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# THE EFFECT OF DELAYED ICING AND GUTTING ON THE QUALITY OF FRESHWATER ARCTIC CHARR (*Salvelinus alpinus L.*)

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## ABSTRACT

Four methods of handling Arctic charr (*Salvelinus alpinus*) were studied. Samples itself was gutted. One group was gutted and iced immediately, a second group was ungutted and iced immediately, a third group was gutted and kept at 10°C for 18 hrs prior to icing, and the fourth were ungutted and kept at 10°C for 18 hrs prior to icing. Whole fish were stored in ice for eight days and then filleted. The changes in freshness were measured using sensory evaluation and microbiological methods. The Quality Index Method for whole fish showed that the fish from the two groups that were iced immediately were of better quality than the fish that were kept at 10°C for 18 hours prior to icing. Total bacterial counts on the flesh remained low for the first eight days and rose dramatically after filleting, indicating possible contamination of fillets during the process of filleting. On the17day of ice storage panellists detected off-flavours and off-odours indicating spoilage and this was the time too when the bacteria counts were very high. A good correlation was found between sensory evaluation and microbiological development in the fish with r: 0.86 and 0.83 respectively for ungutted, iced immediately and gutted, iced immediately.

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# 1 INTRODUCTION

## 1.1 Fish spoilage

Fish is more perishable than most other protein foods (Burgess and Shewaan, 1970) in Huss *et al.*1974. Even at chilled temperatures (0°C) rapid spoilage is observed in wet fish. Even though autolytic activity and natural chemical changes start the degradation process in fish, the spoilage of fish held in ice is mainly a bacteriological phenomenon. The chemical changes that take place are mainly due to bacterial enzymes (Liston 1982, Ronsivalli and Charm 1975, in Alberto *et al.* 1987). Bacteria are considered to play a dominant role in fish spoilage. (Laycock and Regier, 1971, Shaw and Shewan, 1968) in Huss *et al.* 1974. It is usually believed or stated that bacteria penetrate the gill tissue and proceed along the vascular system, particularly along the caudal vein, through the kidney and hence, after some days into the flesh; or through the intestines into the body cavity and belly walls; or through the skin into the flesh, but there is very little direct proof for any of these statements (Shewan, 1971).

The use of ice for chilling is still one of the most important methods of preserving fish, though ice merely slows down microbial activity since fish can support a population of cold-tolerant bacteria (Liston 1982, in Alberto *et al.* 1987). These bacteria are predominantly at the surface of the fish but secrete enzymes into the tissues, bringing about a complex series of chemical changes (Shewan, 1971).

Recent investigations indicate that the fish caught in unpolluted waters carry only a few micro-organisms on their surfaces and in the gut. Most of the bacterial contamination found on the landed fish appears to be related to the handling practice of the fish and bacterial growth during storage (Elinor *et al.*1985).

Much variation exists in the patterns of spoilage of fish species. From the small amount work published on spoilage characteristics of freshwater fish it appears that they have longer shelf lives on ice than those from marine water (Disney 1976, Shewan, 1977 in Gelman *et al.* 1989).

## 1.2 Methods of measuring fish freshness

Various types of analyses have been developed to measure the loss of fish freshness and to detect spoilage. The deteriorative changes occurring in fish result in the gradual accumulation of certain compounds in the flesh. Quantification of these compounds can provide a measure of the progress of deterioration (Connell, 1975).

Sensory methods offer rapid ways of assessing fish freshness and detecting spoilage. The Quality Index Method (QIM) evaluates characteristic features (skin, gill cover stiffness, belly, smell, eyes and gills) of the whole raw fish using a score system ranging from 0 to 4 demerit points. The scores for all the characteristics are added to give an overall sensory score, the so-called quality index. There is a linear correlation between the sensory quality expressed as a demerit score and storage life on ice, which makes it possible to predict remaining storage life on ice (Luten and Martinsdóttir, 1998.). This method was originally developed by the Tasmanian Food Research Unit (Bremmer, 1985). Freshness evaluation of cooked fillets can be done

using the Torry-scheme (Shewan *et al.*1953) which implies the assesses of fish flavour and odour.

Based on the fact that fish spoilage is caused mainly by bacterial activity, bacteriological counts could be proper indicators of spoilage. However, not all bacteria species isolated from fish cause spoilage. Total viable counts have been found to be very poor indicators of both quality and remaining shelf life of chilled fish (Huss *et al*. 1974). Moreover, the number of spoilage organisms as a proportion of the total bacterial population changes as spoilage proceeds (Shewan *et al.* 1960a). Still, a count of specific organisms involved in fish spoilage could be more useful in assessing the degree of spoilage, and possibly predicting the remaining shelf life (Jorgensen *et al.* 1988).

