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Sensory quality and onset of rigor mortis for farmed turbot under various post slaughter conditions

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Table of contents

Summary

As is the case for most farmed fish, the production of turbot is targeting the fresh markets established in Europe and Asia. Usually turbot is packed whole, dead or alive and transported directly to the market. On some occasions the fish are bled and gutted prior to delivery. Except for lipid oxidation and shelf life (Ruff et al., 2002) and humane slaughtering methods (Morzel and van de Vis, 2003) there exist no or little scientific information on the quality of the end product. Some turbot farmers have expressed their concern about the duration of rigor mortis for farmed turbot in relation with eating quality. It was found that 8-9 days after slaughter, rigor may not disappear. At this moment scientific research at our institute is aimed on promoting resolution of rigor mortis, using electro stimulation. (Van de Vis, pers. comm.) Within present study the aim was to evaluate the eating quality, the shelf life as well as the onset and resolution of rigor mortis in relation to various post slaughter conditions. The outcome of this study may enable farmers to select suitable post slaughter conditions to tune the quality of the products to the needs of their customers.

For the first time a clear sensory profile of farmed turbot was presented, using the Quantitative Descriptive Analyses. This will be very useful for further market research within the project. Farmed turbot had a typical non-fishy taste and can be described as having a firm texture, a chicken-like taste and a potato like odour. There were ittle differences in the sensory profiles between the selected farmed turbot conditions of this experiment. Theoretical comparison with wild turbot by QIM reference results suggest an increased shelf life of farmed turbot of maximal 27 days. However, this has to be investigated in future experiments.

Post slaughter electro stimulation has no effect on sensory quality and shelf life. But the resolution of the rigor mortis proceeds faster when turbot is electro stimulated post slaughtering. Further research within this project will continue with these post slaughter conditions.

1. Introduction

As is the case for most farmed fish, the production of turbot is targeting the fresh markets established in Europe and Asia. Usually turbot is packed whole, dead or alive and transported directly to the market. On some occasions the fish are bled and gutted prior to delivery. Except for lipid oxidation and shelf life (Ruff et al., 2002) and humane slaughtering methods (Morzel and van de Vis, 2003) there exist no or little scientific information on the quality of the end product. Some turbot farmers have expressed their concern about the duration of rigor mortis for farmed turbot in relation with eating quality. It was found that 8-9 days after slaughter, rigor may not disappear. At this moment scientific research at our institute is aimed on promoting resolution of rigor mortis, using electro stimulation. (Van de Vis, pers. comm.) Within present study the aim was to evaluate the eating quality, the shelf life as well as the onset and resolution of rigor mortis in relation to various post slaughter conditions. The outcome of this study may enable farmers to select suitable post slaughter conditions to tune the quality of the products to the needs of their customers.

2. Materials and methods

Fish

Immature turbot (*Psetta maxima*) with a live weight on the range 600-700 g, i.e. corresponding approximately to commercial portion-size turbot, were obtained from a fish farm (Zeeland Vis B.V. Yerseke, The Netherlands) with a 50/50 mixed population of males and females. Juvenile turbots, which were purchased from France turbot in September 2002 by Zeeland Vis B.V., were used to produce the turbots of 600 to 700 g. All fishes used, belonged to one family. The fishes were slaughtered for the study at 18th of November 2004.
The fishes were reared in water of 26 ppt salinity, 9 mg O_2/l and 17 °C in tanks (60 m^2, 8x8 m octagon) a recirculation system. The stocking density for the 600-700 g fishes was on average 50 kg/m^2. The fishes were ready for commercial sales meaning the following pre slaughter conditions: day 6 before slaughter withdrawal from feed and day 1 and 5 before slaughter placed in a flow through tank (salinity 34 ppt, 14 mg O_2/l and temperature 12 °C) to continue fasting. The size of the flow through tank was (1.7 x 5.5.x 0.8 m). The stocking density in the flow through tank was 21 kg/m^2

Killing and processing of the fish.

The experiment was designed to test the eating quality, shelf life and onset of rigor mortis under the following post slaughter conditions: gutting versus no gutting, pre rigor filleting versus post rigor filleting, post slaughter electro stimulation versus no post slaughter electro stimulation. (table 1). The current industrial slaughter methods at Zeeland Vis B.V. consist of live chilling of turbots for 70 min in a slurry of flake ice and seawater. The industrial method was carried out by an employee of the company. The electro stimulation for batch 5 is conducted in the following way: prior to chilling the conscious fish was stunned by percussion with a modified air nailer (Hewitt, 1999) one by one and subsequently gutted. The gutted fishes (13-16) were placed in tap water in a Perspex tank. The tank was equipped with two plate electrodes at 10 cm distance. Electro stimulation was performed by applying pulses of 50V, 50 Hz a.c. for 5 minutes. The pulse duration was 1 second and an interval between each pulse of 3 seconds. The surface of each plate electrode was 2450 cm^2. Subsequently all fishes were transported to the processing area.
Both gutting (batch 1, 3 and 4) and filleting (batch 3) was performed manually by an employee of the Zeeland Vis B.V. within one hour after killing.

