.

Thus, our results indicate that the quality reduction of fresh fish in relation to post-catch time differs between fish items. Note, however, that the mean scores per fish may or may not differ significantly.

4. CONCLUSIONS

These extensive storage experiment on cod and haddock from two different season have shown that the storage life of these species can be estimated to from 11 to 14 days from catch. The Quality Index correlates very well with days in iced storage. That means that the remaining shelf life can be predicted if the Quality Index is known. There is also a high correlation between QI and Torry-scores so the Torry-score can also be predicted. The data for cod and haddock indicate that samples taken at late post-catch times (after 8 to 10 days in storage) are more inhomogeneous in sensory quality because of different spoilage rate of individual fish. During early days of storage 3 fish is recommended as a sample size but greater sample size (5 fish) will give more accurate information at later stages of storage. The results from the electronic nose measurements indicate that loss of freshness could be monitored, but a better sampling technique is needed for the FreshSense instrument for whole cod and haddock.

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Appendix 3

1. Quality Index Method Schemes for cod, haddock, ocean perch, pollock, shrimp and salmon

Quality Index Method (QIM) Scheme for Cod *(Gadus morhua)*

Quality parameter		Description	Score
Appearance:	**Skin**	Bright, iridescent pigmentation	0
		Rather dull, becoming discoloured	1
		Dull	2
	Stiffness	In rigor	0
		Firm, elastic	1
		Soft	2
		Very soft	3
Eyes:	**Cornea**	Clear	0
		Opalescent	1
		Milky	2
	Form	Convex	0
		Flat, slightly sunken	1
		Sunken, concave	2
	Colour of pupil	Black	0
		Opaque	1
		Grey	2
Gills:	**Colour**	Bright	0
		Less coloured, becoming discoloured	1
		Discoloured, brown spots	2
		Brown, discoloured	3
	Smell	Fresh, seaweedy, metallic	0
		Neutral, grassy, musty	1
		Yeast, bread, beer, sour milk	2
		Acetic acid, sulphuric, very sour	3
	Mucus	Clear	0
		Milky	1
		Milky, dark, opaque	2
Blood:	**Colour**	Red	0
		Dark red	1
		Brown	2
Fillets:	**Colour**	Translucent, bluish	0
		Waxy, milky	1
		Opaque, yellow, brown spots	2
Quality Index (0-23)			

Quality Index Method (QIM) scheme for Haddock *(Melanogrammus aeglefinus)*

Quality parameter		Description	Score
Appearance:	**Skin**	Bright, iridescent pigmentation	0
		Rather dull, becoming discoloured	1
		Dull	2
	Stiffness	In rigor	0
		Firm, elastic	1
		Soft	2
		Very soft	3
Eyes:	**Cornea**	Clear	0
		Opalescent	1
		Milky	2
	Form	Convex	0
		Flat, slightly sunken	1
		Sunken, concave	2
	Colour of pupil	Black	0
		Opaque	1
		Grey	2
Gills:	**Colour**	Bright	0
		Less coloured, becoming discoloured	1
		Discoloured, brown spots	2
		Brown, discoloured	3
	Smell	Fresh, seaweedy, metallic	0
		Neutral, grassy, musty	1
		Yeast, bread, beer, sour milk	2
		Acetic acid, sulphuric, very sour	3
	Mucus	Clear	0
		Milky	1
		Milky, dark, opaque	2
Blood:	**Colour**	Red	0
		Dark red	1
		Brown	2
Fillets:	**Colour**	Translucent, bluish	0
		Waxy, milky	1
		Opaque, yellow, brown spots	2
Quality Index (0-23)			

Quality Index Method (QIM) scheme for ocean perch *(Sebastus mentella/ Sebastes marinus)*

Quality parameter		Description	Score
Appearance:	**Skin**	Bright, iridescent pigmentation	0
		Rather dull, becoming discoloured	1
		Dull	2
	Stiffness	In rigor	0
		Firm, elastic	1
		Soft	2
		Very soft	3
Eyes:	**Cornea**	Clear	0
		Opalescent	1
		Milky	2
	Form	Convex	0
		Flat, slightly sunken	1
		Sunken, concave	2
	Colour of pupil	Black	0
		Opaque	1
		Grey	2
Gills:	**Colour**	Blood red	0
		Reminds of beef	1
		Reddish areas	2
		Rusty, dark brown	3
	Smell	Fresh, seaweedy, metallic	0
		Neutral, grassy, musty	1
		Yeast, bread, beer, sour milk	2
		Acetic acid, sulphuric, very sour	3
	Mucus	Clear	0
		Milky	1
		Discoloured, rusty, brown, clotted	2
Viscera:	**Solution**	Whole	0
		Beginning to dissolve	1
		Viscera dissolved	2
Fillets:	**Colour**	Translucent, bluish	0
		Waxy, milky	1
		Opaque, yellow, brown spots	2
Quality Index (0-23)			

Quality Index Method (QIM) scheme for Pollock *(Pollachius virens)*

Quality parameter		Description	Score
Appearance:	**Skin**	Bright, iridescent pigmentation	0
		Rather dull, becoming discoloured	1
		Dull	2
	Stiffness	In rigor	0
		Firm, elastic	1
		Soft	2
		Very soft	3
Eyes:	**Cornea**	Clear	0
		Opalescent	1
		Milky	2
	Form	Convex	0
		Flat, slightly sunken	1
		Sunken	2
	Colour of pupil	Black	0
		Opaque	1
		Grey	2
Gills:	**Colour**	Blood red	0
		Reminds of beef	1
		Reddish areas	2
		Rusty, dark brown	3
	Smell	Fresh, seaweedy, metallic	0
		Neutral, grassy, musty	1
		Yeast, bread, beer, sour milk	2
		Acetic acid, sulphuric, very sour	3
	Mucus	Clear	0
		Milky	1
		Discoloured, rusty, brown, clotted	2
Blood in abdomen:	**Colour**	Red	0
		Dark red	1
		Brown	2
Fillets:	**Colour**	Translucent, bluish	0
		Waxy, milky	1
		Opaque, yellow, brown spots	2
Quality Index (0-23)			