### 1.3 Background: Uganda

Uganda fish production is estimated at 210,000 metric tonnes for 1997 and is dominated by capture fisheries. About 70% of the fish landed is marketed fresh while 30% are processed using the traditional methods of smoking, light or heavy salting and sun drying.

Industrial processing of fish is targets mainly Nile perch for the export market and has become significant since 1988 when the first fish freezing, and filleting plants were established. Export of fish fillets have risen from 1,664 tonnes in 1990 valued at USD 1.38m to 14,075 tonnes in 1996 valued at USD 49m. Presently fish exports are the second most important export commodity.

The processing of fish for export requires high standards of hygiene and has therefore called for improvements in the handling of fresh fish. Some have been made in this direction but there is still room for further improvement. Among the notable improvements is the use of ice and insulated containers during the transportation of fish from the landing sites to the factories.

Most of the fish in Uganda is caught by gillnetting. Nets are set in the evenings (6:00 - 8:00pm) and hauled in, in the early hours of the morning (5:00 - 7:00am). Spoilage of the fish begins as soon as the fish die in the nets. Therefore, in a typica catch there may be fish of varying quality depending on the time the fish got caught in the net.

The catch is not always taken at once; it may be taken after a few hours or even after 1 or 2 days after fish are caught. The fishermen do not use ice or gut the fish. Icing is done in transport boats which collect the fish.

On the islands there are no ice plants. Ice can only be used if it is brought from the mainland. At times buyers remain on the islands for 2 to 3 days purchasing fish from fishermen before returning to the mainland.

## 1.4 Justification

Although quantitative and qualitative data on post-harvest losses in Uganda is still scanty, field observations have indicated that losses are mainly related to quality deterioration and spoilage (Masette 1996), and are estimated to be approximately 20% of the 210,000 tones total catch (Fisheries department report, 1996).

The post-harvest losses are high due to several reasons: Fish may remain dead for several hours in the water before being removed from the net. Poor handling of the catch such as no or delayed icing, rough handling or unhygienic handling which all contribute to accelerated spoilage.

It is important to quantify the effect different post-harvest treatments have on the spoilage pattern in fish to evaluate how effective simple measures, such as icing, gutting and bleeding, have on the shelf life and the quality of freshwater fish.

The experiment was conducted at Icelandic Fisheries Laboratories in Iceland on freshwater Arctic charr. The weather conditions were not good for fishing, so farmed fish was used. The fish was deliberately slaughtered unstarved, to simulate the wild fish which has food in the gut at the time of harvesting. One group of fish was kept at 10°C for 18 hrs prior to icing on the assumption that the rate of spoilage at this temperature in Iceland is the same at 25°C in Uganda.

## 1.5 Objectives

- To determine the changes in freshness of freshwater fish during ice storage.
- To find out whether delayed icing and gutting of the fish affects its storage life.

# 2 MATERIALS AND METHODS

Arctic charr *(Salvelinus alpinus*) was harvested from a farm in the Fjallalax fish farm in southern Iceland. The fish had not been starved and was actively feeding on commercial fish feed at the time of harvest. Each fish weighed approximately 400-600g.

The fish were divided into 4 groups for different treatments (Table 1).

**Table 1: Fish treatment groups with 25 fish in each group.**

| Gutted | | Ungutted | |
|---|---|---|---|
| Iced immediately | Kept at 10°C for 18 hours prior to icing | Iced immediately | Kept at 10°C for 18 hours prior to icing |

The iced fish was packed so as not to be in contact with one another and one part of ice to two parts of fish were used at all times. The fish was kept in styropore boxes that had drain holes to allow the escape of melted water.

Whole fish was sampled every 2-3 days and sampling continued until the 8th day.
Then on the 8th day, all the fish was filleted and the fillets of the fish in groups of delayed icing were analysed and their quality compared. These fillets were then discarded. The fillets of the fish in the groups which were iced immediately (both gutted and ungutted), were kept at 0°C on ice for further analysis. The fillets were analysed every 3-4 days until they became spoiled and were no longer acceptable for human consumption.

