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Influence of handling procedures and biological factors on the QIM evaluation of whole herring (*Clupea harengus* L.)

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Abstract

QIM evaluations were performed on herring from ten seasonally and geographically distributed cruises and related to handling procedures and biological and chemical parameters. The results showed clear effects from onboard storage methods. The quality of iced herring was superior to the quality of tank stored herring. Off odours developed faster in tank stored herring, and tank storage resulted in more discoloured gills and duller skin than ice storage. Ice storage gave more blood on gill covers. Large spawning herring with high lipid contents had higher quality than small immature herring with low lipid content. The high lipid content was correlated to low scores for all descriptors except blood on gill cover. Blood on gill cover was the only descriptor not dependent on biological or chemical parameters. Some shortcomings were recognised with the QIM scheme. It could differentiate between the quality of iced and tank stored herring, but could not be used to calculate the remaining shelf life. Suggestions are given for modifications of the scheme.

Keywords: Herring; Biology; Composition; Storage conditions; QIM; Descriptors

1. Introduction

Herring is highly perishable and the principal spoilage factor is deterioration, which can be enzymatic or bacterial (Hansen, Ikkala, & Bjornum, 1970). The shelf life of herring is reported to be between 5 and 10 days (Hansen et al., 1970; Smith, Hardy, McDonald, & Templeton, 1980; Kolakowska, Czerniejewska-Surma, Gajowiecki, Lachowicz, & Zienkowicz, 1992; Özogul, Taylor, Quantick, & Özogul, 2000; Hattula et al., 2002). It is found to vary with fishing season (Kolakowska et al., 1992) and storage conditions (Smith et al., 1980; Özogul et al., 2000; Hattula et al., 2002). One major quality defect is belly bursting which occurs mainly in feeding herring due to high enzymatic activity. Different harvesting procedures e.g. gillnet, poundnet and trawling are found to have similar effects on the sensory quality of herring (Hattula et al., 2002), but different storage condition can have different effects. In Denmark most herring is stored onboard the fishing vessel and transported to the processing plant in tanks with refrigerated (RSW) or chilled seawater (CSW), but in smaller boats icing in boxes is also used. As early as in 1963 Dassow fount that the benefits of RSW compared with ice were faster cooling rate, and economic saving in time and labour (Dassow, 1963). However, Price (1983) showed RSW equipment to be easily contaminated and circulation of slime, blood and bacteria can spoil an entire catch. Smith et al. (1980) compared chemical and sensory properties of herring stored in ice and refrigerated seawater. They found off flavours to occur one day earlier with RSW than ice-storage, but they estimated the difference to have no practical relevance and ascribed it to non-adequate cooling and concluded that if the cold water was

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renewed occasionally the storage methods would have similar influence on the herring.

The sensory quality of herring can be assessed in various ways. A good freshness grading system is the Quality Index Method (QIM) and a QIM scheme for herring is developed (Jónsdóttir, 1992; Martinsdóttir, Sveinsdóttir, Luten, Schelvis-Smith, & Hyldig, 2001). QIM is an objective sensory method based on significant sensory parameters for raw fish and a score system from zero to two or three demerit points. The scores for all the characteristics are then added to give an overall sensory score, the so-called Quality Index. QIM gives scores of zero for very fresh fish and an increasingly larger total result as the fish deteriorate. The description of the evaluation of each parameter is written in guidelines (Nielsen & Jessen, 1997) and QIM-schemes for several fish species including herring have been published (Martinsdóttir et al., 2001). These schemes are followed by pictures and detailed descriptions of all parameters. QIM has several unique advantages, including estimation of past and remaining storage time in ice (Hyldig & Nielsen, 1998). There is a linear correlation between the sensory quality expressed as a demerit score (QI) and storage life in ice, which makes it possible to predict the remaining storage life in ice (Nielsen & Jessen, 1997).

The objectives of this project were (1) to evaluate the influence of handling procedures and biological factors on the QIM evaluation of herring and (2) to evaluate the performance of the QIM scheme for herring.

