Scallop Quality

Seafish Report No. SR469

August 1996

The Sea Fish Industry Authority

Technology Division

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The effects of different handling practices and storage times, prior to processing, on scallop quality and investigation of quality assessment methods/indicators including D-Lactic acid

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Summary

This report outlines a trial carried out to identify the effects of storage temperature, storage time before processing and the soaking of scallop meats upon scallop quality. The trial also investigated the use of a chemical quality assessment measure, D-Lactic acid, by comparing it against the commonly used organoleptical techniques for quality assessment.

It was found that the best scallop meat quality is achieved by chilling the scallops immediately after capture. Chilling can be by direct or indirect icing or by refrigeration. Immediately chilled scallops had a useful storage life of 7-9 days from capture, before they were unacceptable to the consumer. Direct icing of the scallops prior to processing gave slightly better cooked flavour results than refrigeration. However, after several days of directly iced storage there was a significant uptake of water by the scallop and consequent increase in weight and moisture/protein ratio. On fishing vessels landing daily it was found that it is possible to hold the scallops on the vessel in moist, unchilled conditions at temperatures similar to those of the seawater for up to 12 hours whilst they remain "alive", prior to chilling ashore, and still achieve products of good eating quality.

Investigation into storage delays prior to processing showed that with relatively clean scallops, provided they were chilled, the delay prior to shucking did not affect the overall useful storage life from capture. However, it is known that scallops heavily contaminated with grit or mud deteriorate more rapidly. Contaminated scallops should be shucked as soon as possible after capture.

Investigation into the soaking of scallop meats found that this greatly increases their weight and moisture/protein ratio. Soaking the meats created products of neutral flavour yet extended useful storage life in that state. However, soaking of scallop meats is not recommended.

There was a good correlation found between cooked flavour and cooked odour scores for scallops which may, in the future, enable the use of an "electronic nose" for quality assessment. It was also found that after spoilage has become established and flavours were deteriorating there was a good correlation between cooked flavour and D-Lactic acid levels in the scallops which may make this a useful measure for specifying minimum quality standards.

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1. Introduction

The King Scallop, *Pecten maximus*, has the potential, if handled and processed correctly, to be the most desirable scallop on the world market. If the UK scallop fishing industry is to maintain its position in the market place, against a growing number of countries producing scallops for export by aquaculture, notably China and Chile, it is essential that the quality of the natural scallop resource is maximised.

Scallops are filter feeding bivalve molluscs that live in a variety of habitats. In the UK they are caught by a range of fishing vessel types from small day trip boats with limited handling facilities, to large beam trawlers, often fitted with refrigerated fish holds, that fish for up to a week at a time. Scallops are consigned to a number of different niches in the market, the great bulk being marketed as processed product. Fresh, roe-on, unsoaked, scallop meats are the premium, high value processed product.

In summer 1994 Seafish investigated methods for degritting scallops which are destined for 'live' in-shell sale (Ref. 1 and 2). Following on from that work it was decided that scallop quality investigations should continue for the larger sector of the scallop industry ie; scallops destined for processing.

A further series of trials has been conducted to identify the differences in scallop quality that occur with different handling practices (time delays and methods of storage) prior to processing. Trials to quantify the effects of the commercial soaking practices on scallop meats have also been carried out.

Following the publication of scallop quality trials in Japan (Ref. 3) which examined D-Lactic acid as a quality indicator for the Japanese Scallop, *Pectinopecten yessoensis,* it was decided that comparative samples should be tested by this method to see if there was any role for D-Lactic acid as a quality indicator with *Pecten maximus.*

The results of all these further trials are described and discussed in this report.

2. Considerations of Scallop Quality

Quality can be a subjective matter. A general definition of quality is the degree of excellence of a product or the traits, characteristics or attributes that a product possesses. A simpler and more significant view of quality to those in business, is the value accorded to the product by the customer. With food, quality is often expressed in sensory terms of its odour, flavour and texture as experienced by the consumer. These factors are important as, if nothing else, they determine the viable fresh shelf-life of a product. A quantifiable method of assessing these organoleptic factors for fish has been developed by Central Science Laboratory (CSL) Torry. The method assigns scores to different levels of quality. See Appendix 1 for the CSL Torry scoring scheme for scallops, as used in these trials.

Quality can also be quantified in terms of the level of a products biochemical constituents such as Adenosine Tri-Phosphate (ATP), Hypoxanthine (Hx) or possibly D-Lactic acid. Chemical quality analyses are not as practical a day to day tool as sensory assessment but can be used to quantify a product specification. The levels of spoilage bacteria present can also be a quality indicator. The moisture/protein ratio is a measure of quality relating to the water content of the product. Certain markets, especially France, set a maximum moisture/protein ratio, typically 5:1. For processed scallops the quality criteria considered important by the trade are largely the product appearance, the yield upon shucking, the colour, the attachment of roe and the weight uptake potential by soaking.

During these trials, quality has been assessed by a number of means including cooked odour, flavour and texture, as defined by the CSL Torry scoring scheme, moisture/protein ratio, meat yield, soaking potential and D-Lactic acid level.

3. Current Industry Practice

The scallop fishing industry is comprised mainly of two types of vessels : small, 10–15 m dredgers, landing their catch daily; and larger, >15 m beam trawlers, fishing for up to a week at a time. On both types of vessel the normal practice is to place scallops into Hessian sacks, usually 120–144 scallops per sack, after capture. On the smaller vessels these sacks are then left on the deck with little or no protection, or cooling, until the vessel lands at the end of the day. On the larger beam trawlers the sacks are placed in the fishroom. These fishrooms are often chilled but if not, the usual practice is to indirectly ice the scallops by putting ice over the sacks.

Most scallops are sold by direct sale rather than auction. The usual practice is for the scallops once landed to be transferred to a chill store to await transport; or directly into a refrigerated vehicle for transportation to a processing plant. Pre-processing storage at processing plants is also in chill stores. Scallops are manually shucked and then washed to remove any mud or shell pieces. After washing scallops are sometimes soaked. This process involves immersion of the shucked scallop meats into cold water for varying periods of time. The time interval is usually only a matter of hours, however it has been noted that sometimes the time interval can extend to at least 24 hours. After washing or soaking, if carried out, the meats are either frozen or packed into small, plastic, re-sealable tubs for chilled distribution.

4. Trials Objectives and Methodology

4.1 Trials Objectives

- To compare a number of scallop handling practices, prior to processing, to determine their effect on subsequent scallop meat quality.
- To assess the effects of soaking scallop meats on their quality.
- To compare the D-Lactic acid chemical testing method against the CSL Torry, organoleptical quality assessment method for scallop meats.

The variables investigated were :-

- Storage temperature prior to processing, both onboard vessel and ashore (ambient/ chilled/iced).
- Time delay before cutting scallop meats out of their shells (shucking) (2–6 days).
- Scallop meat soaking time (0, 1 and 2 days).