## 2.1 Sensory evaluation

Fish quality was evaluated by a panel of trained sensory experts consisting (8-12 people) from the Icelandic Fisheries Laboratory staff. Whole fish samples were examined for appearance of skin, firmness of flesh, slime formation, colour and form of eyes and finally colour, smell and mucus formation of gills. (Quality Index Method (QIM) scoring scale of whole Arctic charr, Appendix 1).
The whole fish samples were filleted, skinned and cut into small pieces for each panellist. S Samples were cooked in a steam oven in small aluminium boxes which were blind coded before serving to the panellists. Two samples from each treatment were evaluated by each panellist. Panellists tasted the cooked samples and recorded their evaluations using a freshness-scoring sheet (Table 2).

**Table 2: Freshness score sheet for cooked Arctic charr.**

| Scores | Description |
|---|---|
| 10 | Meaty, metallic, fresh oil |
| 9 | Typical flavour for trout, sweet |
| 8 | Typical flavour for trout, with reduced intensity |
| 7 | Neutral, baked, herringlike |
| 6 | Cooked potatoes, meaty, cardboard, woody |
| 5 | Sour odour, slight off-flavour |
| 4 | Little bitter, sour, off-flavour |
| 3 | Nutty, cheesy, butter-like and sour |

Panellists recorded their scores in the computer, which uses Hyper Sense 1.6 software. Samples retaining odours and flavours typical for the species were given scores from 7–10, whereas score 5.5 indicated fish on the borderline of freshness. Scores of 5 and below were used when strong unpleasant off-odours and off-flavours were detected.

## 2.2 Microbiological methods

At each sampling, muscle samples from two individual fish from each treatment group were bacteriologically assessed for aerobic plate count on plate count agar. A tissue sample of 25 g. by weight of muscle was aseptically removed from the fish, minced and used for preparing the primary dilution. Dilution buffer 225 g was then added and homogenized for 1 minute using a stomacher blender.

One ml of the homogenate was inoculated into 2 petri-dishes marked 1/10. Tenfold dilution was then made as required, by taking 1 ml from the dilution to 9 ml of dilution water. Then 45°C hot plate count agar was poured on the plates, stirred and left to cool. Agar plates were incubated at 30°C for 48 hours and the number of colony forming units (c.f.u.) was counted.

Following the removal of samples for bacteriological assessments, fillets were taken from the same fish and used for sensory evaluations as cooked samples.

# 3 RESULTS

From the sensory evaluation of the whole fish made during the first 8 days of ice storage, it was found that all the fish which have been iced immediately had eyes which were convex and bright, gills were red with sea weedy odour and the flesh was firm. Likewise, sensory evaluations of cooked fish provided values for flavour, odour and overall freshness that were very high, all above 7 indicating a high degree of freshness (Table 4).

However, by the 8$^{th}$ day, there were changes in the texture and odour of the fish from the two treatment groups kept at 10°C for 18 hours prior to icing. These samples had a soft and flabby texture, retaining finger indentation slightly.

After 8 days of ice storage the fish which have been iced immediately was of higher quality with lower demerit scores than the fish which was kept at 10°C for 18 hours prior to icing (Table 3).

**Table 3: Demerit scores from the Quality Index Method for whole Arctic charr.**

| Days in ice storage | Ungutted and iced immediately | Gutted and iced immediately | Ungutted and kept at 10°C for 18 hrs prior to icing | Gutted and kept at 10°C for 18 hrs prior to icing |
|---|---|---|---|---|
| | average | average | average | average |
| 1 | 1.8 | 1.3 | 2.8 | 3.5 |
| 4 | 4.2 | 4.9 | 6.7 | 6.1 |
| 6 | 7.2 | 7.3 | 8.2 | 6.6 |
| 8 | 8.0 | 8.1 | 9.1 | 9.6 |

On the 8$^{th}$ day, an informal panel evaluated fillets from all four treatment groups. It was found out that the texture of fillets of the ungutted fish kept at 10°C for 18 hours prior to icing was soft, easily torn, with advanced visible gaping and had a slight

sweet odour (fruity like). However, the texture of the fillets of gutted fish kept at 10°C for 18 hours prior to icing was of slightly better quality with soft texture and small gaping.

