Degritting of King Scallops

Seafish Report No. SR468

August 1996

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The Sea Fish Industry Authority

Seafish Technology

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Summary

Dredged scallops are known to contain 'grit' in the form of sand, silt, mud or broken shell. Although washed out in processing, this contamination limits the marketability of these scallops as a 'live' product and detracts from their value in comparison with scallops landed by divers..

The initial part of this work has confirmed the considerable extent of grit contamination of commercially harvested scallops and that it is effectively removed in the production of a processed product by shucking and washing the meats, but it has also shown that the eating quality of 'gritty' scallops deteriorates rapidly if held unprocessed in the shell.

Earlier Seafish work had shown the feasibility of 'degritting' other species of 'live' bivalve molluscs, such as cockles, by immersing them for a period of time under controlled conditions in clean seawater so that they naturally purge themselves by their filtering action.

By carrying out a series of trials using small-scale mollusc purification tanks, this further work has shown that dredged scallops can be 'degritted' by the same process, and it has determined the conditions required for the process to be successful.

The scallops must remain alive, undamaged and in an unstressed condition prior to immersion in the degritting tank. It is recommended that, after harvesting, the scallops are held within a temperature range of 5°-15°C and for a maximum period of 12 hours before re-immersion in the degritting tank.

The conditions in the degritting tank should be controlled. The seawater (either natural or artificial) should be clean, full salinity and oxygenated. A water temperature of 10°-18°C and an immersion period of 10-24 hours are recommended. A purification tank type system can provide these conditions.

The 'degritted' dredged scallops are of similar quality to the scallops collected by divers.

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1. Introduction

The King scallop (*Pectin maximus*) is a valuable resource. Approximately 9350 tonnes of scallops with a total value of nearly £14million were landed in the UK in 1993 (Ref. 1). The vast majority of these scallops were caught by towing steel dredges on the sea bed. A typical dredge is shown in Figure 1. It is constructed from heavy duty interlinked steel rings forming a bag connected to a strong frame. The size of the bag will vary but typical plan dimensions are 1 m x 1 m. Metal teeth of a length up to 100 mm are attached at the base of the frame. The teeth dig into the ground to disturb the scallops which are then forced into the bag. Tooth length is critical to the catching efficiency and is altered according to the type of substrate, or fishing ground. Longer teeth are used on softer grounds to reduce trash build up and also to remove scallops from deep depressions in the sea bed, shorter teeth are used on hard or rocky grounds (Ref. 2).

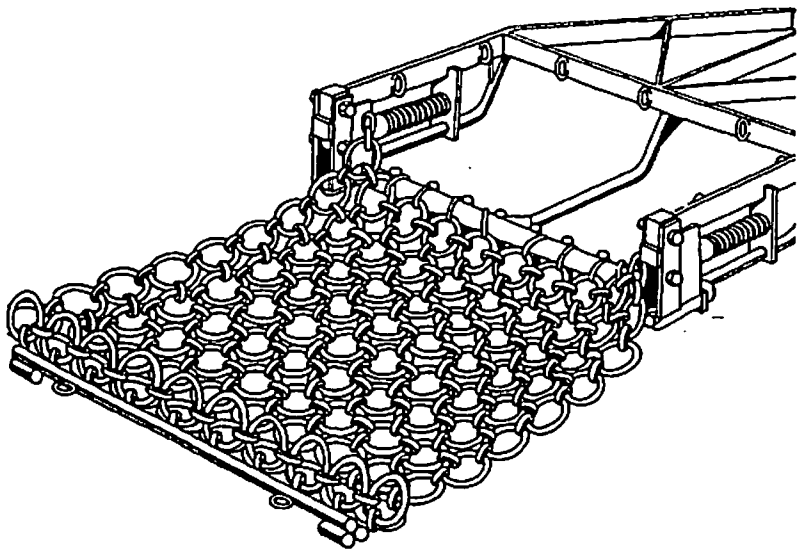

Figure 1 - Typical dredge used for catching scallops

During dredging, the digging action can force 'grit' inside the scallop shells. The type and amount of physical contaminant is dependent on the substrate, the fishing gear and the way in which it is used. In most, cases the contamination within the scallop shell consists of varying amounts of sand, silt, mud or broken bits of shell which is all generally called grit throughout the rest of this report. This grit detracts from the appearance of the scallop and from its eating quality if not completely removed.

Dredged scallops are usually destined for processing into a frozen or chilled product and grit in this raw material is removed during shucking and the extensive washing of the meats. The approximate value of these dredged scallops is £1,480 per tonne (Ref .1). A small percentage of dredged scallops are sold as a live, in-shell product. It is usually the farmed or dived scallops that are sold live and they have an approximate value of £3,000 per tonne. The 'live' in-shell market is highly sensitive to the appearance of its raw material and, depending on the

means of final preparation of products for consumption, if scallops are gritty there also remains a possibility of end-product contamination. High value export markets and up-market restaurants set very strict specifications (Ref. 3) and are prepared to pay a premium price for dived, grit-free scallops. If the grit in dredged scallops could be removed, then there is potential for the value of the catch to be increased considerably, particularly in respect of access to quality orientated markets.

Previous Seafish work (Ref. 13) had shown that cockles, which suffer from similar grit uptake, can be reimmersed in 'purification' type tanks and will, if the conditions are suitable, naturally purge themselves of that grit. Further work (Ref. 4) had shown that carefully handled rope grown scallops could be kept alive in a standard mollusc purification system for periods of up to 9 hours, which may be sufficient time for scallops to remove the grit from within their shells by their own filtering action. This technology may provide a means to enable the scallop industry to raise the value of dredged scallops. The term **degritting** is used throughout this report to mean the removal of the grit, sand, broken shell and mud from live scallops by immersing in tanks of seawater.

This work investigated the contamination in scallops, quantifying the levels of grit and determining the effects on eating quality and processing. Degritting trials were then undertaken to remove grit by immersion in controlled conditions in 'purification' type tanks, together with investigations into some of the conditions that can affect this degritting. The results are presented and recommendations made.

2. Objectives and Outline of Work

1. To determine the levels of grit in dived (scallops collected by divers) and dredged scallops.

2. To determine the effects of this grit on the quality and processing of the scallops.

3. To investigate the degritting of scallops by immersion in seawater, and the effect of this on their quality.

4. To determine the optimum conditions for successful scallop degritting.

To achieve these objectives, the work was divided and is presented as a number of discrete activities, although much of the equipment and methodology used was common to these separate activities.

Firstly, a survey of the grit level in scallops from a wide range of sources was carried out and the effects of this contamination on their eating quality, storage and processing determined.

This was then followed by a series of four separate degritting trials in which the variables possibly affecting degritting were investigated and their effects on grit removal, scallop eating quality and storage determined.

3. General Equipment and Methods

3.1 Degritting Tanks (Mollusc Purification Tanks)

Two tanks were used for the scallop degritting trials. They both operate a recirculating seawater system and each is fitted with a pump, ultra violet light (UV) sterilizer, flowmeter, suction and spray bars, to meet MAFF technical specifications for purification tanks (Ref. 6). Despite being of different capacities, both tanks had the same principles of design and operation.

3.1.1 Model Depuration Plant (MDP)

This is a small lab-scale experimental tank with internal dimensions of 934 x 534 x 502 mm and a maximum capacity of 250 litres (Ref .4). It was used in Trials 1 and 4.

3.1.2 Small-Scale Purification Tank

This has internal dimensions of 1135 x 935 x 600 mm and a maximum capacity of 650 litres (Ref. 5). It is shown in Fig. 2 and was used in Trials 2 and 3.