4.2 Trials Methodology

A number of alternative handling practices were simulated to investigate the range of the current handling practices and to look at the potential benefit of icing scallops directly. A total of 28 different handling/processing combinations were studied, as listed in Table 1 overleaf.

A sea trip was conducted on a 12 m vessel the 'JESSIE LOU', dredging for scallops out of Plymouth on 13 March 1995, during which 1,008 scallops, all of a similar size (100–110 mm), were collected allowing 36 scallops to be held in each regime listed in Table 1. The options of temperature storage investigated were ambient (12–13 °C), chilled storage (0–4° C) and directly iced (0° C). The storage occurred in two stages, firstly on the vessel and then ashore prior to processing. The storage period on the vessel was 12 hours. The onshore storage was up to the point of processing, i.e until shucked from the shells. The total delay between capture and shucking varied between samples from 2 to 6 days.

Table 1 - Handling/processing combinations assessed

Sample No.	Storage conditions on vessel (12 hours)	Storage conditions onshore prior to processing	Delay between capture and shucking (Days)	Meat soak time (Days)
1	Ambient	Ambient	2	0
2	Ambient	Ambient	3	0
3	Ambient	Ambient	4	0
4	Ambient	Ambient	5	0
5	Ambient	Ambient	6	0
6	Ambient	Ambient	2	1
7	Ambient	Ambient	2	2
8	Ambient	Chill	2	0
9	Ambient	Chill	2	1
10	Ambient	Chill	2	2
11	Ambient	Iced	2	0
12	Ambient	Iced	2	1
13	Ambient	Iced	2	2
14	Chill	Chill	2	0
15	Chill	Chill	3	0
16	Chill	Chill	4	0
17	Chill	Chill	5	0
18	Chill	Chill	6	0
19	Chill	Chill	2	1
20	Chill	Chill	2	2
21	Chill	Iced	2	0
22	Iced	Iced	2	0
23	Iced	Iced	3	0
24	Iced	Iced	4	0
25	Iced	Iced	5	0
26	Iced	Iced	6	0
27	Iced	Iced	2	1
28	Iced	Iced	2	2

Ambient = 12–13° C
Chill = 0–4° C
Iced = 0° C

On the vessel the scallops were stored in sacks (normal practice) held on deck for ambient storage; in sacks inside a chilled insulated container for chilled storage; or in fish boxes and directly iced. The same storage methods were used during delivery from Plymouth to Hull for processing. However, some samples were transferred from one storage method to another at the point of landing.

The scallops were brought back to the Seafish Laboratory and stored prior to shucking and assessment, after the appropriate number of days. Scallops were shucked manually and then washed with running water, by Fish Technology staff. After samples were shucked they were stored in re-sealable plastic containers, in a chill store, at 2–3 °C. Samples for soaking were put into the plastic containers with cold water and stored in the chill store in the same way. Samples were then subject to sensory assessment at intervals up to a maximum of 12 days product storage. By comparing the scores of samples stored in different conditions before processing but identical conditions thereafter, we could assess how much effect, if any, the pre-processing storage conditions had on eating quality.

From each of the 28 different scallop storage and handling methods assessed, 6 scallops were used initially to determine the moisture/protein ratio, 6 were used for initial lactic acid determination and 6 were used for final lactic acid determination, leaving 18 scallops for organoleptical assessment. Of these, three were used per assessment, allowing a maximum of 6 assessments of scallop meat, at two day intervals.

Chemical analysis of samples was carried out by Humberside County Scientific Service. Moisture and protein determinations were carried out using protocols specified by CSL Torry, to ensure comparability with their earlier work (Ref. 4 and 5). D-Lactic acid determination was carried out using protocols from Boehringer Mannheim Limited to ensure comparability with work carried out in Japan by Kawashima and Yamanaka (Ref. 3). Organoleptical assessment was carried out using assessment score sheets produced by CSL Torry. The scallops were cooked by boiling in a bag for 5 minutes, using a procedure laid out in an Irish Standard Specification (Ref. 6).

See Appendix I for all sample analysis protocols.

5. Results

5.1 Scallops Subject to Different Storage Conditions for the Minimum Period of 2 Days Prior to Processing

5.1.1 Effects of Storage Conditions on Flavour

The results of this part of the trial are shown in Figures 1 and 2. These relate to samples which were processed 2 days after capture and their meats organoleptically assessed 3, 5, 7, 9 and 11 days after capture. Figure 1 shows differences in scallop flavour scores two days after capture, using the CSL Torry cooked scallop quality scoring system.

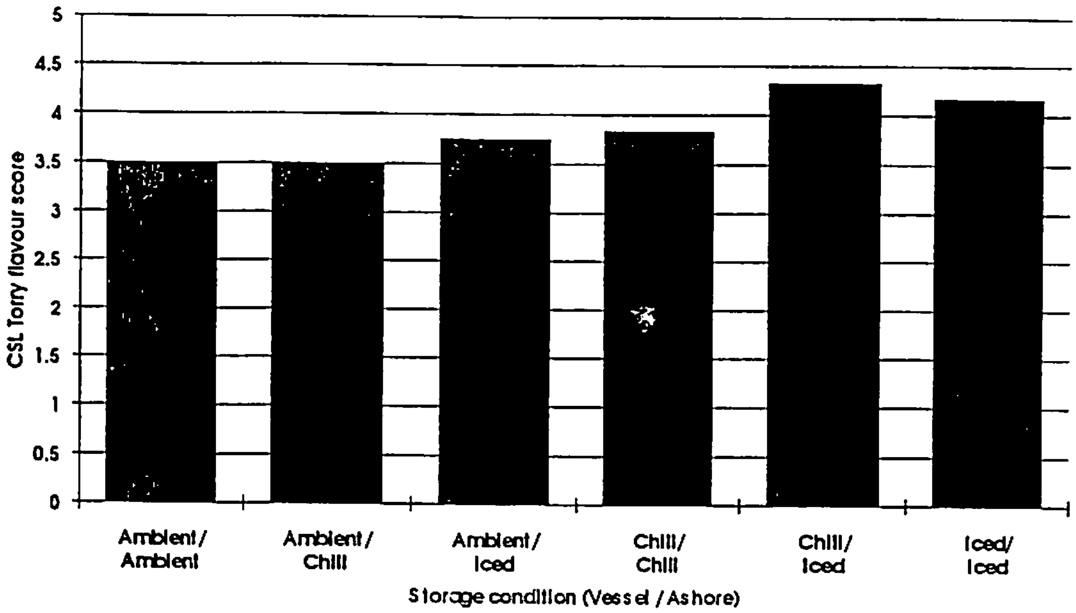

Figure 1 - Flavour scores of scallops, 3 days after capture, that were subject to different storage conditions for 2 days prior to shucking

Figure 1 shows that the best scallop flavour scores, at 3 days after capture, were obtained either by chilling the catch on the vessel and icing 12 hours later upon landing or by icing the catch on the vessel and keeping them iced prior to processing. The worst results were obtained by either keeping the product at ambient temperature both on the vessel and before processing or by keeping at ambient temperature onboard vessel and chilling upon landing. These results point to the importance of rapid chilling to obtain the best organoleptical quality.