**Table 4: Freshness scores for cooked fish from sensory evaluation.**

| Days in ice storage | Ungutted and iced immediately. | Gutted and iced immediately | Ungutted and kept at 10°C for 18 hrs prior to icing. | Gutted and kept at 10°C for 18 hrs prior to icing. |
|---|---|---|---|---|
| 1 | 9.0 | 9.6 | 9.0 | 9.4 |
| 4 | 8.0 | 8.1 | 8.2 | 8.1 |
| 6 | 7.3 | 7.9 | 7.7 | 7.9 |
| 8 | 7.0 | 7.0 | 7.3 | 7.0 |
| 11 | 6.4 | 6.5 | | |
| 14 | 6.4 | 6.5 | | |
| 17 | 4.9 | 5.2 | | |

**Table 5: Bacteriological counts (log 10) in Arctic charr flesh. A is ungutted iced immediately; B ungutted kept at 10°C for 18 hrs prior to icing; C gutted iced immediately; and D gutted kept at 10°C for 18 hrs prior to icing.**

| Storage days in ice | Total counts in A log | Total counts in C log | Total counts in B log | Total counts in D log |
|---|---|---|---|---|
| 1 | <0.70 | <0.70 | <0.70 | <0.70 |
| 4 | <0.70 | 1 | <0.70 | <0.70 |
| 6 | <0.70 | <0.70 | <0.70 | <0.70 |
| 8 | <0.70 | 1.3 | 1.9 | 2.99 |
| 11 | 4.36 | 4.2 | | |
| 14 | 5.02 | 5.46 | | |
| 17 | 5.47 | 6.5 | | |

Freshness quality of cooked fish was unsatisfactory at the 17$^{th}$ day of ice storage because of off-flavours and off-odours. The deterioration of quality was similar for all fish treatments, the characteristic odour of the species gradually decreased in intensity with time during the days of ice storage (Figure 1).

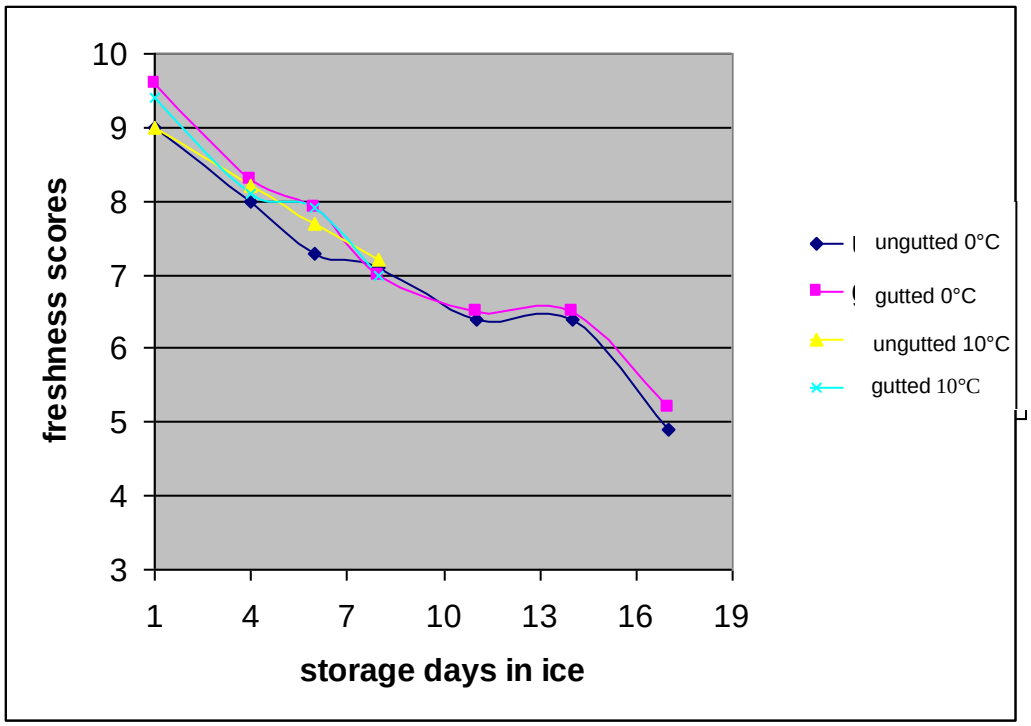


**Figure 1: The changes in sensory quality of cooked Arctic Char for 4 treatment groups during the days in ice storage.**

The method of fish treatment did not have any significant effect on the sensory attributes of cooked fish. The results indicate that the panellists were unable to identify differences between the four treatment groups in the cooked fish (Figure 1).

Initial bacterial levels were very low for all treatments, below 5/g for the first 6 days of ice storage. Thereafter, there was an increase in total viable counts with prolonged storage time, the highest count being in the gutted fish (Figure 2).