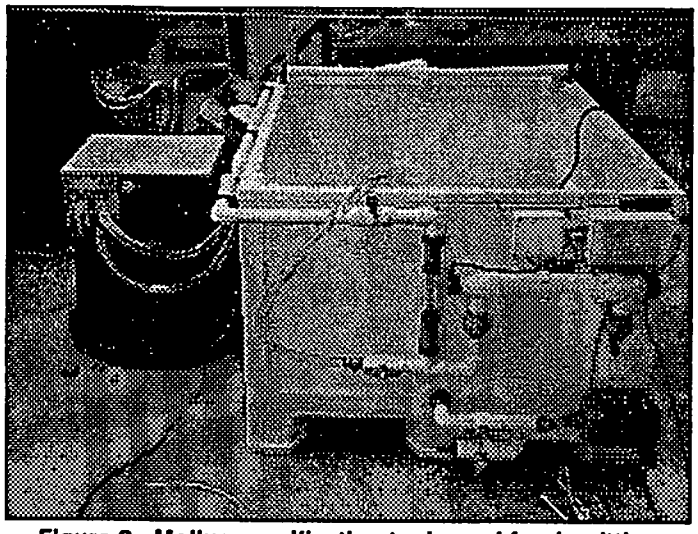

Figure 2 - Mollusc purification tank used for degritting

3.1.3 Temporary Holding Tank

This was a small 40 litre insulated and lidded container which was filled with 30 litres of natural seawater and used on the scallop fishing vessel for zero delay samples in Trials 2 and 3 only. Although it was not a standard purification tank and was without a UV system or seawater recirculation, it had sufficient natural aeration for oxygen levels in the water to remain above 80 % saturation during the short period of immersion.

3.2 Seawater Supply

Artificial seawater was used in Trials 1 and 4 and natural seawater was used in Trials 2 and 3, both at salinity of 35 parts per million (ppm). The artificial seawater was prepared as per MAFF and Seafish recommendations (Ref. 7 and 8). The natural seawater was from a source used by a commercial shellfish purification plant at Falmouth.

3.3 Seawater Temperature Control

A thermostatically controlled Multicirc ® MK 1200 water cooler was used to indirectly cool the seawater in the degritting tanks to below ambient conditions when required. The system worked by pumping cold water from a separate tank via plastic tubing to stainless steel cooling coils that were immersed in the degritting tank.

3.4 Scallop Degritting Containers

Allibert type 41042 standard purification trays of dimensions 750 x 450 x 165 mm were used for holding the scallops. A specially constructed net was also used in Trial 2 which had 36 pockets each with approximate dimensions of 80 mm x 100 mm to hold an individual scallop in a vertical position. This is shown in Fig. 3.

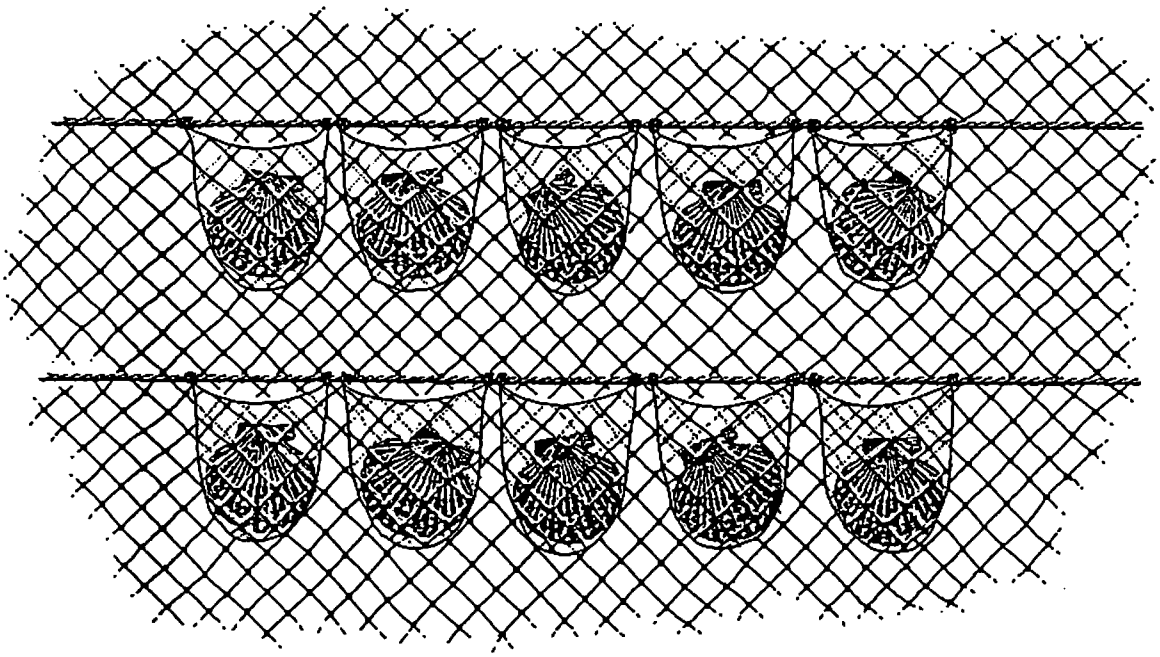

Figure 3 - Scallop net holding system

3.5 Instrumentation

Oxygen levels in the water were measured by a hand held Oxyguard dissolved oxygen meter. Salinity was measured with a hydrometer and temperature with a hand held Oxyguard digital thermometer.

3.6 Degritting Tank Operation

At the start of each trial, the degritting tanks were filled with a fresh batch of clean, full salinity and oxygenated seawater. The lab-scale tanks were filled with 200 litres of artificial seawater in Trials 1 and 4 and the small-scale tanks with 600 litres of natural seawater in Trials 2 and 3.

As these trials were 'degritting trials' rather than 'purification trials', the MAFF specified operating criteria such as ultra-violet sterilisation, set temperature levels and water flows etc., were not required, although the factors that would stimulate the activity of the scallops, such as water temperature and flow rate, were controlled.

3.6.1 Filling the trays and net

All scallops were inspected and any dead or damaged scallops were discarded. The undamaged live scallops were carefully placed on trays with the curved side of the shell facing downwards. The trays were then placed in the tank of seawater.

Individual scallops were carefully placed in the pockets in the net, in a vertical position with the open shell facing downwards. The net was then hung in the purification tank so that all the scallops were fully immersed.

3.6.2 Loading density

Only small numbers of scallops were placed in the tanks so there was always more than a sufficient water to scallop ratio to provide sufficient dissolved oxygen in order to stimulate their activity and to ensure there was little chance of re-ingestion of the grit between scallops.

3.6.3 Water flow and dissolved oxygen levels

The water flow was set at 10 l/min which was sufficient to maintain the levels of dissolved oxygen at above 80% saturation by the cascade of water into the tank whilst being low enough to cause little chance of re-ingestion of the grit between scallops. These conditions would then stimulate the scallops activity.

3.6.4 Water temperature

For each period of immersion the water temperature was set at a point within the range 11-19 °C. This related to the seawater temperature at that time of year or the mains water temperature used to make up the artificial seawater, or was controlled by the Muticirc temperature controller.

3.6.5 Monitoring the trials

At the start of each trial the salinity was measured. During the trials, the water temperature and dissolved oxygen level were monitored to ensure they were maintained at the correct level. The scallop activity was also observed.

3.6.6 Removing the scallops

After a set period of immersion, scallops for analysis were carefully removed without disturbing scallops in other trays and scallops remaining in the tank for a longer period of immersion.

3.7 Assessments

3.7.1 Inspection for grit in 'live' scallops (grit score)

The scallops were carefully opened (shucked) with a sharp knife and the flat shell removed, leaving the otherwise intact scallop adductor muscle, gonad, gut, gills and mantle in the lower cupped shell. Fig. 4 shows the anatomy of the scallop.