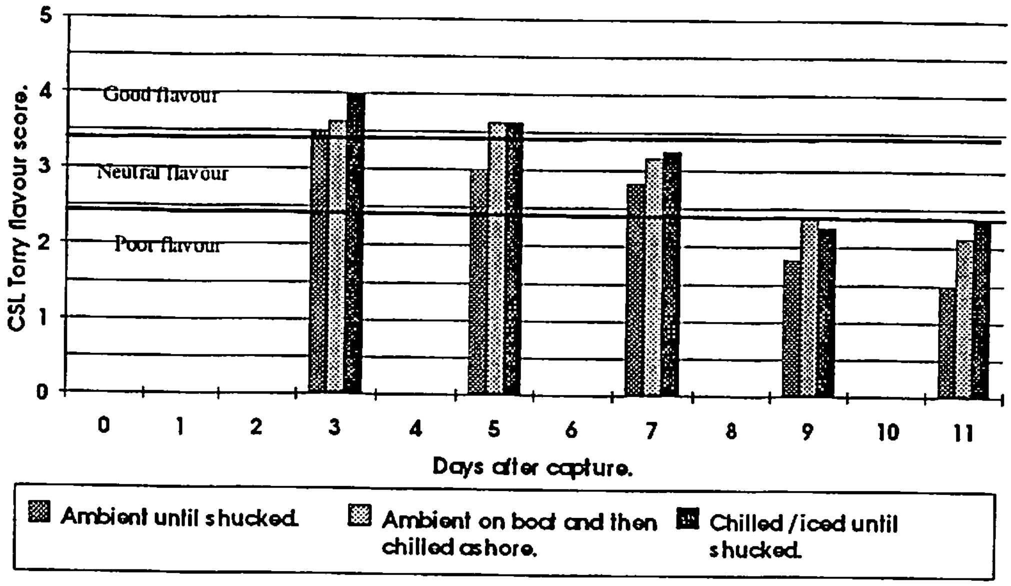

Figure 2 - Flavour scores of scallops, during extended chill storage, that were subject to different storage conditions for 2 days prior to shucking

Figure 2 shows the rate of spoilage of shucked scallop meats from samples subjected to different storage conditions prior to shucking. The data has been grouped into three categories; samples kept at ambient temperature prior to processing, samples kept at ambient temperature when stored on vessel and then either chilled or iced once ashore and samples chilled or iced immediately onboard vessel. The chilled and iced data has been grouped together to simplify the data presentation as the results were essentially the same from these two conditions. These results show that in chilled storage, scallops take between 7 and 9 days to reach the point where flavours would be unacceptable to the consumer. The ambient stored samples had lost their sweet, fresh flavours by 3 days after capture. The samples chilled/iced on vessel had the best initial flavour scores. However, from day 5 onwards the samples which were kept at ambient temperature on the vessel then chilled/iced ashore show a similar pattern of flavour reduction to the chilled/iced samples. These similar results are probably due to the time delay between capture and chilling being only 12 hours. Seafish scallop degritting trials (Ref. 1 and 2) have shown that scallops which are kept at temperatures similar to seawater, for up to 12 hours out of water after capture, can remain alive. Thus the scallop samples stored in ambient conditions on the vessel did not die and start to deteriorate prior to being chilled. The samples kept at ambient temperature for the 2 days prior to shucking show much worse flavour scores and a faster rate of deterioration, due to being stored at warm temperature after death.

5.1.2 Moisture/protein ratio and yield

The results from this part of the trial are shown in Table 2. The table shows moisture/protein ratio's below 5:1 for all the samples, which keeps within the commonly used specifications. The meat weight per scallop was on average 17.5 g per scallop for all the samples except two, those iced aboard and kept iced ashore and those kept at ambient temperature aboard and iced ashore, which gave meat weights of 19.4–19.7 g. This increase in average meat weight's could be due to the scallops soaking up ice meltwater, shortly after death. The chilled then iced samples did not show the same increase as the other iced samples. This may be due to the fact that chilling the samples before icing slowed down their metabolism, which ensured that the scallops stayed tightly shut and did not therefore soak up ice meltwater.

Table 2 - Processed scallop meat data from scallops, 2 days after capture, that were subject to different storage conditions prior to shucking

Sample conditions	Meat yield (%)	Average meat weight per scallop (g)	Moisture/ protein ratio
Ambient/Ambient	13.5	17.64	4.59 :1
Ambient/Chill	13.3	17.47	4.39:1
Ambient/Iced	12.8	19.44	4.51:1
Chill/Chill	13.9	17.44	4.86:1
Chill/Iced	13.6	17.58	4.56:1
Iced/Iced	13.8	19.71	4.78:1

5.2 Scallops Subject to Further Delays Prior to Processing

5.2.1 Effect of shucking delays on scallop flavour

The results from this part of the trials are shown in Figures 3 and 4. Scallops stored in the different storage conditions were shucked after 2, 3, 4, 5 and 6 days. They were then regularly organoleptically tested during the following chilled storage of the meats to determine their quality and consumer acceptability, the first assessment being the day after shucking. Figure 3 details the flavour deterioration of ambient stored samples. It shows that after scallops die they will deteriorate rapidly if stored at a high temperature. The longer scallops are kept at ambient temperature prior to shucking, the lower their quality score becomes and hence their acceptability to the consumer is reduced. In commercial terms this means that scallops which have been stored at ambient temperature for longer than 12 hours (and have probably died) must be shucked as soon as possible, as the process of deterioration has started at an accelerated rate and the quality lost cannot be regained.