Table 1: Experimental design post slaughter procedure farmed turbot.

condition	nr of fishes	slaughter	gutting	fillet	reduce rigor
1:	90	live chilling	gutting	-	-
2:	70	live chilling	no gutting	-	-
3:	40	live chilling	gutting	pre rigor filleting	-
4:	16	live chilling	gutting	post rigor filleting	-
5:	90	percussive stunning	gutting	-	electro stimulation

Storage

All fishes were packed in polystyrene boxes with ice (10-11 kg of fishes per box, 4 kg ice per box) and covered with a polystyrene lid. Melt water was allowed to flow away through a hole in each corner of the box. The boxes were placed in a chilled store room at 0 °C for 14 days.
For batch 4 the fish was filleted after 7 days of storage, based on the assumption that the rigor would have passed through by then. For batch 1 and 5, 20 fishes each were stored separately at 0°C for measuring the onset and resolution of *rigor mortis*.
The sensory experiment was performed from19th November 2004 till 2nd December 2004.

Sensory analyses with Quantitative Descriptive Analyses (QDA)

Panel

The analytical sensory panel consisted of six persons, selected and trained for sensory analytical analyses and experienced in Quantitative Descriptive Analysis (QDA).

Training

Prior to the sensory assessment of turbots in the study, the panel was trained in four one hour during sessions. During the training similar products were introduced in order to establish a framework for comparison as well as selection of the attributes. One batch of farmed turbot purchased at Zeeland Vis (Yerseke The Netherlands) was used for training.

Analyses

For sensory analyses of food products the Quantitative Descriptive Analysis (QDA, also known as profile method) is common for characterization of the differences between products and to be able to provide sensory data for the interpretation of instrumental data. The method consists of procedures for describing and assessing the flavour of a product in a reproducible way. The separate attributes contributing to the formation of the overall impression given by the product are identified and their intensity assessed in order to build up a description of the flavour of the product. The QDA-analyses were carried out according to ISO standard 6564 (1985, Sensory analysis, Methodology flavour profile methods). During the training the panel identified and defined 51 character notes (attributes) for raw as well as cooked turbot fillet (annex 1). With the help of FIZZ® for window 2.10a (Biosystems), the panelists scored on a line scale from 0-100, with anchors on 0 and 100%. For the test artificial daylight (T>5000°K) was used.
Each sampling day, after 1, 4, 6, 8, 11 and 14 days of storage for condition 1, 2, 3 and 5 and after 8 and 11 storage days for condition 4, a session was organized with 6-8 samples. Every sample was assessed in duplicate. Sample presentation order was not randomized between panelists.
Before sensory analyses the turbot of batch 1, 2 and 5 were filleted. For raw evaluation the fillet was cut into pieces of 2 by 4 cm and presented on a plastic dish. For cooked evaluation the fillet was cut into pieces of 2 by 4 cm, placed in a glass dish with a lid and cooked in a microwave for one minute (600 Watts). The samples were presented to the panel on a plastic dish immediately after cooking.

Freshness analyzed by Quality Index Method

Panel

The QIM panel consisted of three persons, selected and trained for using the Quality Index Method.

Training

For the QIM assessment of turbot the panel was trained in four one hour during sessions. For the training the QIM scheme developed for wild turbot was used (ref QIM manual). One batch of farmed turbot purchased at Zeeland Vis (Yerseke The Netherlands) was used for training.

Analyses

The Quality Index Method (QIM) is a method to assess fish freshness. QIM is based on well-defined characteristic changes of raw fish that occur in (for turbot) the following attributes: appearance (dark side, white side, mucus and texture), the eyes (form as well as brightness), gills (odour, colour and mucus) and finally the flesh (colour of the cut surface of the belly flaps). The descriptions of each score for each parameter are listed in the QIM scheme (annex 2). A score is given from 0-3 demerit (index) points per attribute. The scores for all the attributes are summarized to give an overall sensory score, the so called Quality Index. These QI are compared with the calibration curve for wild turbot and expressed in an estimated shelf life (days on ice). The aim when developing QIM for various species is to have the Quality Index increased linearly with storage time in ice. The assessor must evaluate all the attributes presented in the scheme. Sampling and analyzing of condition 1, 2 and 5 was performed after 1, 4, 6, 8, 11, and 14 days of storage. From each condition 5 fishes were randomly selected and placed on a plastic sheet on top of ice in a randomized order and coded.

Rigor mortis

The method to measure *rigor mortis* Index values (RIs) is the following (Bito et al., 1983). The sag of the tail is measured when the front half of the fish's body is placed on a horizontal table. The RI is calculated from the equation:

$$RIt(\%) = 100 * \frac{(Dt - D_0)}{D_0}$$

where D_o and D_t represent the distance of the base of the caudal fin from the horizontal line of the table, as measured pre-rigor and at subsequent intervals during storage, respectively. A value of 100% corresponds to a fish in full rigor. The fish were stored flat between measurements.
Rigor index values were calculated for 20 individual fishes measured 0, 24, 49, 88, 120, 161, 185 and 264 hours after death.

Statistical analysis

Statistical analysis of the sensory data was performed with SAS system for Windows V8. Analysis of Variance (ANOVA) was used for testing dependent variables (sensory attributes) against independent variables (conditions). For post hoc analysis Duncans test were used. Significance is presented at 95% ($p<0.05$) confidence interval unless stated differently. Factor analysis was performed for reduction of attributes.
QIM regression lines were calculated with excel.

Ethics

Prior to the start of the experiments approval was given by a governmental ethical committee.

3. Results and discussion

Sensory profile results

During training the panel selected 52 attributes to describe the farmed turbot (annex 1). Not all of these attributes were meaningful for describing the products of this experiment. Factor analyses and discussion with the panel showed 20 attributes describing the products at the first day of storage and 18 attributes describing the products at the eleventh day of storage. Resulting in a set of 29 attributes, used for further data analyses (annex 1).

Product changes during shelf life.