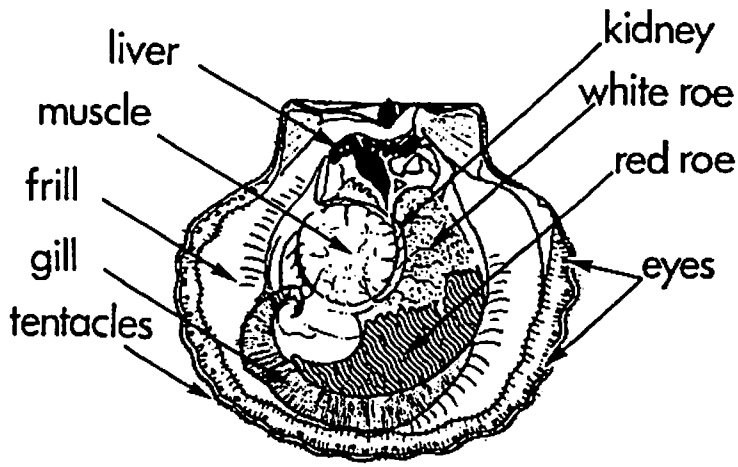

Figure 4 - Scallop with the flat shell valve removed

A visual assessment was then made of the amount of grit in the shell and each scallop was classified according to the descriptors shown in Table 1 overleaf and given a grit score.

Table 1 - Classification of grit score in scallops

Grit score	Classification	Description of scallop appearance
0	No grit.	Clean, no grit.
1	Traces of grit.	Very few minute particles of grit.
2	Slight grit.	Some grit obvious within the shell.
3	Gritty.	Grit very apparent, covering underneath gills and mantle.
4	Very gritty.	Large amounts of grit throughout the shell, often with particles embedded into the muscle which may be discoloured.

The average grit score for a particular batch of scallops was calculated by multiplying the number of scallops in each grit classification by their grit score, adding the totals and then dividing by the number in the sample: e.g. If the following scallops were classified as having the following grit levels:

Table 2 - Example of calculation of grit score

Grit score	Classification	Number of scallops in each category
0	No grit.	3
1	Traces of grit.	2
2	Slight grit.	5
3	Gritty.	20
4	Very gritty.	10
		40

Then the calculation is:

Average Grit Score = [(10 x 4)+(20 x 3)+(5 x 2)+(2 x 1)+(3 x 0)]/40 = 2.8, which equates to a classification of scallops being gritty.

3.7.2 Inspection for grit in processed scallops

The scallop meats were inspected for any traces of grit embedded in the surface. They were classified according to the levels of grit shown in Table 3 below.

Table 3 - Classification of grit score in processed meats

Grit score	Classification	Description of scallop appearance
0	No grit.	Clean, no grit.
1	Traces of grit.	Very few minute particles of grit.
2	Slight grit.	Some grit obvious.
3	Gritty.	Grit very apparent, slight discolouration of the meats.
4	Very gritty.	Large amounts of grit embedded into the meats which may be discoloured.

3.7.3 Assessment of scallop activity in water

Degritting is considered to be a result of filter feeding activity. It was considered that observing scallop activity when immersed would be a good indicator of degritting. During the period of immersion in the degritting tank, the scallops were observed for this level of activity and given scores of 0 to 4 based on the assessment system shown in Table 4. The scoring system, based on previous trial work (Ref. 4), covered scallop activity ranging from good condition to death. It was considered that a score of 3 or 4 would be required during most of the degritting period for successful degritting. The results presented in this report are based on the final level of activity at the end of the immersion period.

Table 4 - Description of scallop activity in degritting tanks

Scallop activity score	Description
4	Shell open (usually 1 to 3 cm). Full mantle, outward bulge. Filaments straight and extended. Active shell movement when removed from seawater
3	Shell partly open (up to 1 cm). Mantle slightly recessed. Filaments less extended, possibly curled. Only slight shell movement out of seawater
2	Shell open but mantle recessed exposing inside lip of shell. Filaments not extended. Very slight or no activity when removed from seawater.
1	Shell shut. Very slight or no activity when removed from seawater
0	Dead. Shell gaping. Mantle totally recessed and detaching from shell. No activity when removed from seawater

3.7.4 Organoleptic assessment of scallop meats

The scallops were shucked manually and the viscera removed. The remaining muscle and gonad were then washed to remove any traces of grit. The shucked scallop meats were placed in a food grade, heat resistant polyethylene bag typically used for boil-in-a-bag food products. 1% salt solution was added at a proportion of 1 ml water to 1 g scallop meat and the bag was placed in boiling water for 5 minutes (Ref. 9). The cooked scallops were assessed and scored according to the Torry scheme for scallops as shown in Table 5 below. However, the experienced sensory assessment panel usually used for this work was not available on-site in Trials 1–4 and so the significance of those results can be questioned.

Table 5 - Torry scoring scheme for cooked scallop meats

Torry Research Station Sensory score sheet for scallops		
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

4. Investigations into Grit Contamination in Scallops

4.1 Method

Dredged and dived 'live' in-shell scallops and commercially processed scallop meats were obtained during the period May 1994 to March 1995 from the different sources shown in Table 6. All scallop samples were placed inside insulated containers and indirectly iced to maintain a temperature of 0 to 2 °C during transport to the Fish Technology laboratory in Hull. There the scallops were initially inspected for grit levels and then assessed by an expert panel for cooked odour, flavour and texture at intervals during storage at a temperature of 0 to 2 °C, for up to 8 days after capture.

Table 6 - Sample source record

Port of landing	Type of sample assessed at Seafish laboratory	
	Commercially processed scallop meats	'Live' in-shell scallops
Brixham	N	Y
Brixham	Y(1)	Y
Brixham	Y(2)	Y
Falmouth	N	Y
Falmouth	N	Y
Fraserburgh	Y(3)	Y
Fraserburgh	Y(2)	Y
Fraserburgh	Y(5)	Y
Fraserburgh	N	Y
Ilfracombe	Y(4)	Y
Plymouth	N	Y
Poole*	N	Y
Shetland Isles	N	Y
Wick	Y(5)	Y
Wick*	N	Y

Key:

1	-	Commercially processed in Brixham
2	-	Commercially processed in Fleetwood
3	-	Commercially processed in Kirkudbright
4	-	Commercially processed in Ilfracombe
5	-	Commercially processed in Dingwall
N	-	No samples assessed
Y	-	Samples assessed at Seafish laboratory
*	-	Dived scallops

4.2 Results and Discussion

4.2.1 The amount of grit in dived and dredged scallops

The grit scores in dredged and dived scallops landed to different UK ports are shown in Table 7 and summarised in Fig.5. Grit is usually found in the shell cavity above and below the mantle, sometimes attached to the gills and occasionally embedded into the adductor muscle. It is clear that dredged scallops had high levels of grit and the dived scallops had very little or none. The levels of grit in dredged scallops landed to different ports varies and is likely to be related to the fishing method and the substrate.

Table 7 - Grit scores of dredged and dived scallops from different ports

Sample source	Number in sample	Average grit score	% scallops in each classification				
			Very gritty	Gritty	Slight grit	Traces of grit	No grit
Dredged Scallops							
Brixham	60	3.3	47	35	16	0	2
Falmouth	161	3.2	44	34	17	4	1
Fraserburgh	84	2.7	25	36	27	7	5
Ilfracombe	24	2.1	24	8	46	0	22
Plymouth	36	3.4	48	30	22	0	0
Shetland	20	2.3	10	25	45	20	0
Wick	12	2.0	9	50	0	17	24
All Ports	397	2.7	30	32	25	5	8
Dived Scallops							
Poole	24	0.3	0	4	8	0	88
Wick	10	0.0	0	0	0	0	100
All Ports	34	0.1	0	2	4	0	94

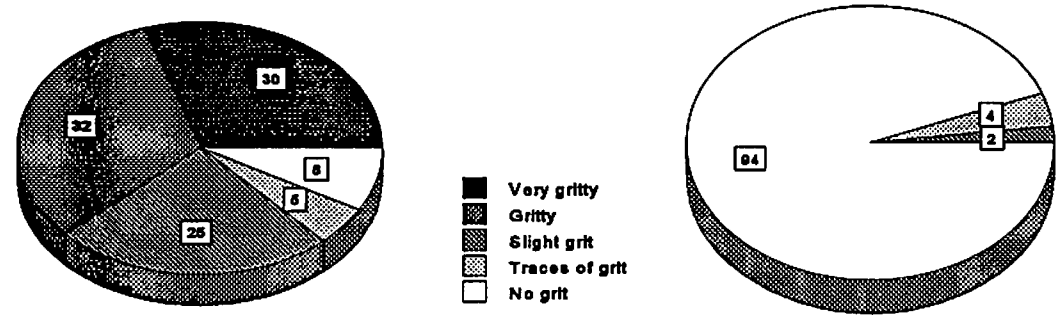

Figure 5 - Percentage of scallops with grit after capture

4.2.2 Effect of grit on commercially processed scallops

Grit as a contaminant in the dredged scallop, is not in itself a problem in the processed product because it is removed by the extensive and effective washing involved in normal scallop processing. The grit scores of commercially processed scallops are shown in Table 8. This clearly indicates that commercial processing removes grit from the scallop meats even if initially they were very gritty with a grit score of 3.3. However, grit contamination remains a quality problem as scallops with high levels of grit within the shell, spoil rapidly and have lower cooked flavour scores than grit-free scallops (see section 4.2.3).