Quality Index Method (QIM) scheme for whole fjord and deep water shrimp *(Pandalus borealis)*

Quality parameter		Description	Score
Whole shrimp	**Dark in the head**	None	0
		Some (25%)	1
		Many (50-75%)	2
		All (75-100%)	3
	Colour	Pink / red	0
		Light Pink	1
		Yellowish	2
		Yellow, greenish, greyish discolouration	3
	Odour	Fresh, seaweedy	0
		Faint odour, reminds of tar	1
		Faint ammonia odour	2
		Obvious ammonia odour, sour, putrid	3
Roe	**Roe colour**	Copper green	0
		Discoloured, faded	1
		Dark	2
Quality index (0- 11)			

Quality Index Method (QIM) schemes for peeled shrimp *(Pandalus borealis)*

Quality parameter		Description	Score
Odour	**Odour of peeled shrimp**	Fresh, sea	0
		None	1
		Hint of ammonia	2
		Strong ammonia	3
Colour	**Colour of peeled shrimp**	Pink / red stripes	0
		Pink	1
		Yellowish	2
Flavour	**Flavour of peeled shrimp**	Sweet fresh shrimp flavour	0
		Faint shrimp flavour, neutral	1
		Hint of spoilage, bitter aftertaste	2
		Obvious spoilage, bitter aftertaste	3
Texture	**Springiness**	Springy	0
		Not springy	1
	Juiciness	Juicy	0
		Not juicy	1
	Crumbleness	Does not crumble when chewed	0
		Crumbles	1
	Toughness	Tough	0
		Tender	1
	Chewiness	Meaty	0
		Not meaty	1
Quality index (0- 13)			

Quality Index method (QIM) scheme for farmed Atlantic salmon (*Salmo salar*)

Quality parameter		Description	Score
Skin:	**Colour/ appearance**	Pearl-shiny all over the skin	0
		The skin is less pearl-shiny	1
		The fish is yellowish, mainly near the abdomen	2
	Mucus	Clear, not clotted	0
		Milky, clotted	1
		Yellow and clotted	2
	Odour	Fresh seaweedy, neutral	0
		Cucumber, metal, hey	1
		Sour, dish cloth	2
		Rotten	3
	Texture	In Rigor	0
		Finger mark disappears rapidly	1
		Finger leaves mark over 3 seconds	2
Eyes:	**Pupils**	Clear and black, metal shiny	0
		Dark grey	1
		Mat, grey	2
	Form	Convex	0
		Flat	1
		Sunken	2
Gills[1]:	**Colour/ appearance**	Red/dark brown	0
		Pale red, pink/light brown	1
		Grey-brown, brown, grey, green	2
	Mucus	Transparent	0
		Milky, clotted	1
		Brown, clotted	2
	Odour	Fresh, seaweed	0
		Metal, cucumber	1
		Sour, mouldy	2
		Rotten	3
Abdomen:	**Blood in abdomen**	Blood red/not present	0
		Blood more brown, yellowish	1
	Odour	Neutral	0
		Cucumber, melon	1
		Sour, reminds of fermentation	2
		Rotten/rotten cabbage	3
Quality Index (0-24)			

[1] Examine the side that has not been cut through

2. Linear regression lines for cod, haddock, ocean perch, pollock, shrimp and salmon.

Calculations of past and remaining storage time:

y = ax + b

where y = Quality Index, x = days in ice

Species	constant (b)	slope (a)	maximum storage time in ice
cod	-0,04	1,200	15
haddock	0,00	1,235	15
ocean perch	-1,41	1,010	18
pollock	0,00	1,040	18
fjord shrimp	2,94	0,741	6
deep water shrimp	1,13	1,032	6
pealed shrimp	-0,27	1,017	6*
salmon	1,57	0,692	20

* The storage life before peeling

3. Guidelines for sensory evaluation of whole fish

General guidelines for QIM assessment

First check

- Icing of fish in fish boxes (enough ice between the fishes)
- Placement of fish in boxes (Fish should be laying neatly in the boxes with their belly-cut under, - to prevent meltwater coming and staying in the bellyflap)
- Temperature
- Check if the fish has been frozen before (should not have been or be frozen)

Facilities

Testing area.

- Easy to clean and disinfect
- Regular cleaning and disinfection (preferably it should not smell of fish and it is necessary to ensure that the cleaning agents used do not leave odours in the testing area)
- Daylight (either real daylight or TL light with a temperature of >5000 K)
- No unauthorised persons allowed to enter
- The noise level shall be kept to a minimum
- Hand wash facilities (use soap without any odour)
- Working table, (ice, plastic sheets, forms)
- Hot and cold running water.

No eating, drinking or smoking allowed.

QIM assessment

Preferably the QIM-assessment is performed by 1-3 inspectors. This must be done independently.

- Define the lot (homogeneous lot of fish is to be assessed), e.g. by fishing day
- Number the boxes in a standard way (i.e. always from left to right and from top to bottom)
- Take one fish out of the boxes as decided above. Make sure the fishes are taken from different places in the box (not always from the top layer). Minimum 3-5 fish should be assessed from the lot (10 for small fish species such as plaice).
- Place the fishes on a table (if there is delay in the assessment of more than 15 minutes, the fishes should be placed on ice between plastic sheets)

- Fill in the table with the general information:

- Inspector ID (Name of the inspector) (**Obs. is not available in QimIT assessment**)
- Date & Time of QIM assessment
- Batch and Customer number (e.g. fishing day and ship)
- Item number (species/product)
- Comments (e.g. Day of catch as given by fisherman, amount of boxes, size of fishes)

- Assess all fishes and use the QIM schemes as provided.

Guidelines for freshness assessment of whole fish with Quality Index Method (QIM)

These guidelines apply to freshness assessment of whole fish in general. Different attributes are though assessed for some species. From a defined lot, preferable 3-5 fishes (10 for small fish species) should be assessed according to QIM schemes. One or more inspectors should carry out the assessment.