2. Material and methods

2.1. Samples

Herring were sampled in 2002 and 2003 from Danish commercial catches (Table 1). The North Sea herring was caught by trawl and stored onboard in refrigerated (RSW) or chilled sea water (CSW) for 2–3 days before sampling. The Kattegat and Baltic Sea herring was caught by net and stored in ice for $\frac{1}{2}$–1 day before sampling. After landing the herring were sampled randomly from the catch (the number of samples is showed in Table 1) and packed in ice in polystyrene boxes and transported to the institute. The herring was stored in a refrigerated room at 0 °C for up to 11 days and new ice was added as the ice melted.

2.2. QIM evaluations

An internal panel consisting of 8 assessors performed the evaluations, and 3–7 assessors participated in each session. They were all selected and tested according to international standards (ISO, 1993) for their ability to make sensory evaluations, i.e. describe and quantify appearance, odour, flavour and texture characteristics, and were especially trained in the principles of QIM-evaluation (Martinsdóttir et al., 2001). The panel was used to perform QIM evaluations on several fish species and the members had previously participated in QIM evaluations of cod, salmon, trout, plaice, flounder and dab. They were especially trained in the evaluation of herring, i.e. in their ability to identify and quantify the descriptors used in the QIM-scheme in herring from different ice-storage-times. This training was conducted during 5 training sessions prior to the first trial and 2–3 additional sessions prior to each of the remaining trials.

Each herring was marked with a three-digit code and placed on cooler bricks (2 °C, 80×60×2 cm), 15 min prior to the evaluations. The evaluations were performed in a well-aerated room under good lighting (≈500 lx). All assessors evaluated all herring by moving from one fish to the other according to a modified version of a scheme developed by Jónsdóttir (1992) (Table 2). The assessors were instructed to check that all descriptors were evalu-

Table 1
Overview of herring used in the QIM evaluations

Trial[a]	Area[b]	ICES-square	Time of catch	On board storage	Days in ice	Number[c]	Abbreviation[d]
1	North Sea, west	43E9	02.09.02	Tank	4, 5, 8, 9, 10, 11	70	NSW/Sep02
1	Kattegat (1)	43G1	04.09.02	Ice	2, 3, 6, 7, 8, 9, 10	83	K/Sep02_1
1	Kattegat (2)	43G1	09.09.02	Ice	1, 2, 3, 4, 5, 8, 9, 10	100	K/Sep02_2
2	North Sea, north	49F1	18.11.02	Tank	3, 4, 5, 8, 9, 10	70	NSN/Nov02
2	Baltic Sea (1)	38G3	12.11.02	Ice	3, 4, 7, 9, 10, 11	75	BS/Nov02_1
2	Baltic Sea (2)	38G3	18.11.02	Ice	2, 3, 4, 5, 8, 9, 10	85	BS/Nov02_2
3	North Sea, north	51F1	22.02.03	Tank	4, 5, 9, 11	40	NSN/Feb03
3	Kattegat (1)	42G1	24.02.03	Ice	1, 3, 4, 8, 10, 11	65	K/Feb03_1
3	Kattegat (2)	42G1	04.03.03	Ice	2, 3, 7, 8, 9, 10	80	K/Feb03_2
4	North Sea, north	47F3	04.05.03	Tank	4, 5, 6, 9	80	NSN/May03
4 Trials	4 Areas	7 Squares		2 Methods		748 Herring	

[a] Group of sessions.
[b] The numbers in parentheses refer to duplicated batches, i.e. herring was sampled in the same area with short time intervals.
[c] Number of herring.
[d] This abbreviation is used in tables.