Table 8 - The effect of processing on the grit score

Port of landing	Place of commercial processing	'In-shell' grit score	Grit score after commercial processing
Brixham	Brixham	3.3	0
Brixham	Fleetwood	2.4	0
Fraserburgh	Kirkcudbright	2.2	0
Fraserburgh	Fleetwood	1.6	0
Ilfracombe	Ilfracombe	1.9	0

4.2.3 Effect of grit on the eating quality of scallops after storage

The effect of grit on scallop cooked odour, flavour and texture following 72 hours storage at chill temperature conditions after capture is shown in Tables 9 (a)–9(f).For the purposes of this section of the work, with relatively small numbers of scallops, the grit classification 'slight grit' (score 2) was not used. The data shows that the gritty scallops had significantly lower odour, flavour and texture scores than grit free scallops. The average differences in score between very gritty and grit free samples

were 1.6 for odour, 0.9 for flavour and 0.8 for texture. The greatest differences were in scallops that were contaminated with mud rather than sand. These muddy scallops had odour and flavour scores of 0 and 3 respectively, but grit free scallops from the same batch had odour and flavour scores of 3.5 and 5. Another reason for lower scores associated with grit contamination may be damage to the scallops internal organs by small shell pieces.

Table 9a - Effect of grit on the cooked odour after 72 hours chilled storage of dredged scallops landed to different UK ports

Sample source	Cooked odour scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Brixham	3.7	–	3.3	–
Brixham	3.5	3.0	3.0	0.0*
Fraserburgh	3.8	3.5	2.7	–
Fraserburgh	3.5	–	3.4	–
Fraserburgh	3.7	3.7	3.5	3.5
Ilfracombe	3.0	3.0	3.0	3.0
Shetland Isles	3.6	3.0	2.4	3.0
Wick	4.0	–	3.5	–
All sources	3.6	3.2	3.1	2.4

Key:

\- Insufficient material for organoleptic assessment

* These samples were found to be contaminated with mud in addition to the more usual grit/sand contamination

Table 9b - Effect of grit on the cooked odour after 72 hours chilled storage of dived scallops landed to different UK ports

Sample source	Cooked odour scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Poole	4	4	–	–
Wick	4	–	–	–

Key:

– Insufficient material for organoleptic assessment.

Table 9c - Effect of grit on the cooked flavour after 72 hours chilled storage of dredged scallops landed to different UK ports

Sample source	Cooked flavour scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Brixham	4.0	–	3.7	–
Brixham	5.0	4.5	4.0	3*
Fraserburgh	3.8	3.3	2.7	–
Fraserburgh	3.6	–	3.3	–
Fraserburgh	3.5	3.8	3.8	3.0
Ilfracombe	3.0	3.0	4.0	3.0
Shetland Isles	4.4	4.4	4.0	3.5
Wick	4.3	–	3.6	–
All sources	4.0	3.8	3.6	3.1

Key:
– Insufficient material for organoleptic assessment
* These samples were found to be contaminated with mud in addition to the more usual grit/sandy contamination

Table 9d - Effect of grit on the cooked flavour after 72 hours chilled storage of dived scallops landed to different UK ports

Sample source	Cooked flavour scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Poole		4	–	–
Wick	4	–	–	–

Key:
– Insufficient material for organoleptic assessment.

Table 9e - Effect of grit on the cooked texture after 72 hours chilled storage of dredged scallops landed to different UK ports

Sample source	Cooked texture scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Brixham	4.0	–	3.5	–
Brixham	5.0	5.0	3.0	4.0*
Fraserburgh	3.5	3.2	3.0	–
Fraserburgh	4.3	–	4.4	–
Fraserburgh	3.5	3.7	4.2	3.2
Ilfracombe	4.0	5.0	5.0	4.0
Shetland Isles	3.5	3.6	3.6	3.6
Wick	4.3	–	4.1	–
All sources	4.0	4.1	3.9	3.7

Key:
– Insufficient material for organoleptic assessment
* These samples were found to be contaminated with mud in addition to the more usual grit/sandy contamination

Table 9f - Effect of grit on the texture after 72 hours chilled storage of dived scallops landed to different UK ports

Sample source	Cooked texture scores for scallops of different grittiness			
	No grit	Traces of grit	Gritty	Very gritty
Poole	4	4	–	–
Wick	4	–	–	–

Key:
– Insufficient material for organoleptic assessment.

5. Degritting Trials

Four separate trials were carried out, divided between the premises of Black Isle mussels, Dingwall (Trials 1 and 4) and the Falmouth Oyster Company, Falmouth (Trials 2 and 3) during the summer of 1994. The procedure and results for each of these trials are detailed separately in sections 5.1 to 5.4.

5.1 Trial 1 - Preliminary Investigations into the Degritting of Scallops

This was a preliminary investigation into whether dredged scallops could remove grit from their shells by their own filtering action during immersion in seawater, and into some of the likely degritting variables and effects.

5.1.1 Procedure

Trial 1 was started on 5 August 1994 at the premises of Black Isle Mussels, Dingwall, using scallops landed to Fraserburgh by day boat. The scallops were held in ambient conditions on the vessel (15 °C). Four samples of the last caught scallops were taken on landing and were subject to the different treatments shown in Table 10 overleaf.

The control sample (treatment 1) was held at ambient and then shucked and assessed for grit within 12 hours of landing. The remaining samples were held at ambient for either 12 or 24 hours then immersed for either 6 or 12 hours on trays in artificial seawater at either 11 or 16 °C in the lab-scale purification tank. These samples were then shucked and assessed for grit within 2 hours of removal from the tank.

Scallops from the control sample (treatment 1) and from one of the degritted samples (treatment 2) were also subject to an investigation of weight gain following further immersion of the shucked meats. The meats were immersed in either chilled fresh water or chilled artificial seawater for further periods of either 24 or 48 hours and were weighed before and after this further immersion.

5.1.2 Results and discussion

The degritting results are shown in Table 10 and the weight gain results are shown in Table 11.

5.1.2.1 Scallop activity

After immersion in tanks, it took several minutes for the scallops to become active to the extent that the shells were open with the mantle full and the gill filaments straight and extended. A photograph of active scallops in a tank is shown in Fig. 6 overleaf.