Appearance/Texture

Skin: Inspect the whole fish, the appearance of skin and fins. The skin of herring iced in tanks or boxes is usually more shiny than the skin of herring chilled in seawater (looses the scales at an earlier stage). Therefore is it necessary to know the storing conditions in the fishing boat.

Mucus: The appearance of slime on skin is assessed. Mucus can be difficult to find on **salmon** skin, but it is often located around the dorsal fin

Odour: The odour of the skin is assessed by smelling by the spine. If the fish has been laying more than 15 minutes on the table, it should be turned around and smelled at the other side. The smell of **herring** chilled in seawater becomes sweet and mushy when it spoils, but the spoilage smell of herring iced in tanks or boxes is also slightly rancid

Blood on gillcovers: The bloodstains on the gillcovers are usually bigger and more obvious on **herring** that has been iced in tanks or boxes, than on herring chilled in seawater

Texture/firmness: The texture is assessed by pressing a finger (firmly, but not to hard) on the spine muscle and observe if/how fast the flesh recovers. Only fish in rigor is given a score of 0

Belly: The consistence of the belly is assessed by pinching it between fingers or by stroking it with the fingertips

Eyes

Avoid touching the eyes with your fingers. If one eye is damaged, assess the other one.

Eyes of **redfish** are often difficult to assess since the cornea often is swollen. The membrane may be stung or cut for easier assessment of the eye

Cornea: Colour and clearness of the cornea is assessed

Form: The form of the eyes is assessed by looking directly at the eye or from the side

Colour: Colour is assessed by looking directly into the pupil

Gills

The gills are assessed by lifting the gill-cover. If the gills have been cut on one side of the fish, assess the gills that have <u>not</u> been cut. If more than one inspector assess the fish, <u>avoid touching the gills</u> since the appearance and mucus of gills can easily be destroyed.

Colour: The colour of the gills is assessed. The gills of **herring** should be assessed on both sides, since the colour may be different on each side, especially herring that has been iced in tanks or boxes. The gills of herring chilled in seawater are usually more pale since they are washed in the sea tank.

Odour: Odour of the gills is assessed by lifting the operculum and smelling by the gill bow

Mucus: Colour and appearance of the mucus is assessed

Viscera

Fish kept in ice with the viscera (ungutted) must be opened. The appearance of the viscera is assessed.

Abdomen

Colour of blood in abdomen: Usually, remains of blood in abdomen are visible in gutted fish. Blood may also be assessed in the cut wound (near the gills), if no remaining blood is left in the abdomen.

Odour: Odour in the abdomen is assessed by smelling inside the abdomen

Fillets/cut surface

Colour of fillets is assessed by the cut surface at the flaps or by assessing the fillets. **Redfish** must be filleted from one side to be able to se the fillets and viscera. When assessing redfish, it should be taken into account that redfish is never bled, and the fillets can be rather reddish which does not have to be in any relation with storage time.

4. Definitions of shelf life of fish

Shelf life is defined as the number of days that whole fresh (gutted) fish can be stored in ice until it becomes unfit for human consumption. **Predicted storage time** in ice is defined as the number of days that the fish has been stored in ice. From these results an estimation can be calculated of the **remaining shelf life** (= shelf life - predicted storage time). It is emphasised that remaining shelf life should be used with some precautions due to the uncertainty in the estimation.

The shelf life and the estimated storage time in ice are based upon the outcome of very well controlled storage experiments with whole fresh (gutted) fish stored in ice under good manufacturing conditions on board of the vessel which implies properly gutting, washing and use fish/ice ratio.

It is emphasised that various factors can effect the remaining shelf life. It depends on the handling of the fish. Rapid cooling after catch, different fishing gears, bleeding and gutting methods are important and season and catching ground can also have effect. Results from the well controlled storage experiment carried out by fish research institutes in Iceland (IFL), the Netherlands (RIVO) and Denmark (DIFRES) are used in this software to predict storage time. In those storage studies the fish is kept at optimal storage conditions. The end of storage time is defined when a trained sensory panel detects spoilage flavour of cooked samples of the fish. A linear relationship between the Quality Index and storage time in ice has been found and best fit of the regression lines calculated for each species. The regression lines are used to estimate storage time in ice after evaluation of the Quality Index.

Appendix 4

Dissemination of results

1. Final meeting and seafood exhibition in Bremen

2. Article from a press conference in Reykjavík May, 29th 2000, Morgunblaðið. May 31st, 2000

3. Articles in Rf Newsletters with pictures of the Icelandic participants and from the daily use of QIM and the software at HB

4. Introduction of Quality Index Method for salmon Article on Masters Thesis of Kolbrún Sveinsdóttir Morgunblaðið. June, 8th, 2000

Final meeting and seafood exhibition in Bremen

The final meeting of all participants R&D and SME´s in Bremen March 25 2000

The results of QimIT: Quality Index Method and the software WiseFresh introduced at the Seafood Exhibition Fisch2000 in Bremen March 23-26, 2000

Niðurskurður á kvóta líklegur

k-íslenski síldarninn á niðurleið

skifræðingur og leiðangursstjóri, segir að norsk-íslenski síldaré á niðurleið og gera megi ráð fyrir kvótaskerðingu á næsta fiskleildarkvótinn í ár er 1.240.000 tonn og hlutur Íslands 194.230 tonn.