Table 2
QIM scheme for sensory evaluation of herring

	Quality parameter	Description	Score	Abbreviation[a]
Whole fish	Appearance of skin	Very shiny	0	Skin_app.
		Shiny	1	
		Matt	2	
	Blood on gill cover	None	0	Gill cover_blood
		Very little (10–30%)	1	
		Some (30–50%)	2	
		Much (50–100%)	3	
	Texture on loin	Hard	0	Texture_loin
		Firm	1	
		Yielding	2	
		Soft	3	
	Texture of belly	Firm	0	Belly bursting
		Soft	1	
		Burst	2	
	Odour	Fresh sea odour	0	Odour
		Neutral	1	
		Slight off odour	2	
		Strong off odour	3	
Eyes	Appearance	Bright	0	Eyes_app.
		Somewhat lustreless	1	
	Shape	Convex	0	Eyes_shape
		Flat	1	
		Sunken	2	
Gills	Colour	Characteristic red	0	Gills_colour
		Somewhat pale, mat, brown	1	
	Odour	Fresh, seaweedy, metallic	0	Gills_odour
		Neutral	1	
		Some off odour	2	
		Strong off odour	3	

The total sum of demerit points, i.e. the Quality Index is 0–20. Modified by Jónsdóttir (1992).
[a] Used in Fig. 2.

ated for all fish, before they handed in their evaluation schemes. 20–30 herring from different storage times were evaluated in each session, i.e. 10–15 from each code, and each trial consisted of 4–8 sessions (Table 1).

2.3. Biological characterisation

Each herring was characterised biologically after the QIM evaluations. Weight, length and thickness were recorded, and sex and gonad status were determined by visual inspection of gonads as recommended by ICES (Anon., 1962): immature = 1–2, maturing = 3–4, ripe = 5, spawning = 6, spent = 7, recovering = 8. Weight, length and thickness were highly correlated and therefore only weight is used in the data analysis. The presence of Anisakis larvae was determined by visual inspection of stomach and fillets. Occurrence was reported if one or more larvae were found.

2.4. Lipid content

Five herring from each code were sampled randomly and used for the analysis of muscle lipid content. The herring were filleted, the skin removed, and fillets belonging to one fish were minced together for 2×5 s at 8 °C in a Knifetec, 1095 Sample Mill (Foss Tecator, Sweden). The lipid content was determined by a modified version of the Bligh and Dyer extraction method on mince from individual herring (not pooled samples). Five grams of herring mince were extracted by 30 ml methanol and 30 ml chloroform (Bligh & Dyer, 1959). The analyses were performed in duplicates.

2.5. Data analysis

Variation in biological properties and lipid content was tested with *t*-test and variance analysis. Differences between mean values and regression lines were related with *t*-tests and pairwise comparison. The calculations were performed with the GraphPad Prism software version 4.00 (GraphPad Software, USA). The significance level was set to $p < 0.05$ if not otherwise stated.

The results from all assessors on the same fish were averaged prior to the data analysis. No corrections were made for varying numbers of assessors, because no assessor differed significantly from the average panel. An initial presentation of average QI-values versus storage days indicated a linear relationship. Therefore the regression lines were estimated using Graph Pad Prism and the difference between results obtained by iced and tank-stored herring was tested by *t*-test for slope values and intercepts.

The relationships between QIM and biological properties were explored by partial least squares regression (PLSR) using The Unscrambler®, version 7.6 SR-1 (Camo ASA, Norway) (Martens & Næs, 1989). Both Discriminant-PLSR (DPLSR) and Anova-PLSR (APLSR) models were calculated making it possible to determine significant variables in both X and Y. In DPLSR the relationship between QIM data (X) and fishing ground/season, storage method and time, and biological variables (Y) was explored. The APLSR was calculated in the same way, but with the former X-variables as Y and vice versa (Martens & Martens, 2001). Each fishing ground/season and storage method/time were represented by an indicator variable (with values 0 or 1). The Jack-knife method (Martens & Martens, 1999) was used to determine significant variables with a significance level of 5% ($p<0.05$). All models were calculated with segmented cross validation (10 samples in each segment sampled continuously with every tenth sample merged in segments). Continuous data were standardized (weighting with 1/SD), while 0/1-data were not weighted. Optimal number of components was determined as the number of components corresponding to the highest explained and validated Y-variation.