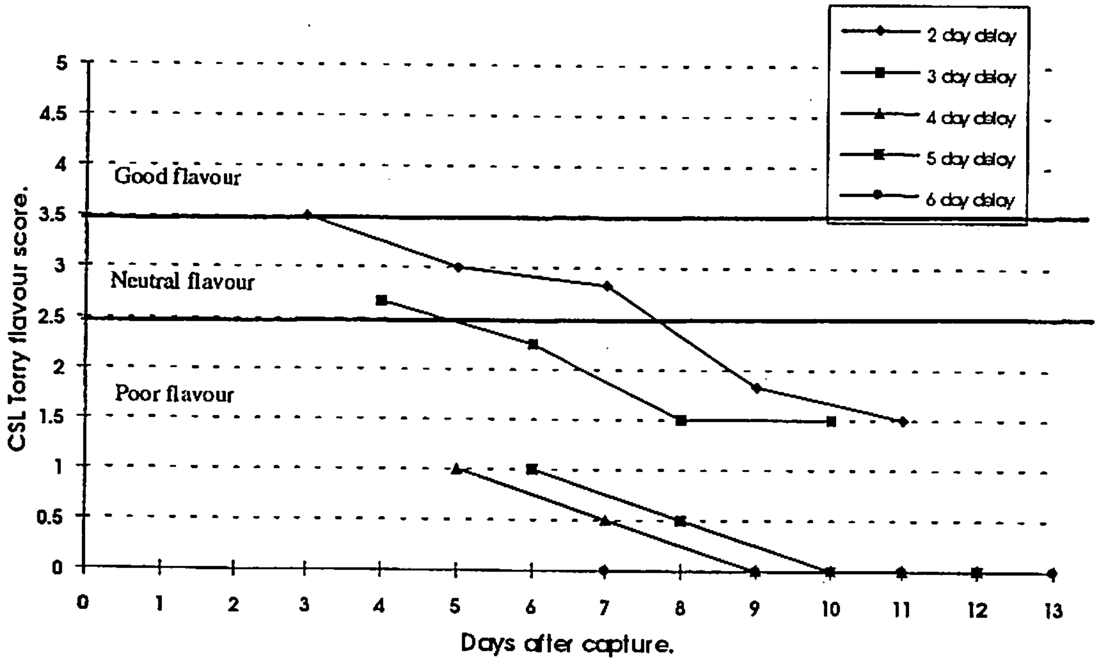

Figure 3 - A comparison of average flavour scores for scallops kept at ambient temperatures for different periods prior to shucking, then held in chilled storage

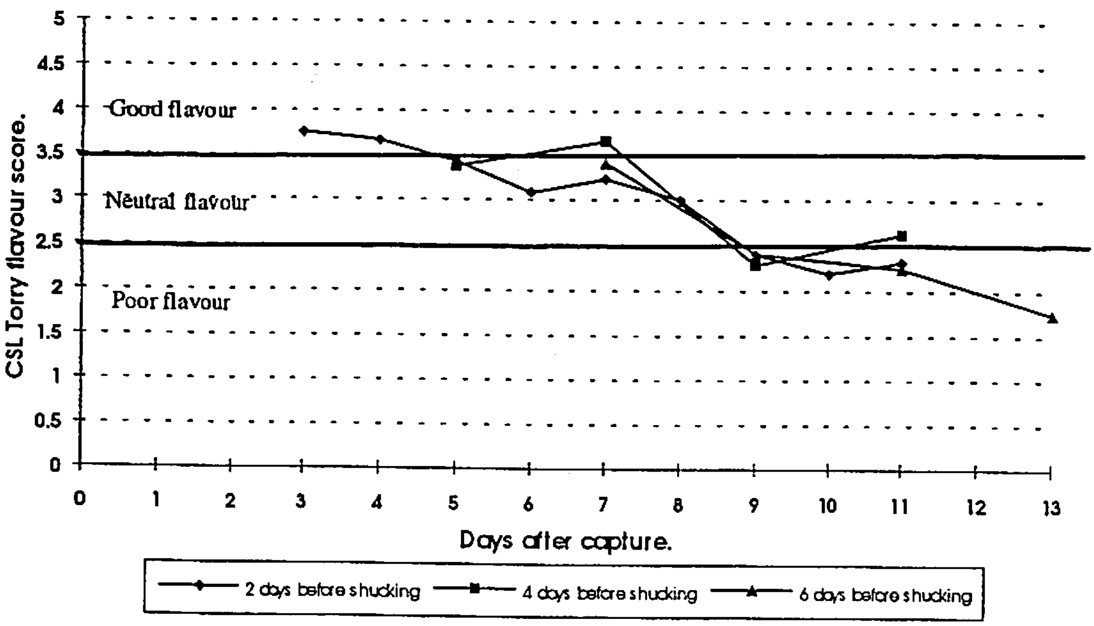

Figure 4 - A comparison of average flavour scores for scallops kept in chill/iced stored conditions for different periods prior to shucking, then held in chilled storage

Figure 4 details the average flavour deterioration over time of iced and chilled samples shucked 2, 4 and 6 days after capture. For ease of interpretation on the figure, the data from samples shucked on days 3 and 5 has been omitted, however these showed the same pattern. The data shows that if scallops are chilled before they die ie; within 12 hours of capture, the rate of quality deterioration is relatively consistent and slow, regardless of whether the scallops are stored unshucked or are shucked.

5.2.2 Moisture/protein ratio and yield

The results from this part of the trials are shown in Figures 5 and 6.

Figure 5 shows that for iced samples, after 4 days delay prior to shucking, there is evidence of an increase in average scallop weights. In chilled samples, after 5 days, there is a similar trend but to a lesser extent. This weight increase is no doubt due to the dead scallops soaking up the surrounding moisture into the meats which is the same effect as post-shucking soaking. Scallops stored in ice obviously have a greater potential for this water uptake due to the presence of ice meltwater. The average weights found were 18.4 g for the ambient stored samples, 18.5 g for the chilled stored samples and 19.7 g for the iced stored samples which is a 6.5% greater weight. Figure 6 shows that the moisture/protein ratios show a degree of variability between 4.25:1 and 4.75:1. It shows that for scallops iced for 6 days prior to shucking the moisture/protein ratio has risen over the critical 5:1 level.

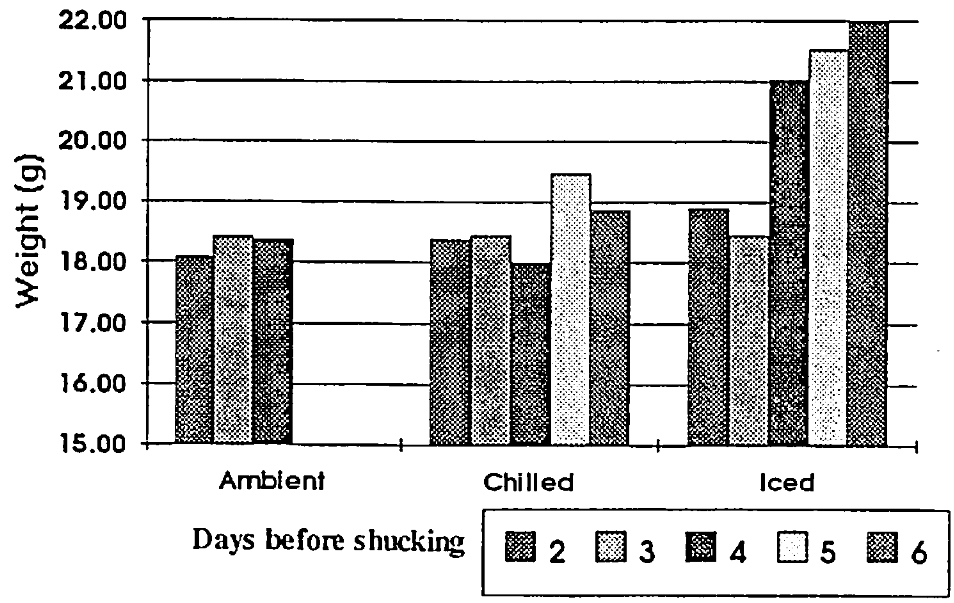

Figure 5 - Average meat weights of scallops subject to different storage conditions and delay before shucking