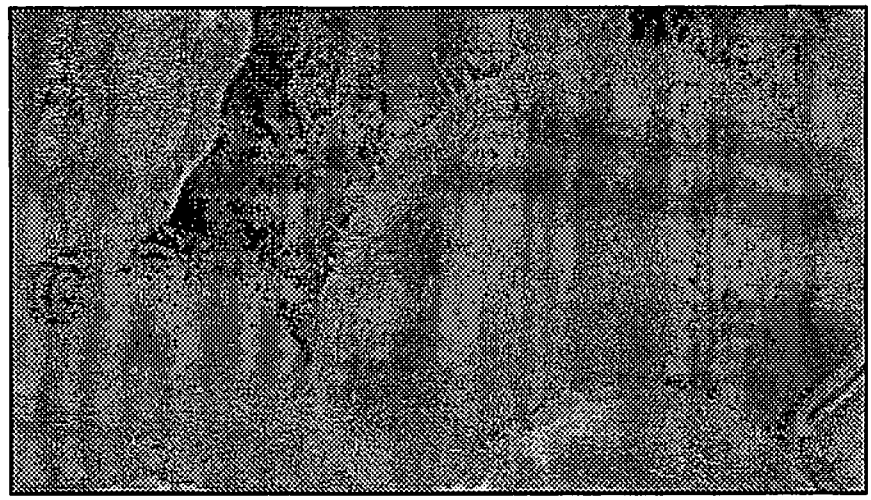

Figure 6 - A photograph of active scallops in a tank with mantle full and the gill filaments straight and extended

Table 10 - Trial 1: Degritting treatments and results

Treatment number-	Holding temp prior to immersion (° C)	Delay between landing and immersion (h)	Period of immersion (h)	Seawater temp (° C)	Number in sample	Average grit score after immersion
1	15	n/a	n/a	n/a	36	2.2
2	15	12	12	11	17	0.4
3	15	24	6	16	61	0.6
4	15	24	12	11	7	1.8

5.1.2.2 Effect of delay prior to immersion on degritting

There are indications that the delay prior to immersion has an effect; as 12 and 24 hour delayed scallops had average grit scores of 0.4 and 1.2 respectively with the period of immersion and seawater temperature being equal. It should be noted that the delays quoted in this trial are delays after landing and that there will have been further delay of a few hours between capture and landing.

5.1.2.3 Effect of period of immersion and seawater temperature on degritting

There is insufficient data from this trial to make any firm conclusions of the separate effects of seawater temperature or immersion period on degritting. However, there are indications that seawater temperature is very important as scallops immersed for 6 hours at 16 °C (treatment 3) substantially degritted themselves unlike those immersed for 12 hours at 11 °C (treatment 4), this being in spite of the longer delay prior to immersion suffered in treatment 3. However, with only a 12 hour delay prior to immersion (treatment 2) and immersion at 11 °C the scallops also substantially degritted themselves.

5.1.2.4 Effect of degritting on weight gain during further soaking

The results in Table 11 show that soaking the meats for 24 hours in chilled water after degritting in seawater for 12 hours, resulted in a weight gain of 51%, with a further increase in weight gain to 58% after 48 hours. The comparable weight gains for the control samples were only 36% and 38% over the same time periods. Weight gains were not as great when the meats were soaked in artificial seawater, probably due to the smaller osmotic difference between the scallop flesh and seawater.

Table 11 - Effect of immersion on weight gain after soaking

Treatment number	Sample type	Soaking water type	% Weight gain	
			24 hour soak time	48 hour soak time
1	Control	Fresh potable water	36	38
		Artificial seawater @ salinity of 35 ppm	21	33
2	Immersed scallops	Fresh potable water	51	58
		Artificial seawater @ salinity of 35 ppm	30	44

5.1.3 Conclusions

This was only a limited trial but with positive results showing that it is possible for dredged scallops to remove grit from their shells by their own filtering action during immersion in seawater. There are indications that delays prior to immersion have an effect on degritting and that degritting may have a further effect on weight gain of scallop meats during subsequent soaking. There are indications of the importance for degritting of immersion temperature. However, more work is required to investigate further the optimum conditions for scallop degritting.

5.2 Trial 2 - Investigation of Factors Affecting Scallop Degritting

This second trial was undertaken to look more closely at effects of holding temperature and delays prior to degritting and of seawater temperature, period of immersion and the method of holding the scallops in degritting tanks.

5.2.1 Procedure

Trial 2 was started on 23 August 1994 on the scallop dredger "GOLDEN FLEECE" landing to Falmouth and subsequently at the premises of Falmouth Oyster Company.

Twenty combinations of treatments were examined as shown in Table 12 overleaf. By manning the vessel it was possible to control delays from the point of bringing the scallops aboard the vessel rather than from landing.

Prior to degritting, the samples were held at 0 °C (directly iced), 3 °C (chilled) or 15 °C (ambient) conditions. Delays prior to degritting were 0, 2, 10 or 15 hours. Degritting was in natural seawater in the small-scale purification tanks for periods of 6, 12 or 24 hours at seawater temperatures of 13 °C, 16 °C or 19 °C. The scallops were held in trays or nets. Within two hours of removal from the degritting tanks the scallops were shucked and assessed for grit. The meats were then kept in chill conditions (0-2 °C) and assessed for organoleptic quality after 1 and 3 days chilled storage.

The zero delay samples were held for up to 2 hours at 16 °C in the small holding tank on the vessel and during transport to the premises, whereupon they were transferred to the purification tank at 13 °C, 16 °C or 19 °C.

The control sample was held at 15 °C, shucked and assessed for grit within 2 hours of landing without immersion and then held in chill for organoleptic assessment.

5.2.2 Results and discussion

The effect of all the various treatments on scallop activity and degritting are shown in Table 12. Average data for each treatment type is summarised in Tables 13 to 17 and in Figs. 7 -10. The effects of the various treatments on organoleptic quality are shown in Table 18.

Table 12 - Trial 2: degritting treatments and results

Treatment number	Holding temp prior to immersion (° C)	Delay between bringing aboard and immersion (h)	Period of immersion (h)	Seawater temp (° C)	Tray or net	Number in sample	Average scallop activity scores	Average grit scores
1	15	n/a	n/a	n/a	n/a	43	n/a	3.2
2	n/a	0	12	13	tray	6	3.0	1.3
3	n/a	0	12	16	tray	6	4.0	0.5
4	0 (iced)	10	12	13	tray	6	1.3	2.8
5	0 (iced)	10	12	16	tray	6	0.0	2.3
6	3	10	12	13	tray	6	2.2	1.5
7	3	10	12	16	tray	6	0.0	2.0.
8	3	10	24	19	tray	8	2.5	1.0
9	3	15	6	19	tray	6	2.2	3.5
10	15	2	12	13	tray	12	4.0	0.8
11	15	2	12	13	net	4	4.0	0.0
12	15	2	12	16	net	4	3.8	0.0
13	15	2	12	16	tray	12	3.5	0.4
14	15	2	24	19	tray	10	4.0	0.3
15	15	2	24	19	net	4	4.0	1.0
16	15	10	12	13	tray	6	3.2	1.3
17	15	10	12	16	tray	6	2.5	2.0
18	15	10	24	19	tray	8	0.7	1.8
19	15	10	24	19	net	8	4.0	0.3
20	15	15	6	19	tray	6	0.0	2.2

Key: n/a - not applicable

5.2.2.1 Effect of holding temperature prior to immersion on scallop activity and degritting

Table 13 - Effect of holding temperature prior to immersion on scallop activity and degritting

Treatment number	Temperature (°C)	Average scallop activity	Average grit score
4 and 5	0	0.6	2.6
6 to 9	3	1.7	2.0
10 to 20	15	3.1	1.1