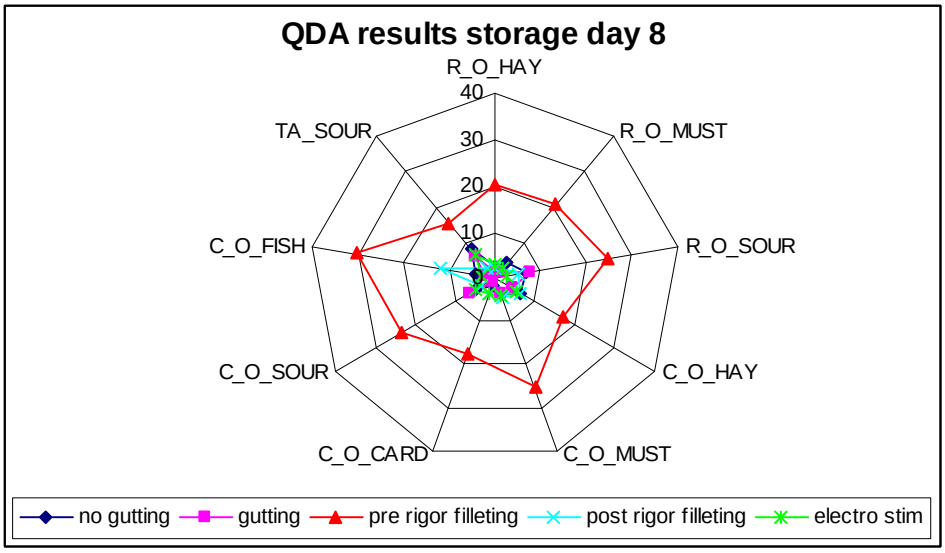
The batches were sampled on day 1, 6, 8, 11 and 14 after slaughtering. The project plan described the sampling moments until day 11. But since none of the products were deemed to be spoiled at that time, the sampling was extended to day 14 (except for condition 4, post rigor filleting). At storage day 14, only the pre rigor fillets were rejected by the panel for tasting. Day 4 was also sampled but QDA results were lost due to computer failure. In table 2 the results (panel means) are presented.

storageday	1					6					8					11					14			
condition	2	1	3	4	5	2	1	3	4	5	2	1	3	4	5	2	1	3	4	5	2	1	3	5
R_A_CREM	55,1	48,7	57,3	48,7	50,8	61,0	47,7	57,8	47,7	44,7	54,8a	33,1ab	50,6ab	31,1b	29,6b	57,5	46,9	44,9	46,9	45,2	38,8	41,0	61,3	62,1
R_A_GLAS	12,7	25,8	16,6	25,8	18,9	14,2	13,4	10,2	13,4	9,3	11,4	13,8	12,4	13,1	9,4	12,7	14,5	13,1	14,7	13,0	10,0	13,3	21,6	8,3
R_A_GREY	11,0	5,7	18,3	5,7	6,5	13,9	8,2	15,2	8,2	18,7	3,6	5,4	10,1	6,6	4,8	7,2	16,2	13,6	9,8	7,5	3,4	2,2	0,4	5,1
R_O_POTA	32,8	26,3	20,8	26,3	24,8	9,4	11,3	15,5	11,3	7,2	5,6	5,3	5,6	7,8	6,6	16,7	10,5	8,5	12,7	4,5	3,4	4,8	6,7	8,6
R_O_HAY	8,7	5,7	12,5	5,7	16,5	6,4	5,8	19,9	5,8	4,6	2,5b	1,34b	20,2a	2,1b	2,9b	5,00b	2,80b	19,50a	4,80b	0,60b	2,50 b	0,80 b	27,7 1a	5,00 b
R_O_MARI	19,3	18,9	11,3	18,9	12,2	5,9	3,7	12,8	3,7	8,1	2,2	1,4	2,6	2,5	4,2	0,2	0,9	0,0	0,6	0,3	0,4	0,3	0,0	2,0
R_O_MUST	2,1	8,2	9,7	8,2	6,4	3,1b	5,4ab	15,7a	5,4ab	4,5ab	4,2b	1,5b	20,4a	2,4b	2,8b	7,40b	4,60b	29,50a	10,70b	1,30b	3,60 b	2,50 b	48,8 6a	11,7 0b
R_O_SOUR	4,0	4,1	10,7	4,1	6,2	5,0b	1,9b	21,7a	1,9b	5,6b	6,6b	7,6b	24,6a	5,1b	2,5b	10,70b	8,70b	38,20a	10,90b	4,90b	4,00 b	10,0 0b	81,7 1a	13,7 0b
C_O_MILK	48,3	48,7	52,1	48,7	44,5	27,9	37,8	35,4	37,8	30,6	30,9	37,6	21,9	29,6	34,1	24,30ab	27,00ab	13,10b	34,90a	34,50a	33,8 0ab	34,4 0ab	13,5 7b	35,7 0a
C_O_HAY	2,5	8,1	6,0	8,1	6,2	6,7	8,7	8,1	8,7	6,7	6,4ab	4,3b	16,7a	6,3ab	5,4b	5,50b	12,10b	28,50a	6,60b	5,80b	6,60 b	7,60 b	38,1 4a	2,20 b
C_O_MUST	2,1	8,4	6,1	8,4	9,3	3,5	13,0	13,0	13,0	11,2	3,8b	3,8b	25,2a	4,4b	4,2b	8,70b	13,30b	43,70a	11,40b	5,40b	4,00 b	6,80 b	45,2 9a	7,50 b
C_O_CARD	1,4	4,4	6,0	4,4	3,8	4,0	6,2	12,4	6,2	8,8	1,8b	0,9b	17,8a	3,2b	3,6b	0,90b	6,40b	19,00a	2,10b	2,60b	4,40 b	6,00 b	37,0 0a	2,30 b
C_O_SOUR	0,9	4,2	2,0	4,2	1,6	1,9	5,6	3,1	5,6	11,3	4,9b	6,2b	23,6a	3,3b	4,6b	8,20b	11,70ab	31,90a	8,70b	8,40b	8,90 b	11,0 0b	68,1 4a	13,3 0b
C_O_FISH	1,0	1,4	2,3	1,4	2,0	6,2b	5,9b	20,4a	5,9b	5,2b	4,1b	2,0b	30,2a	11,8b	3,1b	8,7ab	3,80b	19,10a	2,40b	4,50b	5,40 b	5,10 b	46,7 1a	9,20 b
C_A_CREA*	31,0 ab	16,9 b	39,0 a	16,0 b	27,4 ab	37,6	30,2	32,1	30,2	25,5	41,1a	31,6ab	30,2ab	26,2ab	16,2b	40,9	33,1	43,5	35,1	33,4	37,4	39,6	70,7	43,3
C_A_GREY	12,1	7,5	9,3	7,5	10,9	7,5	6,7	11,6	6,7	11,4	7,9	7,4	7,3	5,6	5,2	10,4	6,5	4,9	5,0	3,1	3,3	2,4	2,6	3,6
C_A_GRE2	18,6	14,3	24,1	14,3	19,9	21,8	8,4	21,7	8,4	17,0	15,8	13,4	24,9	16,2	9,0	30,4a	12,1b	11,7b	15,7ab	18,0ab	17,5	19,8	18,0	24,0
TE_FIRM	62,6	69,0	66,6	69,0	61,1	66,6	62,2	66,7	62,2	50,0	59,5	59,9	44,0	59,1	63,2	53,2ab	46,2b	68,4a	49,0ab	45,0b	57,3	46,3		62,1
TE_TEND	65,1	67,6	60,6	67,6	63,4	62,0	54,1	59,7	54,1	48,1	53,7	49,0	51,7	51,9	56,4	45,6	41,3	42,5	42,9	36,2	36,9	39,8		42,1
TE_FIBR	34,5	45,8	55,2	45,8	43,3	51,1	58,8	55,7	58,8	51,8	45,8	49,9	53,1	42,5	50,4	46,0	57,4	51,1	48,5	45,5	42,6	47,9		46,7
TE_GRAN	32,7 a	9,9b	21,0 ab	9,9b	20,4 ab	17,6	16,7	18,9	16,7	17,5	23,3	21,6	16,3	21,9	15,4	30,8	24,8	13,3	30,5	30,2	41,0	45,2		32,0