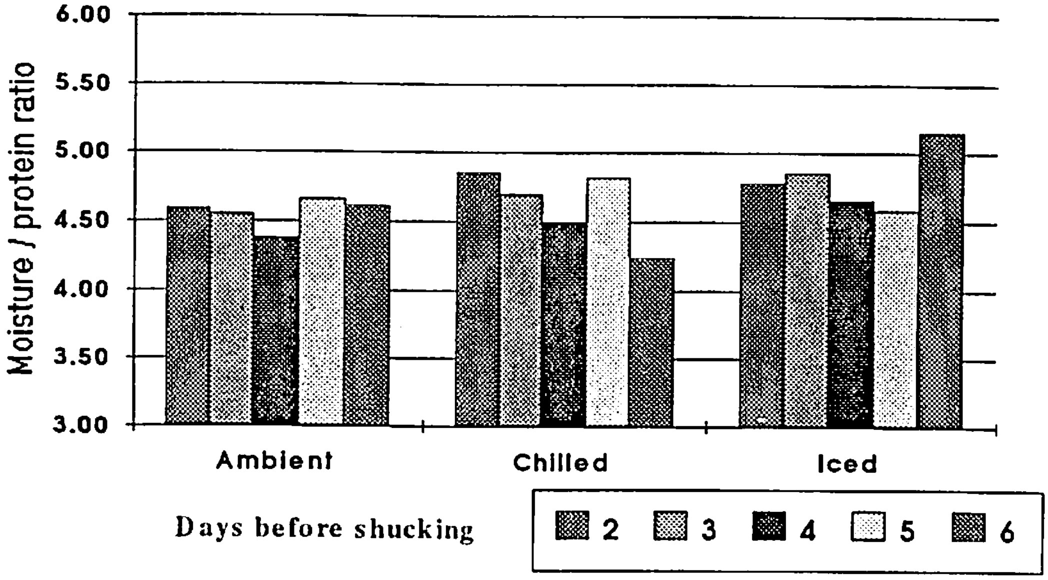

Figure 6 - Average moisture/protein ratios of scallops subject to different storage conditions and delay before shucking

5.3 Soaked Scallop Meats

5.3.1 Effect of soaking on flavour

The results from this part of the trials are shown in Figures 7 and 8.

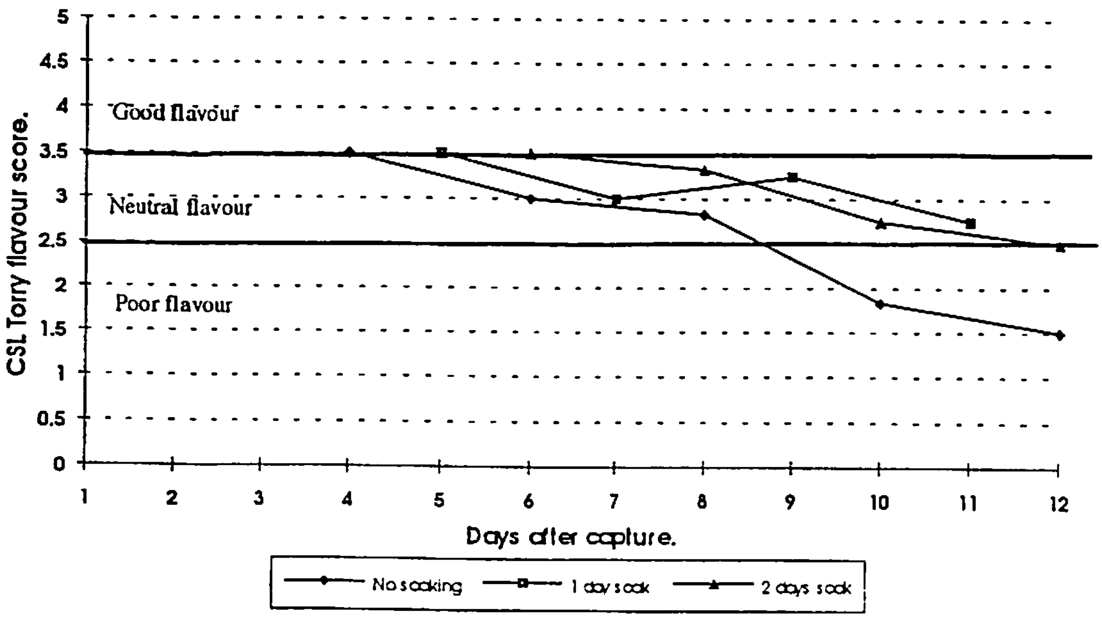

Figure 7 - The effect of soaking time on the flavour of scallops meats (scallops held at ambient temperatures for 2 days before shucking and held in chilled storage after soaking)

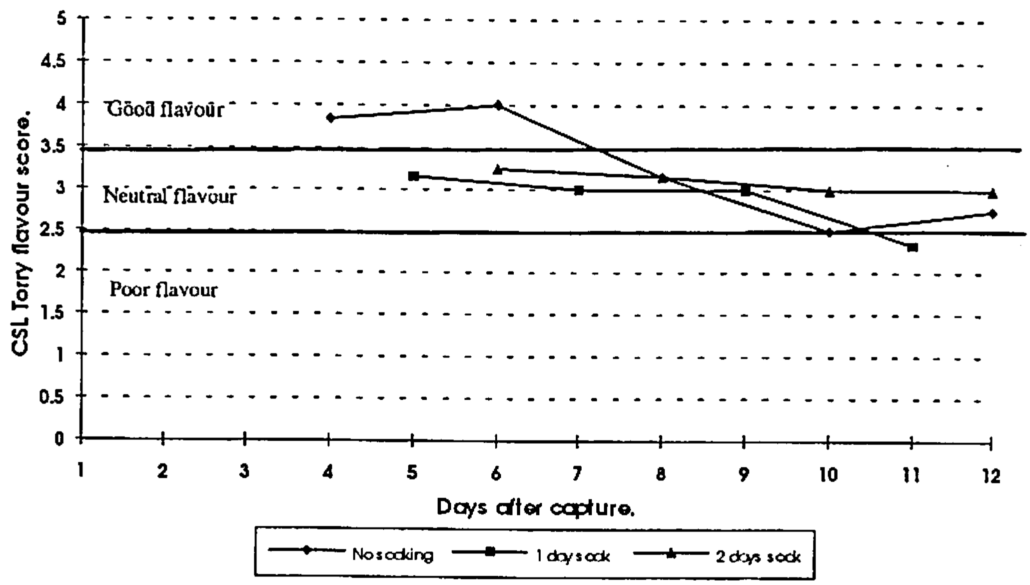

Figure 8 - The effect of soaking time on the flavour of scallop meats (scallops held at chill temperatures for 2 days before shucking and held in chilled storage after soaking)