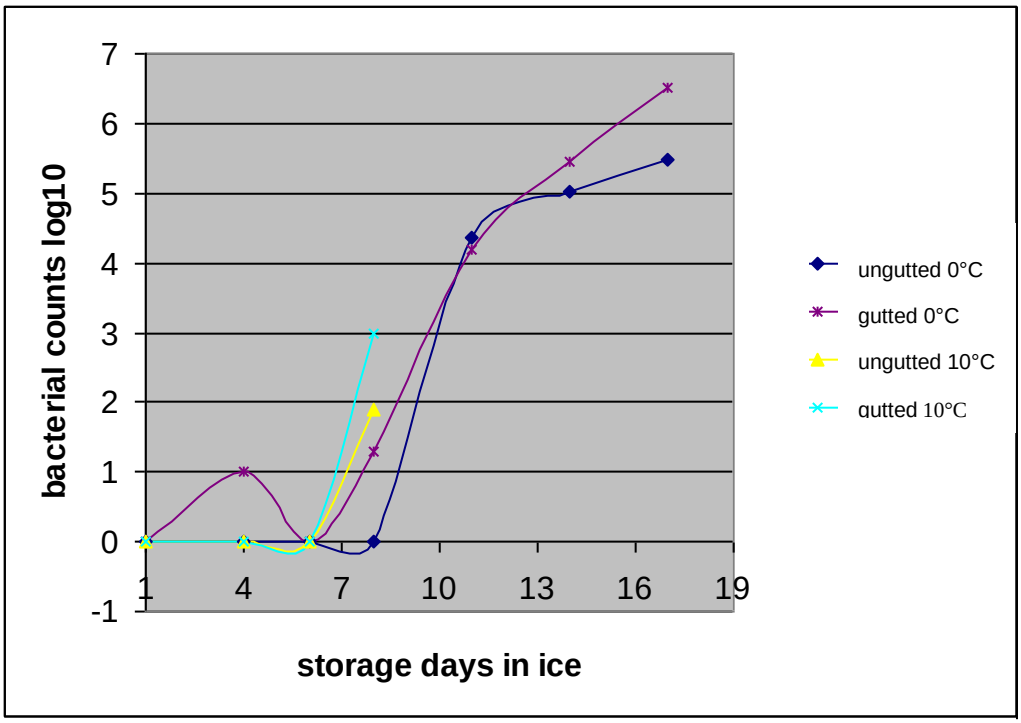


**Figure 2: Bacterial growth in Arctic Char flesh for all treatment groups during their respective storage periods.**

## 4 DISCUSSION

For the first 6 days of ice storage bacterial levels in the muscle were very low for all treatments, below 5/g (Table 5). The fish used in this experiment was grown in very clean water which is pumped directly from the ground to the fish tanks. The fish were fed on commercial fish feeds which are low in bacteria counts. Furthermore, Arctic charr are known to have a thick fat layer lining the gut which makes the penetration of bacteria from the intestines to the flesh difficult. All these factors influence the presence and growth of bacteria in its muscle. This agrees with the findings of Murry and Shewan (1979) who reported that only a limited number of bacteria invade fish flesh during ice storage. A close relationship between initial bacterial microflora of the caught fish and the microflora of the environment has been demonstrated (Swewan 1971). Anderson *et al.* (1965, in Huss 1995) showed that many bacteria are unable to grow at temperatures below 10°C, and even cold-tolerant bacteria grow slowly and sometimes with extended lag phases when temperatures approach 0°C.

After the 8th day in ice storage, when the fish was filleted bacteria counts went up from 20/g for the gutted iced and less than 5/g for the ungutted iced to 16200/g and 23000/g respectively (Table 5). This sharp increase in bacteria count is attributed to bacterial contamination during the process of filleting. In the process of filleting there was contamination by the equipment used in filleting, the surrounding air and the

storage materials in which fillets were kept. Bacterial counts were further found to be highest in the fillets of the gutted fish compared to the ungutted fish. Gutting, according to Shewan (1962 in Alexander *et al.* 1989) extends storage life, but Hoffman *et al*.(1974 in Alexander *et al*. 1989) found it of marginal value with *Tilapia nilotica* and other East African freshwater fish, as did Maia *et al*.(1983) in their work on *Prochilodus scrofa*, a Brazilian freshwater fish.

These changes in bacteria counts are in accordance with findings of Huss *et.al*. (1974 in Huss 1995) who pointed out that gutting the fish exposes the belly area and the cut surfaces to the air, thereby rendering them more susceptible to contamination, oxidation and discolouration.