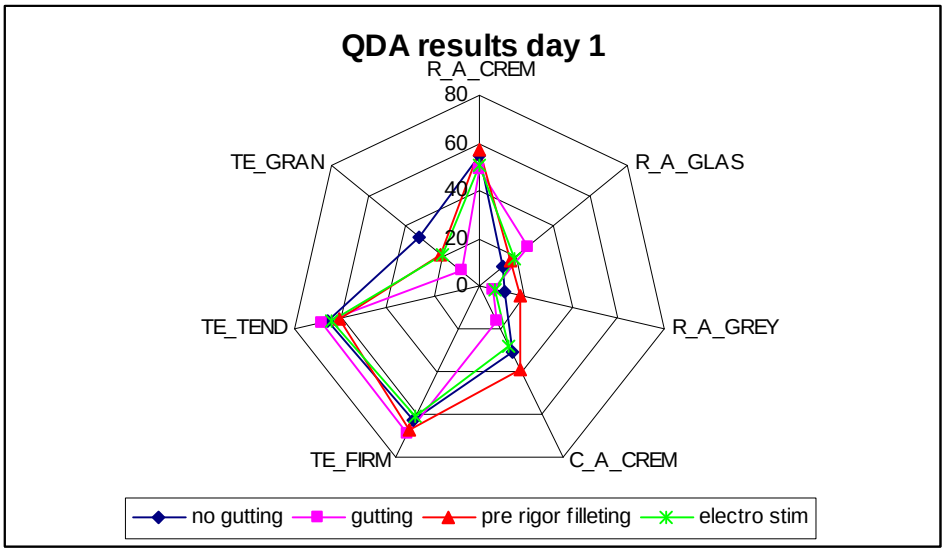
TE_STIC	39,3	32,7	40,8	32,7	39,3	31,6	45,7	37,3	45,7	41,9	27,1	31,6	31,1	29,9	28,3	39,2	29,2	32,1	28,2	31,9	35,1	32,3		29,3
TE_DRY	26,7	29,9	41,6	29,9	45,7	29,5	43,7	31,1	43,7	38,5	31,4	29,5	27,3	31,4	44,4	48,4	41,4	41,9	46,2	44,8	57,8	59,3		49,4
TA_CREA	21,2	14,6	17,3	14,6	12,4	19,2	13,0	15,8	13,0	13,4	9,4	15,2	12,1	13,5	12,9	9,7ab	13,1a	3,8b	7,7ab	7,4ab	10,2	5,7		9,5
TA_POTA	50,7	60,8	61,1	60,8	53,2	43,4	41,6	40,1	41,6	43,5	30,4	36,2	36,2	39,4	36,7	37,1	38,8	22,6	27,7	37,3	43,5	41,2		45,1
TA_CHIC	55,5	50,1	46,8	50,1	45,3	39,4	28,0	43,9	28,0	44,1	28,5	31,4	28,4	28,4	34,8	34,3	30,9	24,0	28,4	22,5	37,7	31,5		44,8
TA_STOC	26,6	14,6	12,6	14,6	19,8	8,5	10,5	12,5	10,5	16,0	9,2	10,9	11,6	7,0	8,1	10,0	7,8	4,0	5,9	4,9	9,6	2,2		5,0
TA_WATE	37,5	31,9	34,6	31,9	41,7	25,8	27,2	28,5	27,2	23,5	26,6	21,4	24,1	23,7	23,1	19,8	23,9	26,0	30,5	22,3	36,1	36,4		19,9
TA_SOUR	4,8	2,4	5,7	2,4	3,0	4,0	11,2	11,3	11,2	4,5	8,0	6,5	15,6	2,8	6,8	7,6	5,9	21,3	9,9	12,6	9,5	10,3		16,1