GAMLA hafrannsóknaskipið Árni Friðriksson kom til Reykjavíkur um helgina eftir könnunarleiðangur á norsk-íslensku síldinni. Jakob Jakangur leiðangursins var að mæla magnið í norskíldarstofninum á hafsvæð-Noregs, Færeyja, Íslands Mayen, auk þess sem umstæður eins og áta og hitakannaðar. Fjögur skip í leiðangrinum og verða ir ræddar á fundi, sem Færeyjum eftir um það bil

Síldin austarlega

segir að leiðangursmenn á öðrikssyni hafi orðið varir rt mikla síld en hún hafi austarlega, eins og komið m.„Hún var austar- og í fyrra en hún var austar unaði tveimur eða þremur ráðum, þó hún hafi verið esturról þegar við fórum af fyrir nær viku,“ segir Jakns og fram kom í Morgungær voru skipin að veiðum gráðu austan við 70. gráðuna. „Við mældum talsverða síld vestur að þremur gráðum vestlægrar lengdar en hún var á talsverðu svæði. Venjan er sú að þegar hún kemur lengra inn í Jan Mayen lögsöguna er kaldari sjór undir, sem hún stingur sér ekki eins í og verður því viðráðanlegri.“

Leiðangursmenn urðu varir við mikla átu og segir Jakob því ástæðu til að ætla að síldin gefi sig til eitthvað vestar á næstunni. „Austurjaðar Austur-Íslandsstraumsins virtist vera á svipuðum slóðum og í fyrra en hitastigið í sjónum austan við kalda sjóinn var ívið lægra en í fyrra.“

Jakob segir að þar sem síldin sé rétt byrjuð að éta sé hún mjög stygg þarna austur frá og svipaður sjávarhiti við yfirborð og á miklu dýpi hafi líka áhrif. „Það eru engin viðbrigði fyrir hana að stinga sér en þegar hún kemur vestar þar sem Austur-Íslandsstraumsins fer að gæta er eins og að fara í ískalda sturta að stinga sér. Reynslan hefur sýnt að þá er meiri veiðivon.“

Þó síldin færist vestar og verði viðráðanlegri eftir að hafa étið meira á Jakob ekki von á henni nálægt Íslandi. „Mér finnst ólíklegt að hún komi að einhverju ráði til okkar í ár og það yrði óvænt ánægja.“

Samdráttur fyrirsjáanlegur

Samtals er heimilt að veiða 1.240.000 tonn af norsk-íslensku síldinni á líðandi fiskveiðiári og er það 50.000 tonna samdráttur frá fyrra ári en kvóti Íslendinga er 194.230 tonn. „Stofninn náði hámarki fyrir tveimur árum og síðan hafa ekki komið góðir árgangar í hann - hann er á niðurleið,“ segir Jakob. „Veiðin hefur verið á aðra milljón tonna á ári og minni stofn veldur því að hann sækir ekki út í eins stórt hafsvæði eins og hann gerði þegar hann fór í færeysku lögsöguna og aðeins inn í okkar. Hins vegar á aldrei að segja aldrei, samanber nokkrar eftirlegukindur út af Melrakkasléttu fram í júlí í fyrra.“

Hann segir líklegt að kvótinn verði minni á næsta fiskveiðiári. „Það er ekki mitt að taka ákvörðun um það en mér finnst það ákaflega líklegt og yrði ekki hissa ef svo yrði því þetta fer í þá áttina þar til kemur sterkur árgangur. Reyndar er talsvert af þriggja ára síld að vaxa upp og er töluvert af henni langt inni í norsku lögsögunni en norska rannsóknaskipið átti eftir að mæla hana.“

Morgunblaðið/Þorkell Þorkelsson

Ólafur Magnússon og Emilía Martinsdóttir sýndu WiseFish-hugbúnaðinn og notagildi hans á kynningu sem Rannsóknarstofnun fiskiðnaðarins og TölvuMyndir stóðu fyrir í gær.

Tölvuvætt skynmat

Samstarfsverkefni Rf og TölvuMynda

RANNSÓKNASTOFNUN fiskiðnaðarins og TölvuMyndir ehf. hafa þróað hugbúnað til nota við ferskleikamat á fiski sem og við rannsóknir og kennslu í skynmati á fiski. Hugbúnaðurinn, sem er markaðssettur undir nafninu WiseFresh, byggir á gæðastöðluðu skynmati með aðstoð tölvu og fer skynmatið fram með gæðastuðulsaðferð. Sú aðferð gefur mjög nákvæmar og gagnlegar upplýsingar um aldur hráefnis og geymslutíma.

Verkefnisstjórar voru þau Emilía Martinsdóttir, efnaverkfræðingur á Rf, og Ólafur Magnússon, kerfisfræðingur hjá TölvuMyndum. Að verkefninu komu að auki margir samstarfsaðilar hér á landi sem erlendis og verkefnið naut einnig stuðnings Evrópusambandsins.

Hugbúnaðurinn er á fjórum tungumálum og inniheldur upplýsingar um tólf fisktegundir en býður jafnframt upp á möguleikann á því að bæta við fisktegundum og tungumálum. Auk greinargóðra lýsinga á helstu matsþáttum er í hugbúnaðinum einnig að finna fjölda mynda til einföldunar á greiningu hráefnisins. Hugbúnaðurinn hefur verið prófaður hjá Haraldi Böðvarssyni hf. á Akranesi undanfarnar vikur og hefur gefist vel.

Margar aðferðir eru til við að meta gæði fisks, en að sögn Emilíu hefur gæðastuðulsaðferðin gefið hvað bestar upplýsingar af þeim aðferðum sem notaðar hafa verið, en með aðferðinni fást betri upplýsingar um ástand og geymsluþol en með fyrri aðferðum. Í ljósi þess að sífellt er verslað með meira af óséðu hráefni eftir að fiskviðskipti hófust á Vefnum er nauðsynlegt að seljendur og kaupendur hafi haldgóðar upplýsingar um ástand hráefnis en gæðastuðulsaðferðin og WiseFresh geta gefið þessar upplýsingar.