The quantitative changes in bacterial numbers during ice storage for the 17 days were similar to those described by Amu and Disney (1973 in Disney 1976). The bacterial changes in freshwater fish are relatively slow compared with the proliferation seen during ice storage of marine fish where similar changes occur in less than two weeks (Poulter *et. al*. 1981 in Huss 1995). The results further indicate longer ice storage time of freshwater fish compared to marine fish species. This concurs with the findings of Lima dos Santos, (1981) who reported that freshwater fish species generally have longer shelf lives than marine water species. Shewan, (1977) also reported that storage characteristics of iced freshwater fish indicate that patterns of spoilage are similar to those of marine species but that their storage lives generally appear to be longer (Bramstedt and Auerbach, 1961 in Alexander Gelman *et al.* 1989). Liston (1980) related differences in shelf life of iced freshwater and marine water fish to differences in bacterial growth rates.

Sensory panelists were able to note freshness differences in the sensory attributes of the whole fish iced immediately and those kept at 10°C for 18 hours prior to icing. But differences were not noted in the cooked samples that were evaluated at the same time. Sensory evaluation of cooked fish flavour showed notable changes during the period of ice storage, and the fish received low score values after 17 days in ice, developing distinctive off-odours and off-flavours. This was also the same storage period when the bacterial counts increased dramatically. Lambert *et al.* (1992) reported that the appearance of off-odours in fish is associated to the growth of spoilage bacteria. A good correlation was found between sensory evaluation of cooked fish and microbiological development in the fish, with correlation coefficients r: 0.86 for ungutted iced immediately and 0.83 gutted iced immediately.

# 5 CONCLUSION

Sensory evaluation of whole fish showed that fish that was iced immediately was of better quality than fish kept at 10°C for 18 hrs prior to icing. But there was no difference between the quality of whole fish which was gutted and ungutted in the two different groups.

The bacterial counts for all group treatments remained low for the first 8 days but after filleting, the total counts rose dramatically.

An observation made on fillets on the 8$^{th}$ day before being cooked showed that fillets from fish iced immediately were of better quality than those from fish kept at 10°C for 18 hours prior to icing.

On the 14$^{th}$ day, fillets were found to be mushy, very soft with advanced gaping. They would not be attractive to a buyer, but when cooked they were scored as suitable for human consumption. So, a freshness scoring scale for fillets of Arctic charr should be used along with the analysis of whole and cooked fish in determining freshness.

After 17 days the panelists detected off-flavours and off-odours in the cooked samples from both treatment groups indicating spoilage.

The sensory evaluation of the whole fish indicates that icing fish immediately improved the quality of fish, but gutting appeared to have no effect on its quality.

Much more work is needed to find out whether or not gutting affects the freshness of Arctic charr.

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**APPENDIX 1: QUALITY INDEX METHOD SCORING SCALE FOR WHOLE ARCTIC CHARR.**

| Quality parameter | | Description | Scores. |
|---|---|---|---|
| **Appearance** | **Skin** | Clear, even silver-gold shiny over whole fish. | **0** |
| | | Dark spots which decrease its appearance. | **1** |
| | | Dull | **2** |
| | **Firmness of flesh** | Rigor | **0** |
| | | Firm, elastic and bounces back when pressed with finger. | **1** |
| | | Soft, weak, less firm but the finger indent disappears. | **2** |
| | | Very soft, mushy and unfirm, finger indent does not disappear so a hole is left in the flesh. | **3** |
| | **Slime** | Fish has little slime as is fish newly caught. | **0** |
| | | Some, brown slime is visible and when fish is held up the slime drips from it. | **1** |
| | | Much clotted blackish, Grey/brown slime is apparent on the fish | **2** |
| **Eyes** | **Colour of pupil** | black | **0** |
| | | opaque | **1** |
| | | grey | **2** |
| | **Form** | convex | **0** |
| | | Flat slightly sunken | **1** |
| | | Concave, sunken | **2** |
| **Gills** | **Colour** | Bright red | **0** |
| | | Light reddish | **1** |
| | | Grayish discoloured | **2** |
| | | Brown, discoloured | **3** |
| | **Smell** | Fresh, muddy, newly cut grass, metallic, seaweed | **0** |
| | | Metallic, cut flower, "green", slight smell of beer | **1** |
| | | Sweet and sour | **2** |
| | | Rotten, stale, lower fatty acid | **3** |
| | **Mucus** | Clear | **0** |
| | | Brown, milky | **1** |
| | | Dark, milky, opaque | **2** |
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