These two graphs show changes in flavour due to soaking the scallop meat samples. Figure 7 shows the data from samples stored in ambient conditions before shucking and Figure 8 shows the data from samples stored in chill conditions before shucking. Figure 7 shows that for scallops stored at ambient temperatures, of initially neutral flavour quality after shucking, soaking seems to maintain the neutral flavours present and reduce the rate of product spoilage compared to the non soaked samples. However, Figure 8 shows that with chill stored scallops of good initial quality, which are showing sweet fresh characteristics, soaking seems to cause the loss of these fresh flavours. Once these scallops had lost their sweet flavours ie; after 7–9 days, soaking is again seen to maintain the neutral phase of quality for longer time periods. This evidence suggests that soaking creates a product of neutral quality with an extended storage life.

5.3.2 Moisture/protein ratio and yield

The results from this part of the trials are shown in Figure 9.

Figure 9 shows the relationship between scallop meat weights and moisture/protein ratios with soaking time. Assuming that the scallop meats are reasonably uniform in weight when caught, this data shows an increase in average meat weight of 32% with one day soak and 51% with a 2 day soak compared to unsoaked scallop samples. These weight increases lead to associated increases in the moisture/protein ratio above the 5:1 level which may well cause labelling or legislative problems for processors selling this type of product.

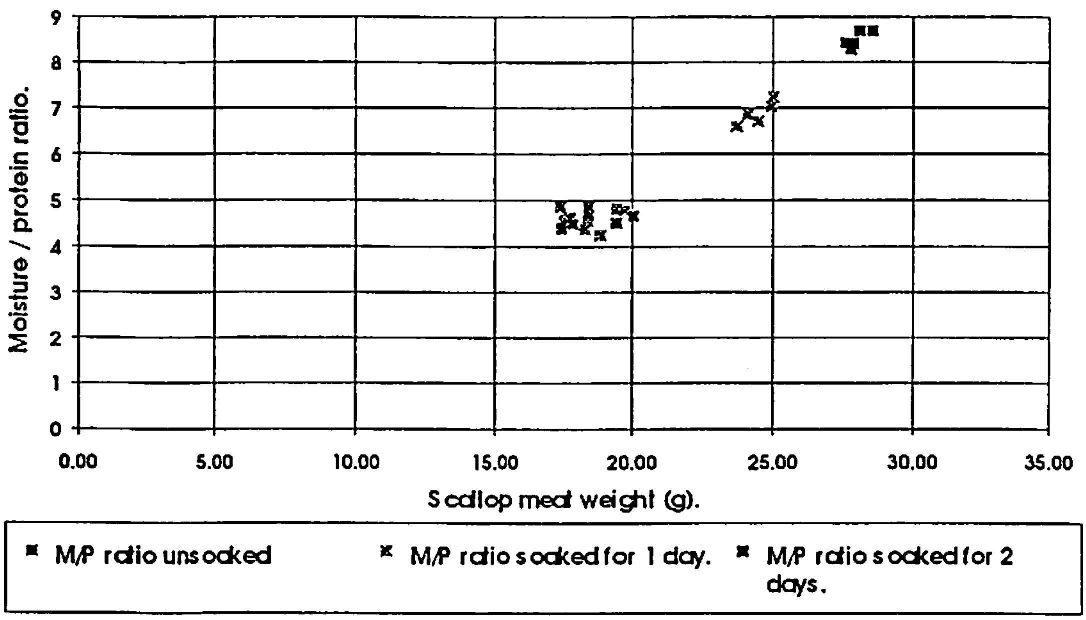

Figure 9 - Correlation between average scallop meat weight and moisture/protein ratio with soak time

5.4 Quality Indicators for Scallops

The main quality indicators used for fish assessments are the organoleptical indicators of odour and flavour. The correlation between scallop meat cooked odour and flavour scores from these trials is shown in Figure 10. This shows that there is a good correlation between odour and flavour. This may become important in the not too distant future due to the emergence of sophisticated electronic odour recognition machines commonly called 'electronic noses'.

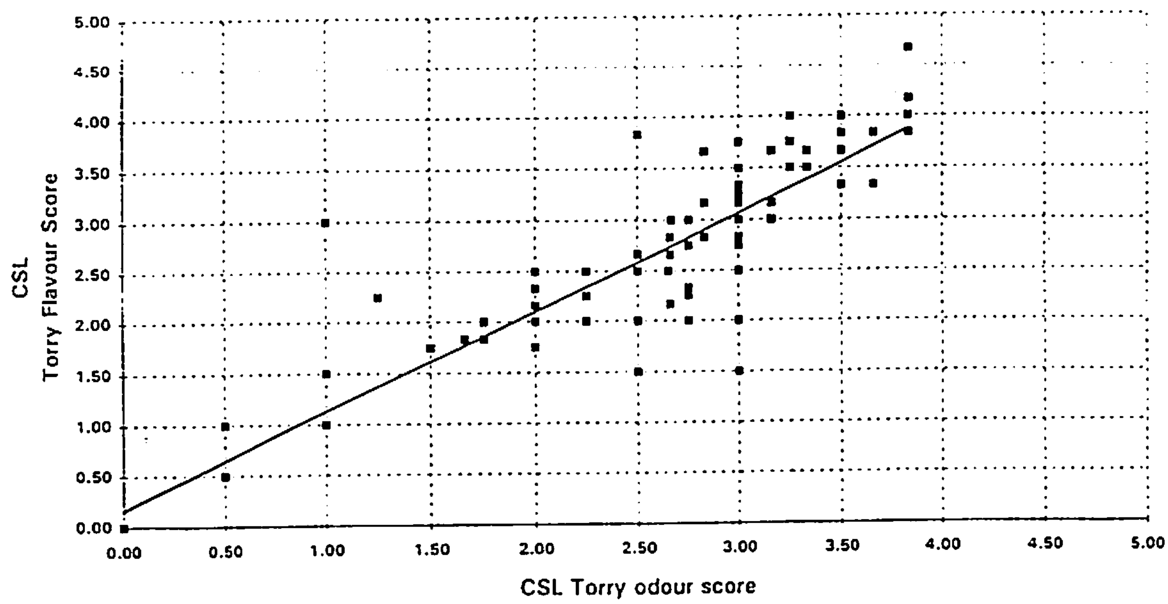

Figure 10 - Correlation between cooked odour and flavour scores for all scallop meat samples

With regard to chemical freshness indices, work by Kawashima and Yamanaka (Ref. 3) has shown that D-Lactic acid and Octopine are the end products of glycolysis for the Japanese scallop, *Pectinopecten yessoensis,* and hence can be measured to assess freshness. Figure 11 shows the correlation between D-Lactic acid levels and cooked flavour scores for *Pecten Maximus* from these trials. These show a good relationship when flavour quality starts to deteriorate and 'off' flavours are developing.