Markaðssetning búnaðarins er hafin erlendis og segir Ólafur Magnússon, kerfisfræðingur hjá TölvuMyndum, að hugbúnaðurinn hafi vakið mikla athygli og séu samningar í gangi um sölu á fyrstu eintökunum. „Hugbúnaðurinn hefur fengið mjög góð viðbrögð og erum við í viðræðum við allmarga aðila um sölu á búnaðinum. Þeir aðilar sem sýnt hafa búnaðinum hvað mestan áhuga eru fiskmarkaðir, framleiðendur og verslanir. Eins er verið að vinna í því að gæðastuðulskerfið verði tekið upp hjá Evrópusambandinu sem staðlað skynmatskerfi þar sem fyrri kerfi hafa ekki gefið eins góða raun og þetta kerfi. Ef svo yrði væri það vitanlega gott fyrir hugbúnaðinn og sölu á honum.“ Ólafur segir að hugbúnaðurinn komi til með að nýtast fyrirtækjum vel í framleiðslustýringu þar sem ferskleiki hefur mikil áhrif á verðmyndun og nýtingu.

Nicklasen, sjávarútvegsráðherra Færeyja, og Árni M. Mathiesen sjávarútvegsráðherra á fundi sjávarútvegsráðherra Norðaustur-Atlantshafsríkja sem haldinn var á Grænlandi nýverið.

Nauðsynlegt er að raga úr sóknargetu

arútvegsráðherrar -Atlantshafs samla um hert eftirlit

ÁRNI M. Mathiesen, sjávarútvegsráðherra, sótti fund sjávarútvegsráðherra Norður-Atlantshafsins sem haldinn var í Ilullisat á Grænlandi dagana 24. - 26. maí sl. Á ræddu ráðherrarnir m.a. hvort og hvernig stýra megi sókn, fækka þann vanda sem skapast þegar umfram sóknargeta er flutt út og að getur tengst ólöglegum, ótilkynntum og stjórnlausum veiðum.

rins komu sjávarútvegsráð- lands, Kanada, Færeyja, Grænlands, en af hálfu s sat fundinn fyrsti varasjávarútvegsnefndar og fyrir Evrópusambandið úr sóknargetu en jafnframt að vandamálið væri erfitt viðfangs, tæki til alls heimsins og gæti verið afar kostnaðarsamt. Ráðherrarnir staðfestu þá ætlun sína að fylgja eftir því sem kveðið er á um í framkvæmda-

Ráðherrarnir lögðu áherslu á hversu mikilvægt er að eftirlit með fiskveiðum sé skilvirkt til að tryggja verndun og sjálfbæra nýtingu fiskistofna. Virkt eftirlit væri nauðsynlegur hluti fiskveiðistjórnunar þannig að umgengni um auðlindina verði sem best. Þeir voru sammála um að mikilvægt væri að beita viðurlögum í þeim tilgangi að fækka brotum. Þeir vísuðu til þess árangurs sem náðst hefur með eftirliti í hverju landi og í svæðisstofnunum um fiskveiðistjórn, svo sem NEAFC og NAFO, og lögðu áherslu á að flýta þyrfti eins og hægt er að koma á fjareftirliti á þeim

Rússar sakaðir

TÍÐINDI
Rannsóknastofnun fiskiðnaðarins

15. árg. 1. tbl. maí 2000

Skynmat í fiskvinnslu tölvuvætt með nýjum íslenskum hugbúnaði

WiseFresh-hugbúnaðurinn er ávöxtur umfangsmikils verkefnis um tölvuvætt skynmat í fiskvinnslu sem Rannsóknastofnun fiskiðnaðarins hefur tekið þátt í síðustu ár. Rf og TölvuMyndir ehf. þróuðu WiseFresh til að nota við mat á ferskleika á fiski og við rannsóknir og kennslu í skynmati á fiski. Hafin er markaðssetning þessa hugbúnaðar hérlendis og erlendis og óhætt er að fullyrða að hann hefur þegar vakið mikla athygli og umtal.

Fjallað er um WiseFresh í miðopnu Rf-tíðinda. Þar kemur m.a. fram að búnaðurinn hefur verið prófaður frá ársbyrjun 2000 hjá Haraldi Böðvarssyni hf. á Akranesi og það með ágætum árangri. Ennfremur er greint frá viðbrögðum gesta á sjávarútvegssýningu í Bremen í mars sl.

Sjá bls. 4 og 5

Þau kynntu WiseFresh á sjávarútvegssýningunni í Bremen. Frá vinstri: Ólafur Magnússon frá TölvuMyndum, Emilía Martinsdóttir frá Rf, Ólafur Þór Jóhannsson frá Fiskmarkaði Suðurnesja og Gunnar Hermannsson frá Haraldi Böðvarssyni á Akranesi.

Vistferilgreining í fiskiðnaði

Fjórir sérfræðingar á Rf og Iðntæknistofnun Íslands hafa nýlega fengið RANNÍS-styrk til að beita aðferð **vistferilgreiningar** á þorsk hérlendis og athyglisvert er í því sambandi að sú aðferð hefur ekki fyrr verið notuð á veiðar og vinnslu fiskjar. Verkefnið er unnið í samvinnu Rf og Iðntæknistofnunar við SÍF og Harald Böðvarsson hf. en fleiri sjávarútvegsfyrirtæki koma þar við sögu. Helga R. Eyjólfsdóttir verkefnisstjóri segir að útkoman ráðist að miklu leyti af því hve gjöful samvinnan við sjávarútvegsfyrirtækin verði. Meginmáli skipti að fá sem bestar upplýsingar þaðan um veiðar, vinnslu, efna- og orkunotkun og fleira til að meta umhverfisáhrif frá því fiskur er dreginn úr sjó þar til hann er kominn á markað.

Vistferilgreining (Life Cycle Assessment) er nýstárleg rannsóknaaðferð sem notuð er til að meta umhverfisáhrif vöru „frá vöggu til grafar". Vistferilgreining í sjávarútvegi var rædd á ráðstefnu sem Rf efndi til í Reykjavík um miðjan maí, um það leyti sem blaðið var að fara í prentun. Ráðstefnan var í samráði við systurstofnanir á Norðurlöndum og norrænu ráðherranefndina.