3. Results and discussion

3.1. Biological data and lipid content

The 10 catches differed according to body weight, lipid content and presence of Anisakis larvae (all $p<0.0001$, Tables 3 and 4). The North Sea herring were significantly ($p<0.0001$) smaller and had a lower lipid content than herring from Kattegat and the Baltic Sea. Fishing season had no clear effect on herring size, but the lipid content differed significantly with the time of year. It increased from an average of 7.6% in February and May to 15.4% in September and subsequently decreased to 12.2% in November. This variation coincides with the cycle of feeding and maturation (Wood, 1957; Iles & Wood, 1965; Henderson & Almatar, 1989).

Table 3
Weight, lipid content (average±SD), and amount of herring infested with Anisakis larvae

	Body weight (g)	Lipid content (%)	Infested with Anisakis larvae (%)
NSW/Sep02	152.7±22.8ab	10.9±2.2cd	69.1bc
K/Sep02_1	156.7±23.6ab	16.4±2.8f	28.6a
K/Sep02_2	223.8±20.6f	18.3±2.4f	59.0b
NSN/Nov02	174.6±26.2cd	9.0±2.7bc	88.3c
BS/Nov02_1	147.7±25.3a	13.4±2.7de	56.9b
BS/Nov02_2	192.7±26.3e	13.5±2.9e	78.2bc
NSN/Feb03	167.3±17.8bc	3.8±1.4a	100.0c
K/Feb03_1	186.8±22.7de	10.6±3.2c	96.7c
K/Feb03_2	193.6±30.0e	7.6±4.2b	92.5c
NSN/May03	160.8±20.9b	7.2±1.7b	38.8b

Means in the same column followed by different subscripts are significantly different ($p<0.05$). Abbreviations are explained in Table 1.

The number of Anisakis larvae in herring from different fishing grounds did not differ significantly ($p>0.05$), but the time of year had an effect. Herring caught in February, i.e. during the feeding period, were significantly ($p<0.0001$) more frequently infested with Anisakis larvae. Larvae were found solely in the intestines. These results agree with Tolonen and Karlsbakk (2003) and Podolska and Horbowy (2003), who found the prevalence of Anisakis larvae in Norwegian spring spawners and Baltic herring, respectively, to increase during the feeding period.

The type of spawning stocks was revealed in the gonad status (Table 4). North Sea herring are autumn spawners, and this was seen in the high proportion of ripe, spawning and spent herring in September. Herring

Table 4
Sex and gonad status (female/male, relative amount in %)

	Sex %F/%M[a]	Immature %F/%M	Maturing %F/%M	Ripe %F/%M	Spawning %F/%M	Spent %F/%M
NSW/Sep02	45.7/54.3	1.4/0.0	15.7/12.9	15.7/12.9	8.6/15.7	4.3/12.9
K/Sep02_1	32.5/67.5	6.0/2.4	19.3/44.6	3.6/7.2	1.2/3.6	2.4/9.6
K/Sep02_2	38.0/62.0		34.0/21.0	4.0/34.0	0.0/7.0	
NSN/Nov02	52.9/47.1	47.1/44.3	1.4/1.4	1.4/1.4	2.9/0.0	
BS/Nov02_1	42.7/57.3	1.3/1.3	37.4/13.3	4.0/20.0	0.0/21.3	0.0/1.3
BS/Nov02_2	68.2/31.8	2.4/1.2	24.7/2.4	25.9/3.5	15.3/24.7	
NSN/Feb03	32.5/67.5	30.0/45.0	2.5/22.5			
K/Feb03_1	44.6/55.4	4.6/4.6	3.1/0.0	13.8/12.3	20.0/38.5	3.1/0.0
K/Feb03_2	57.5/42.5	3.8/23.8		13.8/1.3	40.0/17.5	
NSN/May03	68.8/31.3	63.8/28.8	3.8/2.6	1.3/0.0		

Abbreviations are explained in Table 1.
[a] F: female, M: male.

caught in the western part of the Baltic Sea in November were found in a broad range of the cycle of maturation. The female were predominantly maturing and ripe while the males were ripe or spawning. Iles (1964) also found males to mature at higher rates than females. Herring caught in this area are spring spawners (Aro, 1989; Johannessen & Jørgensen, 1990). In Kattegat both spring and autumn spawners are found (Rosenberg & Palmén, 1982), but in this project spring spawners dominated with a high proportion of spawning herring in February (Table 4).