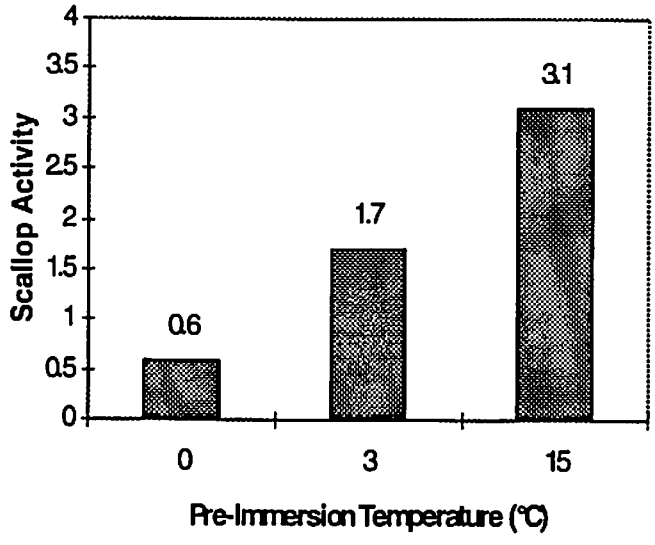

Figure 7a - Effect of holding temperature prior to immersion on scallop activity

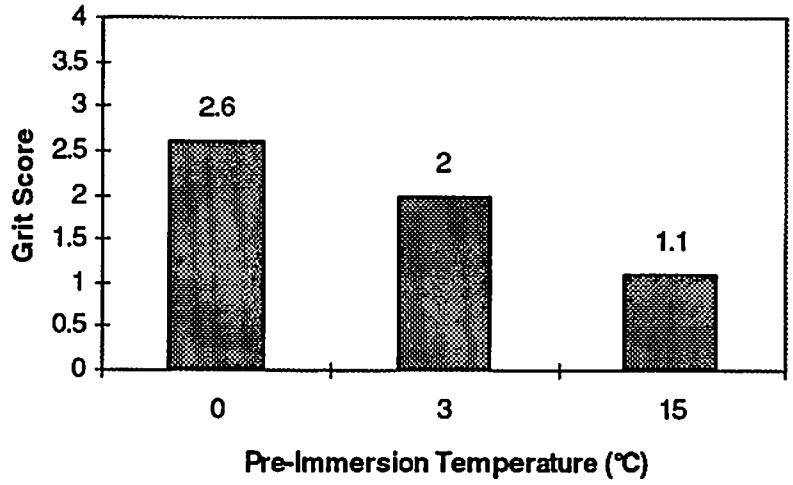

Figure 7b - Effect of holding temperature prior to immersion on degritting

The holding temperature prior to immersion has a major effect on the activity and degritting of scallops. Despite the range in treatments, scallops that were kept at temperatures of 15 °C were more active when immersed and had lower grit scores than those kept at chill temperatures. This is likely to be due to the fact that they were kept at a similar temperature to the seawater temperature from which they were caught and so there was no thermal shock. Scallops held on ice prior to immersion had little activity in the tank, some being considered dead, which resulted in little reduction from the initial grit score of 3.2.

5.2.2.2 Effect of delays prior to immersion on scallop activity and degritting

Table 14 - Effect of delays prior to immersion on scallop activity and degritting

Treatment number	Delay prior to immersion (h)	Average scallop activity	Average grit score
2 and 3	0	3.5	0.9
10 to 15	2	3.9	1.0
4 to 8, 16 to 19	10	1.8	1.5
9 and 20	15	1.1	2.6

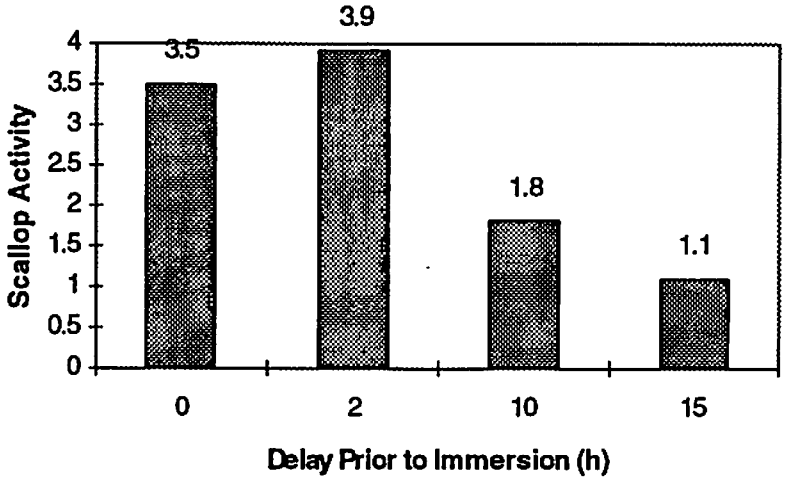

Figure 8a - Effect of delay prior to immersion on scallop activity

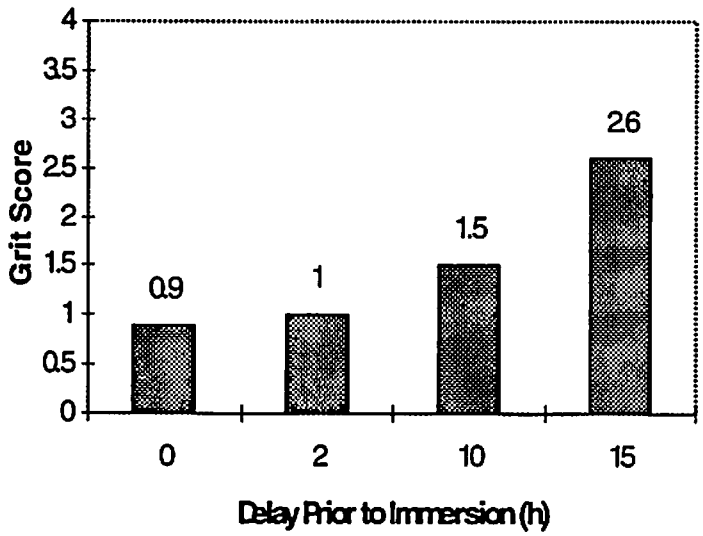

Figure 8b - Effect of delay prior to immersion on degritting

The delay prior to immersion also has a major effect on scallop activity and degritting. Scallops with no delays were active in the temporary holding tank on the fishing vessel, remained active when transferred to the degritting tank and produced scallops with only traces of grit. Scallops with a 2 hour delay prior to immersion were similarly active and resulted in similar grit scores. A 10 hour delay resulted in less activity and higher grit scores, and when delayed for 15 hours the scallops showed little activity and little reduction in the initial grit score of 3.2.

5.2.2.3 Effect of seawater temperature in the tank on scallop activity and degritting

Table 15 - Effect of seawater temperature on scallop activity and degritting

Treatment number	Seawater temperature (°C)	Average scallop activity	Average grit score
2,4,6,10,11,16	13	2.9	1.3
3,5,7,12,13,17	16	2.3	1.2
8,9,14,15,18,19,20	19	2.5	1.4

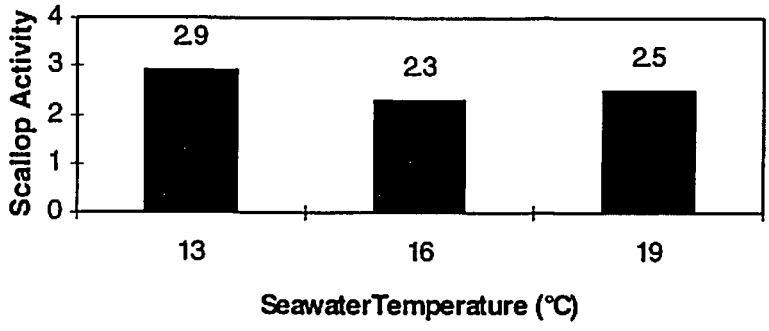

Figure 9a - Effect of seawater temperature on scallop activity

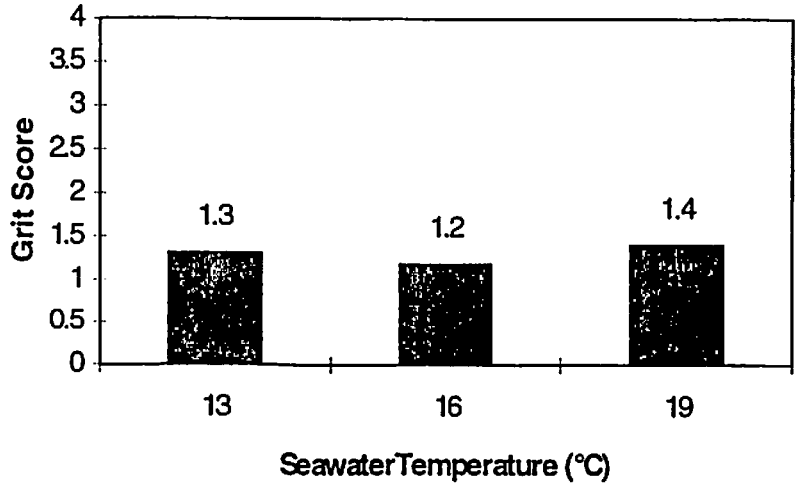

Figure 9b - Effect of seawater temperature on degritting

There was little difference in the activity or degritting of scallops held at different seawater temperatures within the investigated range 13-19 °C. The temperature of 16 °C was similar to the shallow inshore seawater temperature at that particular time of year.