Typical attributes describing the fresh product were: raw odour marine and potato, cooked odour milk, taste chicken, stock, cream and potato, texture tender and firm. These attributes showed decreasing mean scores during the storage period. Typical attributes describing 'not-so-fresh' products (increasing mean scores during the storage period) were: raw odour sour, cooked odour musty, sour and fishy cooked appearance creme and texture dry and granular.
The typical taste of fresh farmed turbot was not at all fishy or marine but more chicken like whilst the odour could best be described as potato like. The intensity of the odour of farmed turbot was very low, resulting in low mean scores for all odour attributes. None of the whole stored turbot samples were rejected by the panel after a storage period of 14 days. The shelf life of farmed whole turbot in this experiment was therefore longer than 14 days.

Product differences due to post harvest processing.
Analyses of Variance showed significant differences for the pre rigor filleted condition compared to the other conditions. In general this difference could be described as a shorter shelf life. Already at storage day 8 it had significant higher scores for the 'spoilage' attributes.



If spoilage was not taken into account (e.g. storage day 1) the differences between the five products were significant for cooked appearance crème colour; and granular texture.

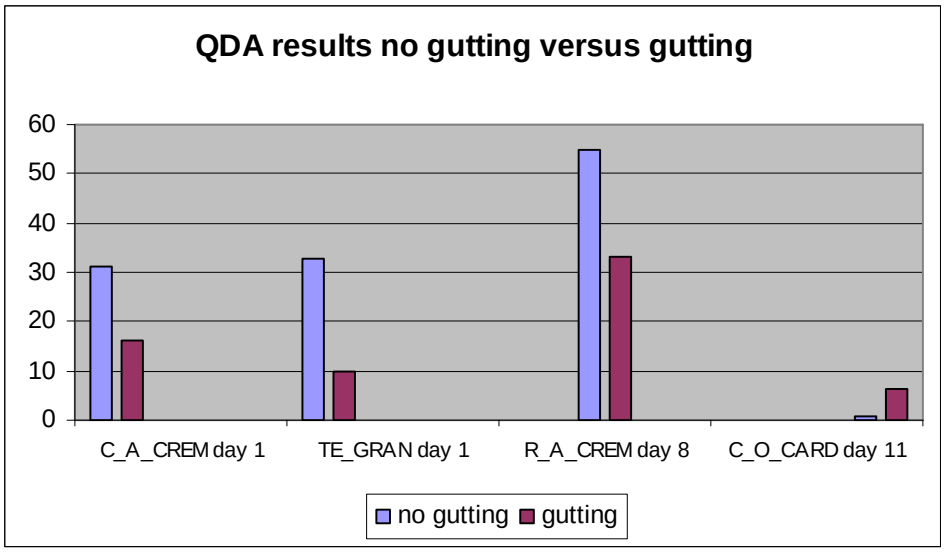


Interaction effect shelf life x post harvest processing.
There are interaction effects for the attributes: raw odour musty and sour, cooked odour hay and musty, cooked odour sour and fishy. This means the trends during shelf life are not similar for all products.

Differences between sets of products (rigor/no rigor, pre/post rigor filleting, with/without electro stimulation) during complete shelf life.
The experimental design was mainly based on comparison of sets of 2 products.

Gutted versus un-gutted

The two products differed for whiteness at both raw and cooked samples and pinkness of the raw samples. The un-gutted turbot being less white and more pink. Per storage sampling day there were differences for a few attributes, at day one there was a significant difference in the cooked appearance crème colour gutted scored 16, un-gutted scored 31 and the granular texture gutted scored 9.9 and un-gutted scored 32,7. At day 8 the crème colour of the raw appearance differs (un-gutted 54,8, gutted 33). At day 11 the cardboard-like odour differs significantly (un-gutted 0,9, gutted 6,4).