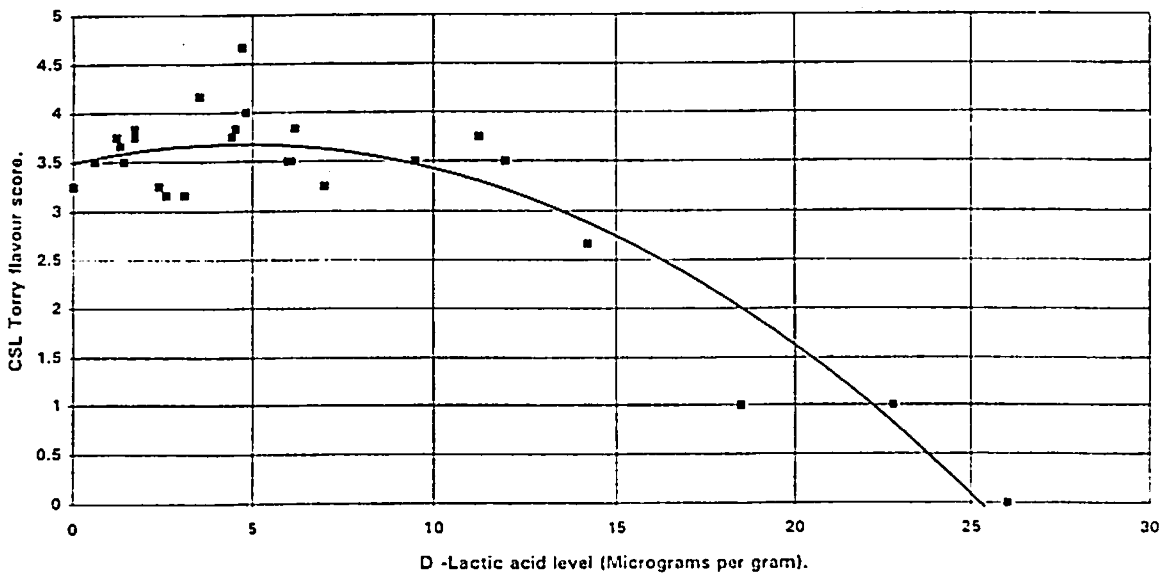

Figure 11 - Correlation between scallop flavour scores and D-Lactic acid levels

6. Discussion

It is important to point out that the findings in this report are the result of a single trial with one batch of scallops; therefore the results obtained cannot be held up to be a definitive study of all the factors affecting scallop quality and processing. Fishing method, fishing area, seasonality and probably many other factors not covered by this trial, will affect scallop quality or processing. However, given that the trial was conducted with 28 similar batches of 36 scallops each, caught from the same location, at the same time, this trial endeavours to unravel in a controlled and comparable manner some of the factors which effect scallop quality and processing.

6.1 Effects of Storage Conditions both Onboard Vessel and Prior to Processing

Scallops are prone to rapid spoilage if not kept chilled after death. To maintain a good quality product they should be chilled before they die i.e. within about the first 12 hours after capture. This work shows that to keep scallops in best condition they should be iced. However, this will increase the scallop meats moisture content. The sample stored for 6 days on ice before shucking increased in moisture content above the often critical 5:1 moisture/protein ratio threshold. If this is not acceptable then the scallops should be chilled by other means. On large vessels with refrigerated fishholds, the storage of scallops without ice is acceptable but the refrigeration systems should be rated for this chilling purpose rather than simply maintaining low temperatures with ice assistance. To maintain chill conditions on vessels without refrigerated fishrooms there is no alternative but to use ice, but it can be used indirectly to chill the scallops. On vessels fishing daily it may be possible to leave scallops, moist, uniced, at temperatures similar to seawater, for up to 12 hours between capture and landing without accelerating quality losses, but only if they are rapidly chilled by icing as soon as they are brought ashore. This finding is borne out of the results of these trials and also the findings of the previous trials looking at scallop de-gritting, where samples were stored at different temperatures prior to re-immersion in water to allow natural purging of sandy/gritty contaminants from within the shell cavity. Both colder and warmer storage temperatures were found to reduce the scallops ability to carry out this natural purging activity (Ref. 1 and 2).

Correct storage temperature is essential both to reduce quality losses and to give processors options as to the type of product that can be achieved. If scallop storage temperatures are poor or even inconsistent from batch to batch, processors have no option but to consign the scallops to a lower grade product such as a soaked or frozen product, which will therefore fetch a lower price. This may then reflect in the price offered to fishermen.

6.2 Shucking Delays

If scallops are chilled rapidly after capture, delays in processing scallops will not accelerate the spoilage rate, unless the scallops are heavily contaminated with grit, sand, mud, etc (Ref. 1). The spoilage rate is greatly increased if scallops are held at warm ambient temperatures after they have died.

6.3 Effect of Icing on Water Uptake

With regard to processed scallops, shucked meat weights and moisture/protein ratio's are fairly consistent for all non iced samples. Icing however, increases the meat weights and the moisture/protein ratio in a similar way to soaking shucked meats. This may cause problems of product specification. If so, the scallops should be chilled rather than iced.

6.4 Soaking Scallop Meats

This trial has found that soaking scallop meat causes two effects :-

1. It increases the weight and moisture/protein ratio of the scallop.
2. It creates a product of neutral quality with an extended shelf life in this neutral state.

Certain markets, especially France, set a maximum moisture/protein ratio of 5:1. This trial has shown that the soaked product will not meet this requirement. Earlier work by Seafish on scallop degritting showed that the fresher and more alive a scallop is before shucking, the greater the amount of moisture the scallop meat would take up during soaking.

6.5 Quality Indicators for Scallops

Recent food science advances such as the 'electronic nose', which is a computer controlled machine that quantifies smells, may be of use as a quality assessment tool, given the usefulness of the CSL Torry odour scoring scheme as a quality indicator. In the US, scallops have already been assessed using the 'electronic nose'. For use with the UK scallop the machines would initially have to be calibrated and assessed against the current quality assessment methods.

The data comparing CSL Torry flavour scores to D-Lactic acid levels is very positive. There is a good correlation between these quality indicators when the scallops start to deteriorate and the breakdown process of the energy stores in the muscle tissues is occurring. This chemical analysis technique is not a practical day to day tool but could be used to quantify a minimum product specification.