Sjá bls. 5

Rf tekur þátt í að tölvuvæða skynmat í fiskvinnslu

Rannsóknastofnun fiskiðnaðarins og TölvuMyndir ehf. hafa þróað hugbúnað til að nota við mat á ferskleika á fiski og við rannsóknir og kennslu í skynmati á fiski. Hugbúnaðurinn er markaðssettur undir heitinu WiseFresh og með aðstoð hans getur notandinn tileinkað sér aðferðir skynmats í máli og myndum. Fjallað er um skynmat tólf fisktegunda á fjórum tungumálum. Hugbúnaðurinn hefur undanfarnar vikur verið prófaður hjá Haraldi Böðvarssyni hf. á Akranesi með ágætum árangri.

WiseFresh-hugbúnaðurinn er gæðasstaðlað skynmat með aðstoð tölvu. Skynmatið vísar til þess að skynfærin, einkum lykt og útlit, séu notuð til að meta ástand hráefnisins en gæðastuðulsaðferðin, sem beitt er (QIM), byggist á því að margir gæðaþættir eru metnir og einkunnir gefnar eftir mikilvægi matsþátta. Gæðastuðulsaðferðin er hlutlæg, áreiðanleg, auðveld til kennslu og þjálfunar og veitir miklar upplýsingar um ferskleika fisks.

WiseFresh er ávöxtur verkefnis um tölvuvætt skynmat í fiskvinnslu, sem naut stuðnings Evrópusambandsins. TölvuMyndir þróuðu sjálft forritið en Rf þróaði gæðastuðulsaðferðir og notkun þeirra. Emilía Martinsdóttir, efnaverkfræðingur á Rf, og Ólafur Magnússon, kerfisfræðingur hjá TölvuMyndum, voru verkefnisstjórar. Að verkefninu standa, auk Rf og TölvuMynda, Fiskmarkaður Suðurnesja, Haraldur Böðvarsson hf., Hólmadrangur, hollenska fiskrannsóknastofnunin RIVO-DLO, hollensku fiskmarkaðirnir Zeehaven IJmuiden og Den Helder og danska fiskrannsóknastofnunin DIFRES. Skýringarmyndirnar eru afar þýðingarmiklar og gefa WiseFresh enn meira gildi. Ragnar Th. Sigurðsson tók myndir af öllum íslenskum fiski og annaðist vinnslu alls myndefnis.

Trausti Árnason frá TölvuMyndum t.v. og Gunnar Hermannsson hjá Haraldi Böðvarssyni hf. voru að meta reynsluna af WiseFresh þegar Rf-tíðindi bar að garði.

Tölvuvætt skynmat getur verið mjög öflugt stjórntæki í gæða- og framleiðslustýringu í fiskvinnslunni. Þessi tækninýjung skiptir ekki síður sköpum þegar fiskur gengur kaupum og sölum í stórum stíl óséður á mörkuðum og víðar. Þá skiptir máli að tiltækar séu áreiðanlegar upplýsingar um ferskleika vörunnar fyrir seljanda og kaupanda. Umfang fisksölu af þessu tagi mun vaxa ört, ekki síst í gegnum tölvupóst og á Vefnum. WiseFresh kemur hér að góðum notum, hvort heldur eiga í hlut fiskmarkaðir, fiskvinnslufyrirtæki eða verslanir.

Einfalt og þægilegt í notkun

Gunnar Hermannsson, starfsmaður hjá Haraldi Böðvarssyni hf. á Akranesi, hefur unnið með WiseFresh til reynslu frá því í byrjun árs 2000 og lætur mjög vel af hugbúnaðinum.

„Meirihlutinn af fiskinum á markaði hér gengur kaupum og sölum óséður. Tölvuvætt skynmat með samræmdum gæðastuðlum hlýtur að gera þessi viðskipti öruggari og einfaldari", segir Gunnar. „Það er augljós kostur við þennan búnað að fljótlegt og þægilegt er að læra á hann og nota. Við erum yfirleitt tveir sem vinnum saman, annar skynmetur fiskinn en hinn slær inn upplýsingarnar. Eina vandamálið í upphafi var að tölvan hafði varla undan að taka við því sem að henni var rétt en það var lagfært!"

Gunnar Hermannsson skynmetur fiskinn og skráir niðurstöðurnar í tölvu í samræmi við staðla WiseFresh.

MENNTUN

Matvælafræði – Vaxandi spurn er eftir matvælafræðingum, vegna matvælaframleiðslu þjóðarinnar á frumvinnslustigi. Spáð er að fyrirtæki muni leggja áherslu á þróun og framleiðslu matreiddra og tilbúinna matvæla. **Gunnar Hersveinn** kynnti sér matvælafræði við Háskóla Íslands og efni þriggja nýrra meistaraprófsverkefna.

Lýðheilsa og hollustusjónarmið

- Strákar drekka meira af mjólk, stúlkur meira af undanrennu.
- Líftækni og erfðatækni er beitt í sífellt auknum mæli

TUTTUGU ár eru síðan fyrsti hópur matvælafræðinga útskrifaðist frá Háskóla Íslands en þá útskrifuðust 25 nemendur með B.S.-próf. Að vísu hafði lítill hópur fólks sem kom úr öðrum greinum útskrifast árið áður. Nú eru um 65 nemendur í matvælafræðiskor en 12 þeirra stunda framhaldsnám, þ.e. meistara- og doktorsnám, í matvælafræði og næringarfræði við skorina. Frá upphafi hafa að meðaltali 10–12 matvælafræðingar útskrifast á ári með B.S.-próf. Vaxandi fjöldi nemenda fer í meistara- og doktorsnám að loknu B.S.-prófi.

„Verkefnin í framhaldsnámi eru mjög fjölbreytileg og spanna allt frá grunnrannsóknum í líftækni og erfðatækni yfir í mjög hagnýt verkefni sem flest eru unnin í samstarfi við matvælafyrirtæki," segir Ágústa Guðmundsdóttir prófessor og skorarformaður matvælafræðiskorar sem er innan raunvísindadeildar Háskólans. „Matvælafræðin er fræðigrein sem byggir á þekkingu og skilningi á eðli og samsetningu hráefna til matvælaframleiðslu og hvaða áhrif mismunandi vinnsluferli hafa á lokaafurðir. Næringarfræðin fjallar um samband næringar og líkamsstarfsemi og tengsl mataræðis og heilsu." En boðið er upp á áherslulínu í næringarfræði innan matvælafræðiskorar auk framhaldsnáms í þeirri grein.