5.2.2.4 Effect of the period of immersion on scallop activity and degritting

Table 16 - Effect of the period of immersion on scallop activity and degritting

Treatment number	Period of Immersion (h)	Average Scallop Activity	Average grit score
9 and 20	6	1.1	2.6
2 to 7, 10 to 13, 16 and 17	12	2.6	1.3
8,14,15,18,19	24	3.0	0.9

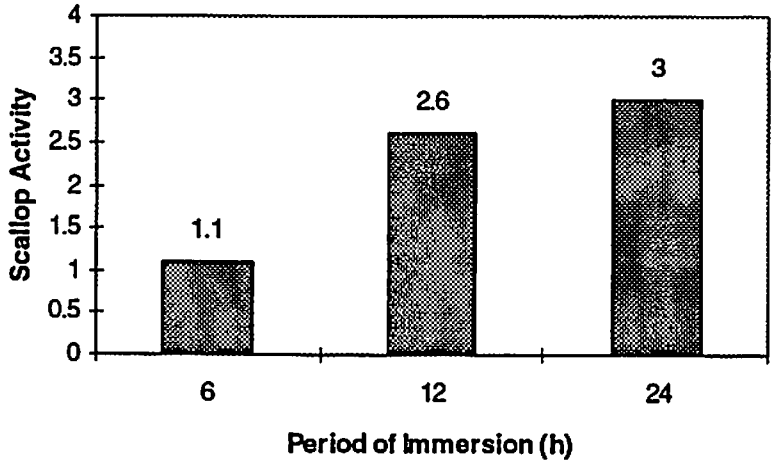

Figure 10a - Effect of the period of immersion on scallop activity

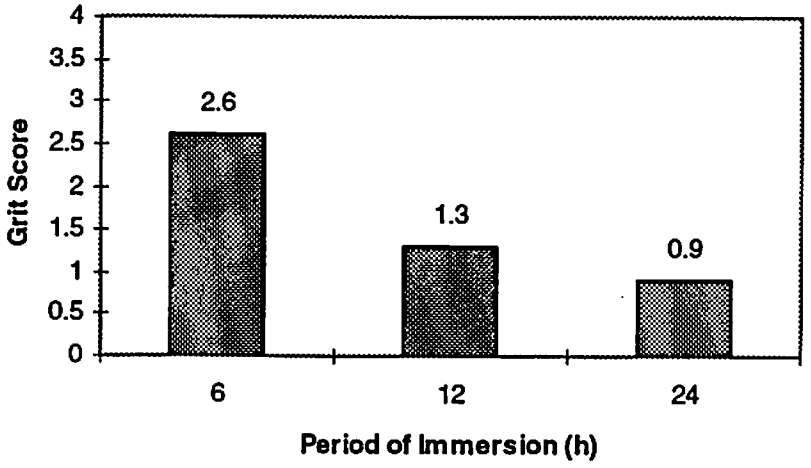

Figure10b - Effect of period of immersion on degritting

Immersion periods of 12 and 24 hours both resulted in effective degritting, giving grit scores of 1.3 and 0.9 respectively. There may be little need to immerse scallops beyond 12 hours. There are indications that an immersion period of 6 hours may be insufficient, but those particular samples had been subjected to delays of 15 hours prior to immersion which may have had a greater effect than the immersion period. It is possible that there may be a minimum immersion time required for scallops to recover from any handling stresses such as dredging and storage out of water.

5.2.2.5 Effect of trays and nets on scallop activity and degritting

Table 17 - Effect of trays and nets on scallop activity and degritting

Treatment number	Holding method	Average scallop activity	Average grit score
11,12,15,19	net	3.9	0.3
10,13,14,18	tray	3.7	0.7

A very clean product, with no grit in the shell was achieved by suspending the scallops vertically in the net. This is probably due to grit falling out directly from the scallops. However, it is harder to assess the activity of the scallops in the net, including whether they are dead or alive. Dead or dying scallops left in the tank are likely to affect the water quality and consequently affect the other scallops and degritting.

5.2.2.6 Effect of degritting on organoleptic quality

The results are shown in Table 18 overleaf. None of the treatments appeared to significantly effect the eating quality of the scallops although quality deteriorated during final chilled storage.

Table 18 - Organoleptic results of Trial 2

Treatment number	Holding temp prior to immersion	Delay prior to immersion (h)	Period of immersion (h)	Seawater temp (° C)	Tray or net	Organoleptic assessment after final chilled storage					
						1 day storage			3 days storage		
						O	F	T	O	F	T
1	15	n/a	n/a	n/a	n/a	4.0	5.0	4.0	3.0	3.0	3.0
2	n/a	0	12	13	tray	4.0	4.5	4.0	3.0	3.0	3.0
3	n/a	0	12	16	tray	5.0	5.0	3.0	3.0	3.0	4.0
4	0 (iced)	10	12	13	tray	4.0	4.5	3.0	3.0	2.5	5.0
5	0 (iced)	10	12	16	tray	5.0	5.0	5.0	3.0	3.0	3.0
6	3	10	12	13	tray	4.5	4.5	4.5	3.0	3.0	5.0
7	3	10	12	16	tray	4.0	5.0	3.0	3.5	3.5	4.0
8	3	10	24	19	tray	3.5	3.5	4.0	3.0	3.0	3.0
9	3	15	6	19	tray	4.0	4.0	3.0	3.0	3.0	3.0
10	15	2	12	13	tray	5.0	5.0	4.0	3.5	3.5	4.0
11	15	2	12	13	net	5.0	5.0	4.0	2.5	2.5	4.0
12	15	2	12	16	net	5.0	5.0	4.0	3.0	3.0	2.5
13	15	2	12	16	tray	3.0	5.0	3.0	3.0	3.0	4.0
14	15	2	24	19	tray	3.5	4.0	4.0	3.0	3.0	3.0
15	15	2	24	19	net	3.5	4.0	4.0	3.0	3.5	2.0
16	15	10	12	13	tray	5.0	5.0	4.0	3.5	4.0	3.0
17	15	10	12	16	tray	3.0	4.0	4.0	4.5	4.5	4.5
18	15	10	24	19	tray	3.0	3.0	3.0	3.0	4.0	3.0
19	15	10	24	19	net	3.5	4.0	4.0	3.0	3.0	3.0
20	15	15	6	19	net	3.0	4.0	3.0	3.5	4.0	3.0

Key: O - Odour
F - Flavour
T - Texture

5.2.3 Conclusions

1. Scallops can be successfully degritted in purification tanks to produce a scallop with little or no grit from an initially gritty scallop.

2. Extended delay between bringing aboard and immersion reduces the effectiveness of degritting. This became significant at 15 hours delay.

3. Chilling the scallops prior to immersion reduces the effectiveness of degritting.

4. Degritting was not significantly affected by water temperature within the range 13–19 °C.

5. Immersion times over 12 hours resulted in little further degritting.

6. Holding scallops vertically in pockets in nets during immersion produced the cleanest scallops.

7. Degritting had no significant effect on the organoleptic quality of the scallops.

5.3 Trial 3 - Further Investigation of the Effects of Pre-Immersion Holding Temperature and Delays and of Immersion Times, on Scallop Degritting

This trial was undertaken to investigate in more detail the effects of treatment prior to immersion and the period of immersion. Pre-immersion samples were held at chill and ambient temperature but were not iced because of the adverse effect shown in Trial 2. All the scallops were placed on trays in the purification tank and held at the same seawater temperature.