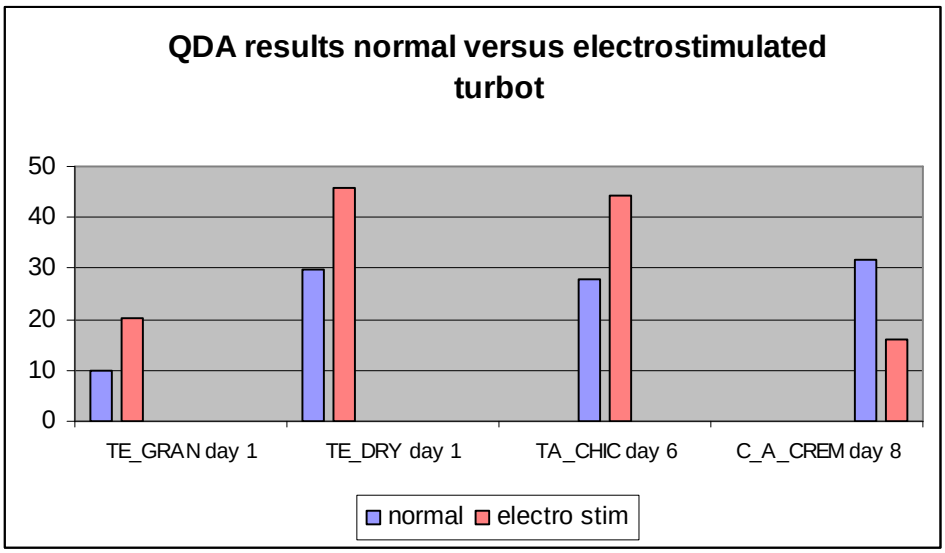


Pre versus post rigor filleting

The two products did not differ apart from shelf life. From storage day 8 the differences for freshness-related attributes were significant. This shows that in general there was no effect from pre or post rigor filleting but on storage as whole fish or as fillet.

With or without electro stimulation to reduce the rigor mortis

No significant differences were observed between turbot that was treated with post slaughter electro stimulation. Though there were some trends noticeable: electro stimulated turbot was more dry (46 versus 30) and more granular (20 versus 10), specially in the beginning of the shelf life. At day six of the storage period, the electro stimulated turbot had a more chicken flavour (44,1 versus 28,0). At the eight day of storage the electro stimulated turbot had a less crème colour for the cooked fillet. (16,2 versus 31,6).

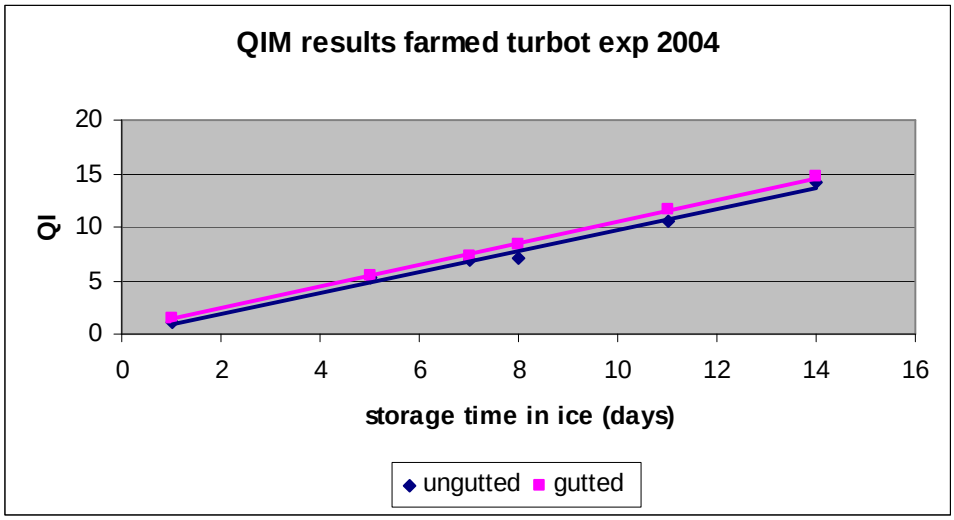


These colour differences do not correspond with the findings of Morzel et al, (2003) where a more red and darker colour was detected for electro stimulated fish (caused by less bleeding). The fact that there are no significant differences in texture does correspond with Morzel regarding the sensory results. Though they did find texture (hardness) differences with instrumental analyses where raw fillets of turbot killed by electricity had a softer texture.

QIM analyses

The QIM results were presented as the linear relation between Quality Index scores and the storage time in ice. This QIM scheme has been developed for wild turbot and the reference calibration curve was therefore only valid for wild turbot. Figure 1: The two calibration curves for gutted and un-gutted turbot were fairly the same (for calculation of the results the scores for the attribute 'incision (wound caused by gutting the fish)' were taken out of the dataset.). At storage day 14 the Quality Index was below 10 for both products. The end of shelf life for wild turbot was determined at a QI score of 28 (QIM manual).

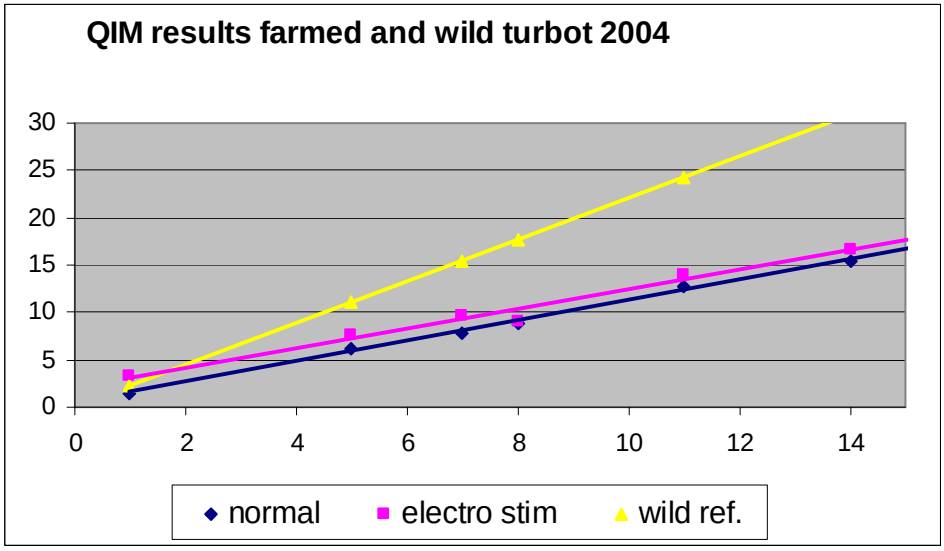
Figure 1: QIM results gutted versus un-gutted turbot.