3.2. The quality index related to storage time and method

The Quality Index was calculated as the total sum of demerit points given to each herring and averaged over all assessments made on herring with equal storage conditions. In all catches the relationship between Quality Index and storage time was linear ($R^2=0.75$–0.98, $p=0.0001-0.04$, Table 5). However, the regression lines differed significantly from the regression line reported to result from this QIM scheme for herring. The regression line obtained during the development and testing of the scheme was Quality Index$=2.3\times$days in ice$+0.97$ (Jónsdóttir, 1992). Compared to this line our study resulted in lower slopes (0.361–0.743) and except for two of the batches higher intercepts (2.471–10.127) (Table 5). According to Jónsdóttir (1992) the rejection limit is a Quality Index of 16, corresponding to 6.5 days in ice. This limit was not reached in this study, even after 10 days of storage, when the herring were clearly spoiled.

The regression line slopes differed significantly ($p<0.05$, Table 5) due to fishing ground/storage method (both $p<0.0001$, confounded effects). The results apparently indicate that herring with a superior starting quality (low intercept) spoil faster (high slope) than vice versa. This effect is however only seen between and not within storage methods. This means that there is an initial difference in quality between herring from the two storage methods. The quality of tank-stored herring from the North Sea was lower than the quality of ice-stored herring from Kattegat and the Baltic Sea during the storage period. The deterioration seems to proceed faster in ice-stored herring, but this is most likely due to the QIM scheme not being fully applicable for tank stored herring. The tank stored herring had a low quality on delivery and therefore it is reasonable to suggest, that the herring reached a high QI at an early stage making it impossible to describe the quality of the tank stored herring adequately with the scheme during the storage period. Smith et al. (1980) found parallel spoilage changes in RSW and ice stored herring, but off-flavours developed approximately one day earlier in RSW-stored herring than in iced herring, and the deterioration in RSW-stored herring was faster than in ice stored herring. They assigned this to insufficient change of cold water during storage, and estimated the difference to have no practical relevance.

There was not found any significant difference between batches of herring caught in the same area but sampled with short intervals (e.g. K/Sep02_1 and K/Sep02_2), and time of catch had no effect ($p>0.05$) on the quality index. Kolakowska et al. (1992), however, found the shelf life of iced herring to vary with seasonal condition of the herring. It was longest (8–14 days) in herring caught during winter and autumn and shortest (3–8 days) in post-spawning and feeding herring.

Table 5
Linear regression of Quality Index versus storage time (QI$=a\times$days in ice$+b$)

	Slope (a)	Y-intercept (b)	R^2
NSW/Sep02	0.388a	10.127	0.963
K/Sep02_1	0.527bc	5.413	0.951
K/Sep02_2	0.452bc	8.279	0.932
NSN/Nov02	0.361a	9.584	0.754
BS/Nov02_1	0.590bc	6.990	0.914
BS/Nov02_2	0.678b	2.471	0.873
NSNFeb03	0.362a	9.727	0.922
K/Feb03_1	0.438b	5.380	0.914
K/Feb03_2	0.692bc	3.272	0.954
NSN/May03	0.743c	6.968	0.980

All correlations (R^2) are significant ($p=0.0001-0.04$). Slopes with different subscripts are significantly different ($p<0.05$). Abbreviations are explained in Table 1.

3.3. Descriptors in the quality index scheme in relation to storage time and method

Many of the descriptors were not used fully (Fig. 1), and this can explain the discrepancy between reported relationships between Quality Index and storage time in our and a previous study (Jónsdóttir, 1992). For all descriptors except belly bursting and colour of gills in tank-stored herring a linear relationship existed between the given demerit point and storage time ($R^2=0.02$–0.43, $p<0.0001$).