Matvælafræðin og næringarfræðin byggja á góðum grunni í undirstöðugreinum raunvísinda," segir Ágústa. „Matvælafræðin tekur í sívaxandi mæli mið af lýðheilsu- og hollustusjónarmiðum og tengist því næringarfræði sterkum böndum.

Fræðigreinin er í sífelldri þróun þar sem notkun tækninýjunga og sífelld nýsköpun þurfa að haldast í hendur við hámarksnýtingu hráefnis og hollustu- og umhverfissjónarmið. Aukin krafa neytenda um að tekið sé tillit til alls þessa mótar matvælafræðina og leiðir hana til áhrifa í þróun landbúnaðar, fiskiðnaðar og annarrar matvælaframleiðslu."

Aðferðum líftækni og erfðatækni er beitt í síauknum mæli við rannsóknir og framleiðslu matvæla. Sumar rótgrónar greinar matvælaiðnaðar geta talist til líftækni og má í því sambandi nefna ýmsar mjólkurafurðir eins og jógúrt og ost auk bjórgerðar og víngerðar. Erfðabreytt matvæli, sem þegar eru komin á markað og hafa mikið verið til umræðu á undanförnum árum, eru lýsandi dæmi um þá framtíð sem við okkur blasir varðandi landbúnaðarafurðir.

„Matvælafræðingar sinna í dag mjög mikilvægum störfum á flestum sviðum sem tengjast matvælafræði og manneldi," segir Ágústa, „um helmingur þeirra starfar í matvælaiðnaði við gæðastjórnun, vöruþróun, framleiðslustjórnun og framkvæmdastjórn fyrirtækja. Aðrir starfa hjá opinberum stofnunum við rannsóknir og mælingar á matvælum svo og við líftækniiðnað. Næringarfræðingar starfa við heilbrigðisstofnanir, líftækniiðnað, umhverfismál og rannsóknir."

Björn Sigurður Gunnarsson, Kolbrún Sveinsdóttir og Kristín Anna Þórarinsdóttir eru meðal þeirra sem eru nú að útskrifast með meistaraprófsgráðu í þessum fræðum og er sagt frá þeim hér á síðunum. Meistara- og doktorsverkefnin í matvælafræði eru flest unnin í samstarfi við erlenda aðila og dvelja nemendur hluta námstímans við erlenda háskóla og rannsóknarstofnanir.

Morgunblaðið/Jim Smart

Kristín, Kolbrún og Björn hafa lagt síðustu hönd á meistaraverkefnin sín með opinberum flutningi í HÍ.

Eðliseiginleikar saltfisks

VERKEFNIÐ „Eðliseiginleikar saltfisks" er meistaranámsverkefni Kristínar Önnu Þórarinsdóttur við matvælafræðiskor Háskóla Íslands. Það var unnið á Rannsóknastofnun fiskiðnaðarins í samvinnu við SÍF, undir leiðsögn Sigurjóns Arasonar, dr. Kristbergs Kristbergsson og dr. Sigurðar G. Bogasonar. Styrktaraðilar voru Rannsóknastofnun fiskiðnaðarins, Rannís og SÍF.

Íslendingar hafa flutt út saltfisk frá því um 1800 en vitað er að útlendingar sáu um útflutning fyrir þann tíma, allt frá 16. öld. Í dag er enn mikið flutt út af saltfiski, þrátt fyrir að nýjar og breyttar vinnsluaðferðir hafi komið til sögunnar. Samkvæmt tölum frá Hagstofu Íslands voru flutt út 49.500 tonn of saltfiski árið 1998, þar af var saltaður þorskur um 84,5%. Stærstu markaðssvæðin eru í Suður-Evrópu og Rómönsku-Ameríku.

Við verkun saltfisks er algengt að byrja á því að leggja flattan fisk eða flök í sterkan saltpækil (18%) í einn til tvo sólarhringa. Síðan er hann þurrsaltaður í tíu til tólf daga en að því loknu pakkað og komið fyrir í geymslu til útflutnings. Algengast er að nota þorsk til saltfiskframleiðslu. Ferskur þorskur inniheldur um 82% vatn og 0,4% salt. Eftir söltun er hlutfall vatns í vöðvanum á bilinu 55-57% og salt um 20% af þyngd fisksins. Fyrir neyslu er fiskurinn útvatnaður þar sem hlutföllin breytast aftur. Vöðvinn tekur upp vatn þannig að innihald vatns verður svipað því sem gerist í ferskum fiski en saltinnihald er heldur hærra, um og yfir 1%. Ýmsar breytingar eiga sér stað í vöðvanum við söltunina, s.s. afmyndun próteina og myndun á bragðefnum.

Markmiðið með verkefninu var að skoða áhrif mismunandi pæklunaraðferða á þætti eins og nýtingu og gæði saltfisks. Hluti verkefnisins var að kanna áhrif af íblöndun aukefna í pækilinn. Ekki er vitað til að aukefni séu notuð við saltfiskverkun hér á landi, þar sem kaupendur hafa ekki sóst eftir því. Hins vegar er líklegt að framleiðendur velti fyrir sér hagnaði af notkun þeirra þar sem þau hafa bætt nýtingu í öðrum sjávar- og kjötafurðum.