The calibration curves of normal slaughtered turbot (gutted) and post slaughter electro stimulated turbot are the same (figure 2). There is only a different intercept: electro stimulated turbot 2,1 versus normal 0,5.

In comparison with the wild turbot, the farmed turbot by far did not reach the end of shelf life after 14 days of storage in ice. The end of shelf life for wild turbot was determined at a QI score of 28 (QIM manual) If shelf life of farmed turbot is also represented by a QI of 28, the shelf life of commercially produced farmed turbot theoretically would be 41 days.

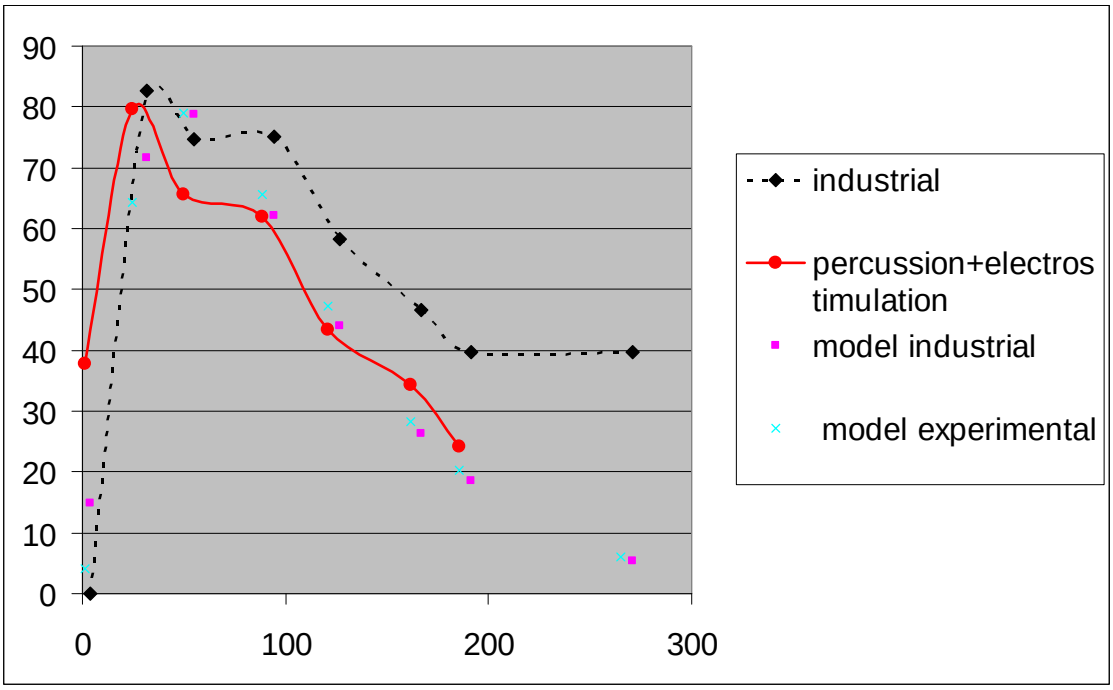
Figure 2: QIM results normal post slaughter processing versus post slaughter electro stimulation of farmed turbot.



Rigor Mortis

The development of rigor mortis was shown in figure 3. Fish treated with electro stimulation showed a faster onset of rigor mortis as expected.
Statistical analysis revealed that there was a significant difference between the two batches. The measured values were given in figure 3. It appeared that due to electro stimulation onset of rigor mortis occurred sooner than for the batch not subjected to this treatment. Resolution appeared to occur to a higher extent due to electro stimulation than for the non treated batch RI value 24% vs 40% for the non treated batch.

Figure 3. Evolution of rigor mortis in turbot (n=20) with and without electro stimulation.



4. Conclusion

For the first time a clear sensory profile of farmed turbot was presented, using the Quantitative Descriptive Analyses. This will be very useful for further market research within the project. Farmed turbot had a typical non-fishy taste and can be described as having a firm texture, a chicken-like taste and a potato like odour. Little differences in the sensory profiles between the selected farmed turbot conditions of this experiment. Theoretical comparison with wild turbot by QIM reference results suggest an increased shelf life of farmed turbot of maximal 27 days. However, this has to be investigated in future experiments.

Post slaughter electro stimulation has no effect on sensory quality and shelf life. But the resolution of the rigor mortis proceeds faster when turbot is electro stimulated post slaughtering. Further research within this project will continue with these post slaughter conditions.