A significant difference was found between how fast the changes occur (i.e. the slope values) in the odour of whole herring, the appearance of eyes and the odour of gills in ice and tank-stored herring (Fig. 1). In the cases were a linear relationship exists between the point for a descriptor and storage time, but were slope values were not significantly different, a significant difference was found in the starting quality (i.e. the intercepts with Y-axis) between the storage methods. This means that the starting quality described by appearance of skin, blood on gill cover, texture on loin and shape of eyes was different. Tank stored herring obtained higher demerit points than ice stored herring for all descriptors except blood on gill cover. Tank storage induced more development of off odours, discoloured gills and dull

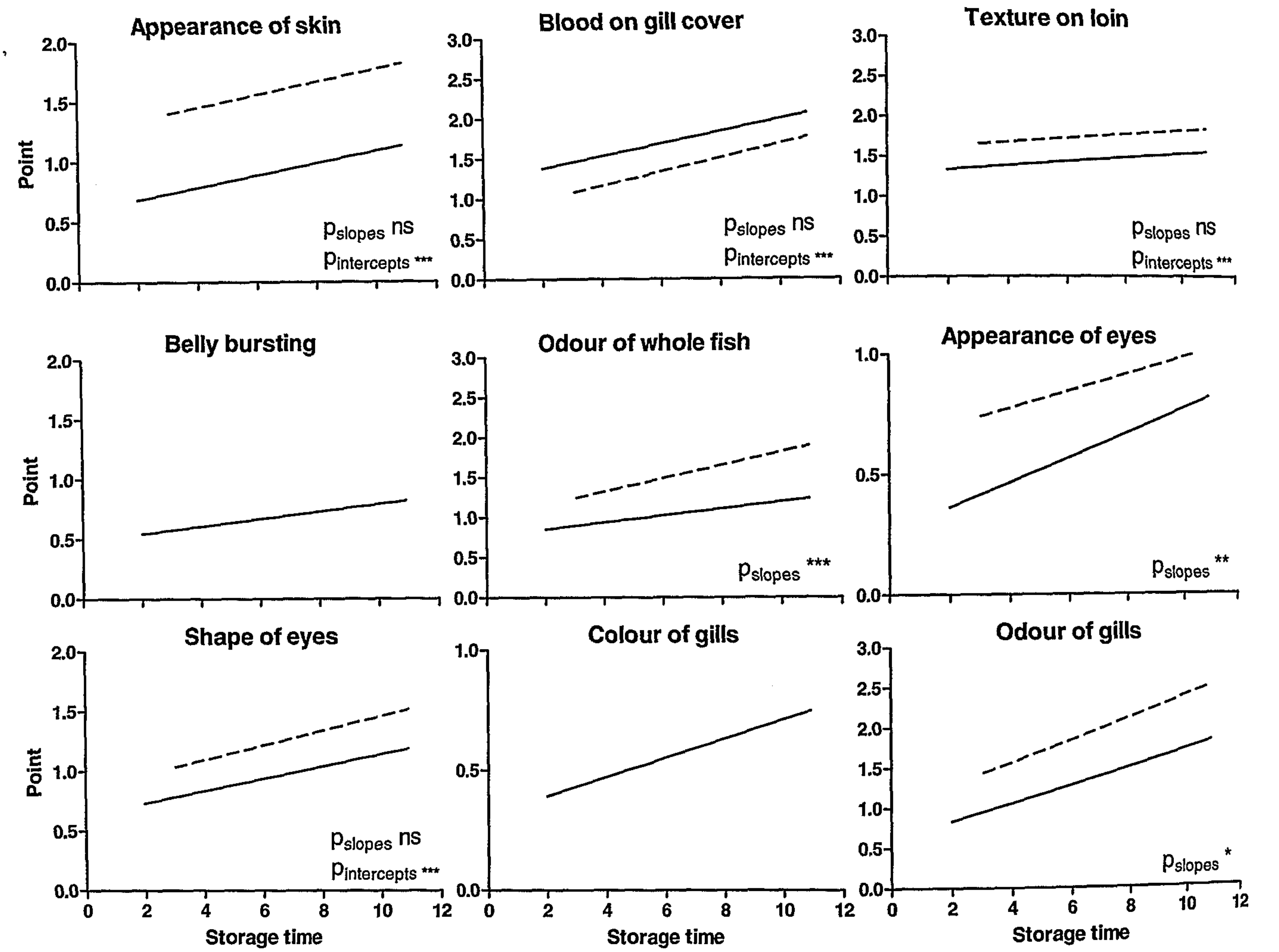

Fig. 1. Linear relationship between demerit points given to the individual descriptors in the QIM scheme and storage time for ice- (—) and tank-stored (- - -) herring. Only significant ($p<0.05$) linear relationships are shown. P values for slopes and intercepts are significance values from t-tests relating regression lines from both storage methods. The significance levels are $***p<0.001$, $**p<0.01$, $*p<0.05$, ns: $p>0.05$.

skin than ice storage. Ice storage, on the other hand, resulted in more blood on gill covers. These observations are similar to the results reported by Jónsdóttir (1992). All herring were transferred to ice or ice water immediately after catch, so the observed difference is likely due to different handling during and immediately after harvesting. Inadequate cleaning and temperature regulation in storage tanks are well known factors contributing to accelerated deterioration of the fish (Smith et al., 1980; Price, 1983). The cold water dewaters the outer surfaces including the gill covers (Jónsdóttir, 1992), and if the temperature is not controlled adequately the spoilage reactions will accelerate and off odours will quickly spread through the tank water (Smith et al., 1980; Kraus, 1992). Any rough handling e.g. disturbance due to bad weather conditions will cause the herring to collide and thereby induce physical damages, resulting in bloodstains and dull skin. The friction between herring in onboard cooling tanks causes the scales to loosen and therefore the skin of tank stored herring is less shiny than the skin of iced herring (Jónsdóttir, 1992).

3.4. Applicability of the descriptors