7. Conclusions and Recommendations

1. These were limited trials in the sense that they do not include the effects of fishing method, ground and seasonality. However, for a significant sample of scallops, harvested by dredging on the South Coast during March, they precisely determined the effects of storage conditions and storage time prior to shucking, and of soaking on the quality of the scallop meats.

2. The best scallop meat quality, as indicated by cooked flavour scores, is achieved by chilling the scallops immediately after capture. Chilling can be by direct or indirect icing or by refrigeration.

3. The immediately chilled scallops in the trials had a useful storage life of 7–9 days from capture before the quality deteriorated to the point at which the flavours start to become unacceptable to the consumer.

4. Direct icing of the scallops prior to processing gave slightly better cooked flavour results than refrigeration. However, after several days of directly iced storage there was a significant uptake of water by the scallop and consequent increase in weight and moisture/protein ratio. After 5 days directly iced storage the shucked meats exceeded the maximum moisture/protein ratio of 5:1 specified for many markets.

5. On vessels fishing day trips it is possible to hold the scallops on the vessel in moist, unchilled conditions at temperatures similar to those of the seawater for up to 12 hours whilst they remain 'alive', prior to chilling ashore, and still achieve products of good eating quality. However, scallops deteriorate rapidly at ambient temperatures after they have 'died'. Harsh treatment or temperature stress, including chilling or overheating, hastens the death of the scallops.

6. These trials using relatively clean scallops showed that, provided they were chilled, a delay prior to shucking did not affect the overall useful storage life from capture. However, it is known that scallops heavily contaminated with grit or mud deteriorate more rapidly. Those contaminated scallops should be shucked as soon as possible after capture.

7. The commercial process of soaking the scallop meats, greatly increases their weight and moisture/protein ratio. After soaking, the moisture/protein ratio generally exceeded 5:1 and may well result in marketing and labelling/legal difficulty. Such soaking is not recommended.

8. Soaking the meats also created products of neutral flavour although with extended useful storage life in that state.

9. There was good correlation between cooked flavour and cooked odour scores for scallops which may, in the future, enable the use of an 'electronic nose' for quality assessment.

10. After spoilage has become established and flavours were deteriorating there was a good correlation between cooked flavour and D-Lactic acid levels in the scallops which may make this a useful measure for specifying minimum quality standards.

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Appendix I

Analysis Protocols

CSL Torry Sensory Score Sheet for Scallops

Cooking Method

Place approximately 100 g of the meats in a boilable plastic bag with 100 ml of one per cent sodium chloride solution. Close the bag and suspend in boiling water. When the water returns to the boil, cook for 5 minutes (Ref. 6).

Cooked Odour

Score	
5	Sweet milky; condensed milk
4	Slt milky sweet; seaweed
3	Neutral; musty
2	Slt sour
1	Sour; sweaty; ammoniacal
0	Sulphide, faecal, stale cabbage

Cooked Flavour

Score	
5	Intensely sweet; cloying
4	Less sweet; milky
3	Neutral; slt musty; some residual sweetness
2	Slt sour; musty; some residual sweetness
1	Sour; bitter; off; some sweetness may still be detectable
0	Very bitter; off; rubber; nauseating

Cooked Texture

Score	
5	Chewy; fibrous, rubbery
3	Slt chewy; slt soft
1	Soft; gelatinous; sticky

Moisture/Protein Ratio

Moisture and Ash

Weigh 5 g of minced sample into a large pre-weighed silica crucible, place crucible into an oven at 105 °C for 24 hours. Take crucible out and place in a desiccator to cool. After cooling, reweigh.

If only moisture is required you then do the calculation.

If ash is required add 1 ml magnesium acetate using a Finnpipette, crucibles are then placed in a furnace set at 550 °C for 24 hours. Crucibles are then reweighed after cooling in a desiccator.

Calculation:

$$\% \text{ moisture} = 100 \times \frac{\text{loss of weight in g}}{\text{weight of sample in g}}$$

$$\% \text{ ash} = 100 \times \frac{\text{weight of ash in g - wt of magnesium acetate}}{\text{weight of sample in g}}$$

Magnesium Acetate

100 g magnesium oxide
1000 ml glacial acetic acid
made up to 2 litres with distilled water

Each time you make up a fresh solution of magnesium acetate, weight 8 crucibles, pipette 1ml of solution into each, place in furnace at 55 °C for 24 hours, cool and reweigh. The average weight is the weight used for 1 ml when doing the calculation.

Total Nitrogen

Protective clothing, safety glasses and gloves should be worn at all times. The method should only be carried out by named persons with appropriate experience. When filling the sulphuric acid dispenser from a Winchester, two people should be present. Spillage absorption should be on hand.

Weight 2 g minced sample accurately into straight sided Tecator tubes, the filter paper is also added.

Add 2 Cu jkeltabs and 15 ml conc $H_2 SO_4$ (sulphuric acid).

Digestion blocks should be in a fume cupboard.

Put digestion blocks full on and put samples in. When the samples have cleared (turned a light green colour) turn the setting of the blocks down to 8 and leave for one hour. Turn the water pump on to suck off any fumes.

When analysing wet white fish put the blocks on to heat in advance, but if oily fish or breaded products put the tubes in cold. Since inserting samples high in oil or starch into heated blocks causes frothing.

After digesting for one hour switch on the fume cupboard and put tubes onto cooling racks. Leave for 10 minutes. Using a wash bottle, dilute with distilled water until tubes are about quarter full. Leave until cold, set up 'Tecator' and put samples through. A blank is carried out on a Tecator tube containing acid, catalyst and filter paper.

Normally 0.1m Hcl is used as tritrant.

$$\% N = \frac{(\text{titre} - \text{blank}) \times 1.4 \times m}{W}$$

M = molarity of HCl used in titration
W = weight of sample in grams

D-Lactic acid/L-Lactic acid

UV-method for the determination of D- and L-lactic acid in foodstuffs and other materials.

Determination of D- and L-lactic acid in meat products
Weigh approximately 5 g of homogenized sample accurately into a homogenizer beaker, add approximately 20 ml perchloric acid (1 mol/l) and homogenize for 10 minutes. Transfer the contents quantitatively into a beaker with approximately 40 ml water. Adjust to pH 10–11 with potassium hydroxide (2 mol/1) while stirring (magnetic stirrer). Transfer contents quantitatively into a 100 ml volumetric flask with water, fill up to the mark with water, whereby it must be taken care that the fatty layer is above the mark and the aqueous layer is at the mark. Shake the mixture. For separation of fat and for precipitation of the potassium perchlorate refrigerate for 20 minute. Afterwards filter. The first few ml are to be discarded. Use the clear, possibly slightly turbid solution diluted, if necessary, for the assay.