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Ir. H. van der Mheen

Signature: _____

Date: November 2006

Annex 1

52 attributes for QDA analyses of turbot and selection after factor analyses

attributes accronym	full name	scale	description	day 1	day 11	finally selected
R_A_whit	Raw appearance white	not-much	the amount of white colour			
R_A_crem	raw appearance crème	not-much	the amount of creme colour	x	x	x
R_A_pink	raw appearance pink	not-much	the amount of pink colour			
R_A_glas	raw appearancy glassy	not-much	the amount of glassy appearance, transparent	x		x
R_A_glos	raw appearance glossy	not-much	the glossy surface			
R_A_grey	raw appearance grey	not-much	grey colour			x
R_A_grey2	raw appearance grabby	not-much	grabby appearance		x	
R_O_fres	raw odour fresh	weak-strong	fresh odour no off-odour or taint			
R_O_Crea	raw odour cream	weak-strong	like whipped cream			
R_O_gras	raw odour gras	weak-strong	fresh cut grass			
R_O_milk	raw odour milk	weak-strong	boiled milk, fruity/mushy odour			
R_O_pota	raw odour potato	weak-strong	odour of boiled potatoes	x		x
R_O_swee	raw odour sweet	weak-strong	sweet odour			
R_O_hay	raw odour hay	weak-strong	odour like hay, little musty	x		x
R_O_mari	raw odour marine	weak-strong	marine like the sea odour	x	x	x
R_O_meta	raw odour metalic	weak-strong	metallic flavour			
R_O_must	raw odour musty	weak-strong	Reminds of a table cloth (damp cloth used to clean kitchen table, left for 36 hours on the table)		x	x
R_O_sour	raw odour sour	weak-strong	sour odour, spoilage sour, acetic acid	x	x	x
R_O_fish	raw odour fishy	weak-strong	TMA odour, reminds of dried salted fish, amine			
C_O_milk	cooked odour milk	weak-strong	boiled milk, fruity/mushy odour	x		x
C_O_pota	cooked odour potato	weak-strong	odour of boiled potatoes			
C_O_crea	cooked odour cream	weak-strong	like whipped cream			
C_O_stoc	cooked odour stock	weak-strong	like stock, clear soup little salt taste			
C_O_hay	cooked odour hay	weak-strong	odour like hay, little musty		x	x
C_O_must	cooked odour musty	weak-strong	Reminds of a table cloth (damp cloth used to clean kitchen table, left for 36 hours on the table)		x	x
C_O_card	cooked odour carboard	weak-strong	like wet cardboard		x	x
C_O_sour	cooked odour sour	weak-strong	sour taste, spoilage sour		x	x
C_O_fish	cooked odour fishy	weak-strong	TMA odour, reminds of dried salted fish, amine	x		x
CA_whit	cooked appearance white	not-much	the amount of white colour			
C_A_crea	cooked appearance crème	not-much	the amount of crème colour			x
C_A_pear	cooked appearance pearl	not-much	like the inside of a shell			
C_A_grey	cooked appearance grey	not-much	the amount of grey colour		x	x
C_A_grey2	cooked appearance grabby	not-much	the grabby appearance		x	x
C_A_brow	cooked appearance brown	not-much	the amount of brown colour			
TE_firm	texture firm	not-much	Evaluate how firm or soft the fish is during the first bite	x		x
TE_tend	texture tender	not-much	Evaluated after chewing several times	x		x

TE_juic	texture juicy	not-much	Evaluated after chewing several times: juice in the mouth			
TE_fibr	texture fibrous	not-much	meaty texture, meaty mouthfeel	x		x
TE_gran	texture granular	not-much	small granular particles	x	x	x
TE_stic	texture sticky	not-much	sticks to your teeth	x	x	x
TE_dry	texture dry	not-much	Evaluated after chewing several times: dry - pulls juice from the mouth		x	x
TA_crea	taste cream	weak-strong	like whipped cream, butter or popcorn	x		x
TA_pota	taste potato	weak-strong	like boiled potato		x	x
TA_stoc	taste stock	weak-strong	like stock, clear soup little salt taste	x		x
TA_chic	taste chicken	weak-strong	like chicken flavour			x
TA_wate	taste watery	weak-strong	juice no flavour	x		x
TA_sour	taste sour	weak-strong	sour taste, spoilage sour			x
TA_fish	taste fishy	weak-strong	TMA flavour, reminds of dried salted fish, amine			
AF_crea	aftertaste cream	weak-strong	like whipped cream	x		
AF_waln	aftertaste walnut	weak-strong	like walnut	x	x	
AF_pota	aftertaste potato	weak-strong	like boiled potato	x	x	
AF_stoc	aftertaste stock	weak-strong	like stock, clear soup little salt taste	x		
AF_sour	aftertaste sour	weak-strong	sour taste, spoilage sour		x	

Annex 2

Quality Index Method (QIM) scheme for turbot

Quality parameter		Description	Score
Appearance	Dark side	Fresh, bright, no discolouration	0
		Rather dull or pale, somewhat darker and shrunken skin	1
		Dull, pale, fins are greenish and discoloured	2
		Dull, green and purple discolouration	3
	White side	Fresh, bright, wound near the tails is fresh red	0
		Rather mat, wound near the tails is yellow / brownish	1
		Mat, yellowish, wound near the tails is brown	2
		Yellow and purple discolouration	3
	Mucus	Clear, not clotted	0
		Slightly clotted and milky	1
		Clotted and slightly yellow	2
		Yellow and clotted	3
	Texture, backside	Firm, elastic (In rigor)	0
		Less firm, elastic	1
		Soft	2
		Very soft	3
Eyes	Form	Flat, eye socked convex	0
		Slightly sunken, eye socked shrunken	1
		Sunken and or swollen, eye socked shrunken	2
	Brightness	Black and clear, golden rim around the pupil	0
		Rather mat, faint golden rim around the pupil	1
		Mat, purple / reddish	2
Gills	Odour	Fresh, seeweedy	0
		Neutral, metallic, rubbery	1
		Musty, sour	2
		Rotten, sour, sulphurous	3
	Colour	Bright, light red	0
		Slightly discoloured	1
		Discoloured, light brown	2
		Yellowish, green / blue, brown	3

	Mucus	No mucus	0
		Clear	1
		Milky, slightly clotted	2
		Yellow, thick, clotted	3
Flesh, fillets	Colour	Fresh, crème white	0
		Slightly yellowish	1
		Yellow, discoloured	2
		Yellow, brown, blue, discoloured	3
Quality Index			0-28