Í verkefni Kristínar voru notaðar efnablöndurnar Brifisol 512 og Pescamine 190. Brifisol 512 er blanda af fjölfosfötum en Pescamine 190 inniheldur einnatríumglútamat (MSG), natríumglýsínat og natríumsítrat. Þessi efni bera E-númer og er því skylt að geta um notkun þeirra í innihaldslýsingu matvæla. Efnablöndurnar voru notaðar í sitt hvoru lagi. Til samanburðar var fiskur verkaður á sama hátt að undanskildri notkun efnanna. Með því að fylgjast með breytingum í fiskvöðvanum, bæði í gegnum söltun og útvötnun og nota mismunandi mælingar fengust upplýsingar um áhrif efnanna. Brifisol 512 bætti nýtingu eftir söltun og þriggja vikna geymslu, hins vegar var nýting lakari eftir útvötnun sem var framkvæmd eftir um fjögurra vikna geymslu. Áhrif efnanna á gæði voru neikvæð, fiskurinn kom verr út í gæðamati eftir þurrsöltun og geymslu. Samkvæmt niðurstöðum úr skynmati eftir útvötnun og suðu var þó ekki hægt að greina marktækan mun á skynrænum eiginleikum, s.s. bragði og seigju. Áhrif af notkun Pescamine 190 voru svipuð og af Brifisol m.t.t. gæða og skynrænna eiginleika. Hins vegar bætti efnablandan ekki nýtingu eftir söltun og geymslu en nýting var heldur hærri eftir útvötnun.

Lokaniðurstaðan var sú að ekki er mælt með notkun efnanna Brifisol 512 og Pescamine 190 við verkun saltfisks. Kristín tekur það fram að þessar niðurstöður eiga einungis við þessar efnablöndur og ekki er hægt að heimfæra þær á notkun aukaefna almennt.

Gæðastuðulsaðferð fyrir eldislax

MEISTARAVERKEFNI Kolbrúnar Sveinsdóttur, „Þróun Gæðastuðulsaðferðar (QIM) fyrir eldislax", er unnið innan matvælafræðiskorar Háskóla Íslands, en einnig í samvinnu við Tækniháskóla Danmerkur (Danmarks Tekniske Universitet, DTU).

Verkefninu var skipt í tvo hluta og var sá fyrri unninn í Danmörku við DTU. Þar var Gæðastuðulsaðferðin fyrir eldislax þróuð og var þar hluti af stærra verkefni sem fjallaði um gæðastýringu í reykhúsum. Seinni hlutinn var unninn á Íslandi á Rannsóknastofnun fiskiðnaðarins. Þar var Gæðastuðulsaðferðin endurmetin og notuð í geymsluþolstilraun á eldislaxi, sem hluti af stóru verkefni (QimIT) sem styrkt var af Evrópusambandinu.

Meginmarkmið mastersverkefnis Kolbrúnar var að þróa og prófa aðferð til að meta ferskleika með því að hanna einkunnaskala skv. Gæðastuðulsaðferðinni (QIM) fyrir eldislax. Ljósmyndir voru teknar af laxinum misferskum sem stuðningsefni við matið með einkunnaskalanum. Einnig var hámarksgeymsluþol fyrir eldislax sem geymdur var í ís ákvarðað með skynmati á soðnum sýnum. Aðrir þættir voru skoðaðir að auki svo sem fita, áferð og örverur á roði og í holdi til að fá betri heildarmynd af gæðum laxins.

Með notkun einkunnaskalans fyrir eldislax fékkst há fylgni milli gæða stuðuls og geymslutíma ís, sem gefur möguleika á að áætla hversu lengi laxinn hefur verið geymdur í ís. Hámarksgeymslutími í ís var 20 dagar og þær upplýsingar má nota til að áætla hversu langt er eftir af geymsluþoli laxins miðað við eðlilegar geymsluaðstæður í ís. Mjög nákvæmar lýsingar eru gefnar fyrir mat á hverjum metnum gæðaþætti með einkunnaskalanum, studdar af ljósmyndum af þeim breytingum sem verða með geymslunni. Því er auðvelt að meta ferskleika laxins með aðferðinni. Aðferðin gefur nákvæmar og mikilvægar upplýsingar um ferskleika.

Framleiðsla á eldislaxi hefur verið í stöðugum vexti í Evrópu síðasta áratuginn og sömuleiðis hafa viðskipti með fisk milli landa aukist. Þetta kallar á þörf fyrir gott ferskleikamatskerfi, svo sem Gæðastuðulsaðferðinni og hefur einkunnaskalinn fyrir eldislax þegar vakið athygli víðsvegar í Evrópu.

Gæðastuðulsaðferð QIM (Quality Index Method) er aðferð til að meta ferskleika fisks og er upprunalega frá Ástralíu. Aðferðin felur í sér að hver gæðaþáttur (t.d. lykt af tálknum og litur augna) er metinn og einkunn á bilinu 0–1, 1–2, eða 0–3 er gefin fyrir hvern þátt eftir vægi hvers þáttar. Þessar einkunnir eru síðan lagðar saman í heildareinkunn, gæðastuðul, sem fylgir beinni línu eftir geymslutíma í ís. Einkunnaskalarnir eru þróaðir í geymsluþolstilraunum og er notað skynmat á soðnum fiski með hjálp um skynmatshópi til að fylgjast með skemmdarferli og ákveða lok geymsluþols. Nú eru til einkunnaskalar og myndir til að meta þorsk, ýsu, síld, karfa, ufsa, rækju, lax, sandhverfu, skarkola, slétthverfu og sólflúru.

QimIT er stytting úr Quality Index Method and Information Technology, og er samvinnuverkefni milli Íslands, Hollands og Danmerkur, með það að markmiði að þróa einkunnaskala samkvæmt Gæðastuðulsaðferðinni fyrir ýmsar fisktegundir og þróa hugbúnað til að nota við gæðamatið. Verkefnið hefur staðið yfir í 3 ár en er að ljúka um þessar mundir. TölvuMyndir þróuðu hugbúnaðinn, en þróun einkunnaskalanna var í höndum Rannsóknastofnunar fiskiðnaðarins og hollensku rannsóknastofnunarinnar RIVO-DLO. Aðrir þátttakendur í verkefninu voru Fiskmarkaður Suðurnesja, Haraldur Böðvarsson hf., Hólmadrangur hf. og tveir hollenskir fiskmarkaðir: Zeehaven IJmuiden og Den Helder.