Higher demerit points were given as the storage time increased but in many cases neither the lowest nor the highest points were used (Fig. 1). According to how the QIM-schemes are constructed, iced fish evaluated shortly after catch should be given the lowest points that subsequently increase as deterioration progresses (Jónsdóttir, 1992; Nielsen & Jessen, 1997; Martinsdóttir et al., 2001). Therefore ice-stored herring should be given points near to zero immediately postmortem. This is not consistently the case (Fig. 1) and therefore it is necessary to adjust some of the parameters. All descriptors were evaluated individually in order to assess and, if necessary, improve their applicability. The descriptors appearance of skin, appearance of eyes, shape of eyes and odour of gills need no revision. Furthermore, the descriptors belly bursting and colour of gills can be used for iced herring, but should be omitted for tank stored herring because they are not related to storage time. It is necessary to adjust the range for the descriptors blood on gill cover and odour of whole fish. This can be done for blood on gill cover by merging the categories currently giving 0 or 1 points to a new category giving 0 point and reduce the latter categories correspondingly. For the descriptors odour of whole fish the category giving 3 points should be included in the 2 points category. Finally, the descriptor texture on loin needs to be revised completely because it does not adequately describe the changes during storage. This revision will need additional trials.

The influence of theses changes on the results obtained by the corrected QIM scheme was evaluated by new calculations using the original data corrected as above mentioned. The correlation between QI and storage time was still high ($R^2=0.85$–0.99). The Y-intercepts were reduced from 2.5–10.1 to 1.8–5.8, and although the slope values did not change markedly (from 0.4–0.7 to 0.3–0.6) the variation between replicated batches decreased. This shows that these changes will improve the usefulness of the QIM scheme.

3.5. QIM descriptors in relation to biological and chemical parameters

The relationship between QIM descriptors and biological and chemical parameters is showed in Fig. 2. The main variation in the direction of the first PC is due to lipid content and weight. High lipid contents and high weights correspond to primarily spawning herring, and these herring are assigned low demerit points for all descriptors except blood on gill cover. A combination of the first and second PC describes the variation between immature herring and other maturity classes. Immature herring in general score higher than the other maturity classes. According to this small immature herring with low lipid content have inferior quality compared to larger spawning herring with high lipid content. This agrees with the general observation that small fish spoil faster than large fish (Huss, 1995). There is no difference between males and females and the occurrence of Anisakis larvae does not influence the quality described by the QIM descriptors.

A negative correlation exists between the lipid content and most QIM descriptors. Only the amount of blood on gill cover is completely unaffected by the lipid content. Soft texture and belly bursting are highly correlated and are related to high lipid contents in mainly ripe and spawning herring. Since herring is a fatty fish and therefore susceptible for oxidation one might expect the odour of whole fish to be correlated to high lipid contents. High scores for odour were given to fish with a high degree of off odours. In this study odour was not accompanied by high lipid contents, and this agrees with the observation that the off odour found in the whole herring even after 11 days did not contain rancid but cabbage-like notes. This confirms other studies (Hansen et al., 1970; Bilinski, Jonas, & Lau, 1978; Kolakowska et al., 1992).

4. Conclusion

The QIM evaluations performed on herring from ten cruises over a nine-month period show the onboard storage methods to have profound influence on quality. The quality of iced herring from Kattegat and the Baltic

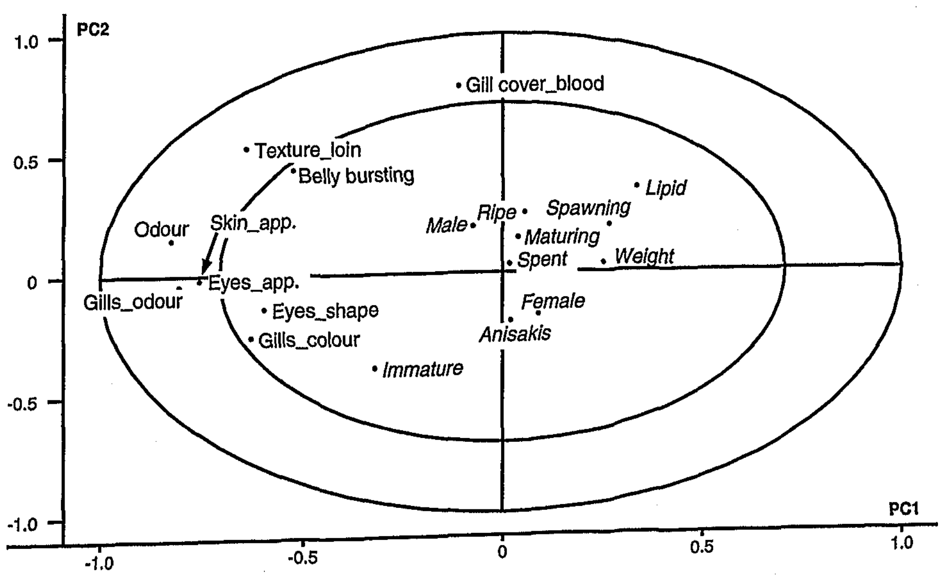

Fig. 2. QIM descriptors (X) versus *biological and chemical parameters* (Y). Correlation loadings from a PLSR-model with full cross validation and weighted (1/SD) data. PC1 explains 49% of X and 2% of Y, while PC2 explains 14% of X and 2% of Y.

Sea is clearly superior to the quality of tank stored herring from the North Sea. Off-odours develop faster in tank stored herring, and tank storage results in more discoloured gills and duller skin than ice storage. Ice storage, on the other hand, gives more blood on gill covers.

The results show that large spawning herring with high lipid contents have superior quality compared to small immature herring with low lipid content. The high lipid content is correlated to low scores for all descriptors except blood on gill cover, that furthermore is the only descriptor not dependent on biological or chemical parameters. Sex or the seasonal variation in prevalence of Anisakis larvae had no effect on the quality.

The results also show some shortcomings of the QIM scheme. It can be used to compare the quality of iced and tank stored herring, but it cannot be used to calculate the remaining shelf life. However, this can be achieved by some modifications of the scheme.

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