5.3.1 Procedure

Trial 3 was started on 12 September 1994 on the scallop dredger "GOLDEN FLEECE" landing to Falmouth and subsequently at the premises of Falmouth Oyster Company.

Eighteen combinations of treatments were examined as shown in Table 19 overleaf.

Prior to degritting, the scallops were held at 3 °C (chilled) or 15 °C (ambient). Delays between bringing aboard and immersion for degritting were 0, 6, 12 or 24 hours. Degritting was in natural seawater in the small-scale purification tank at 16 °C. The scallops were immersed for 9, 12, 24 or 36 hours. Within two hours of removal from the degritting tanks the scallops were shucked and assessed for grit.

The zero delay samples were held for up to two hours at 16 °C in the small handling tank on the vessel and in transport before being transferred to the purification tank.

The control sample was held at 15 °C, shucked and assessed for grit within two hours of landing without being immersed.

5.3.2 Results and discussion

The results of the effect of all the various treatments on scallop activity and degritting are shown in Table 19 below. Average data for each treatment type is summarised in Tables 20 to 22 and Figs. 11-13.

Table 19 - Trial 3: Degritting treatments and results

Treatment No	Holding temp prior to immersion (° C)	Delay between bringing onboard and immersion (h)	Period of immersion (h)	Number in sample	Average scallop activity scores	Average grit scores
1	15	n/a	n/a	57	n/a	3.0
2	n/a	0	12	12	4.0	1.4
3	n/a	0	24	12	4.0	0.8
4	n/a	0	36	12	4.0	0.7
5	3	12	12	11	3.8	1.3
6	3	12	24	12	3.8	0.8
7	3	24	9	12	1.8	2.3
8	3	24	15	10	1.7	3.1
9	3	24	24	12	2.2	2.6
10	15	6	15	8	4.0	0.6
11	15	6	24	12	3.8	0.8
12	15	6	36	4	4.0	0.5
13	15	6	12	6	3.5	0.7
14	15	6	24	6	4.0	0.7
15	15	12	12	11	3.9	0.9
16	15	12	24	15	3.9	1.1
17	15	12	36	23	3.8	0.7
18	15	24	15	43	3.5	1.3

All scallops placed on trays.
Tank temperature was 16 °C for all treatments.

Key: n/a - not applicable

5.3.2.1 Effect of holding temperature prior to immersion on scallop activity and degritting

Table 20 - Effect of holding temperature prior to immersion on scallop activity and degritting

Treatment number	Temperature (°C)	Average scallop activity	Average grit score
5 to 9	3	2.9	2.0
10 to 18	15	3.9	0.8

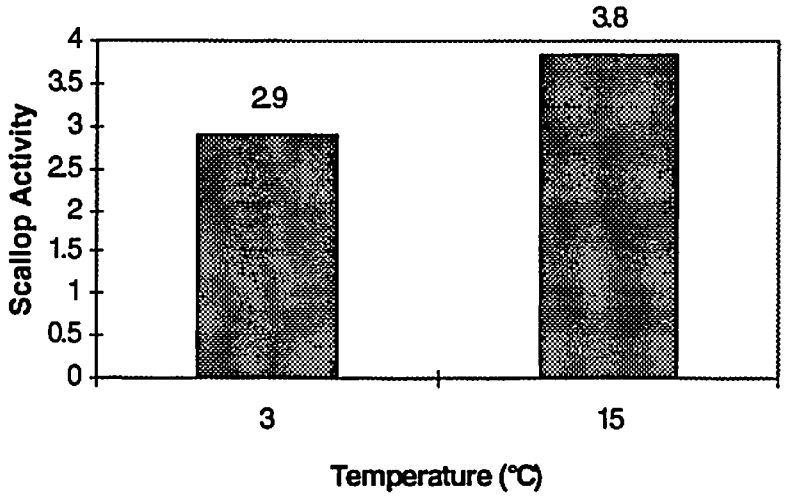

Figure 11a - Effect of holding temperature prior to immersion on scallop activity

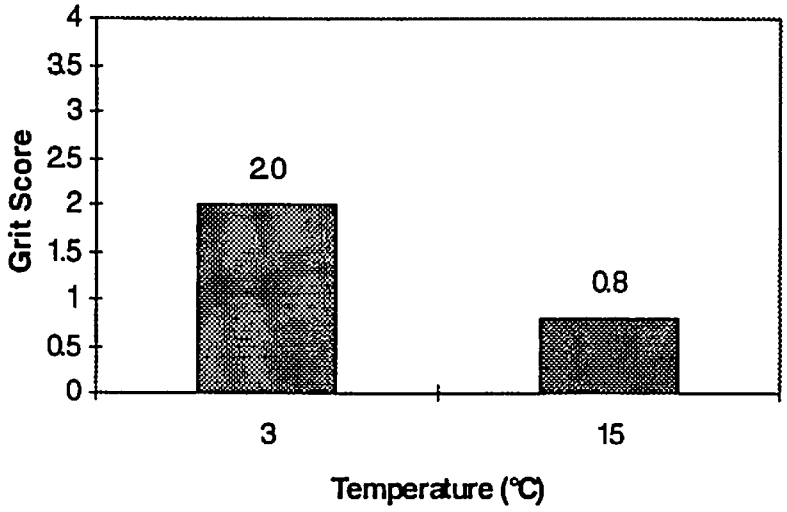

Figure 11b - Effect of holding temperature prior to immersion on degritting

The holding temperature prior to immersion had a major effect on scallop activity and degritting. Despite the range in results, scallops that were kept at ambient temperatures of 15 °C prior to immersion were more active and had lower grit scores than those kept at chill temperature, particularly if kept at chill temperatures for long periods. Those kept at 3 °C prior to immersion were active only if the storage at this temperature was short.

5.3.2.2 Effect of delays prior to immersion on scallop activity and degritting

Table 21 - Effect of delays prior to immersion on scallop activity and degritting

Treatment number	Delay prior to immersion (h)	Average scallop activity	Average grit score
2 to 4	0	4.0	0.9
10 to 14	6	3.9	0.7
5, 6,6 15 to 17	12	3.8	0.9
7 to 9, 18	24	2.6	2.3

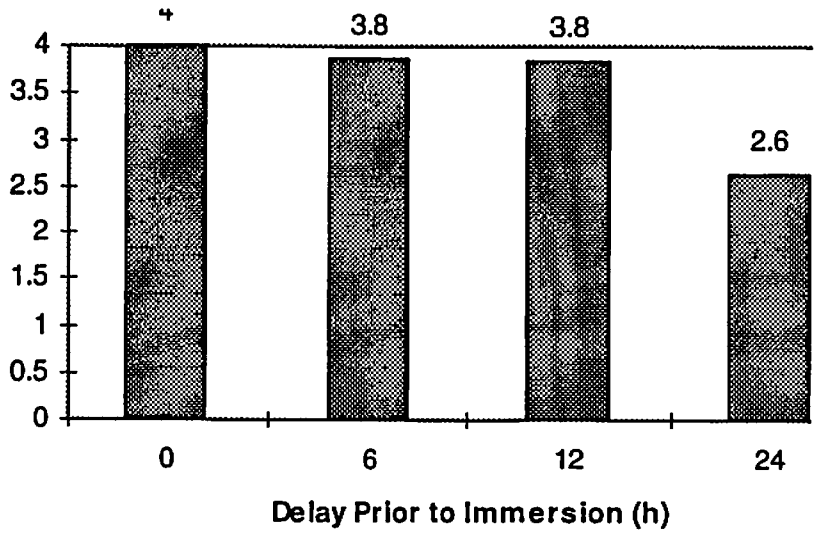

Figure 12a - Effect of delay prior to immersion on scallop activity

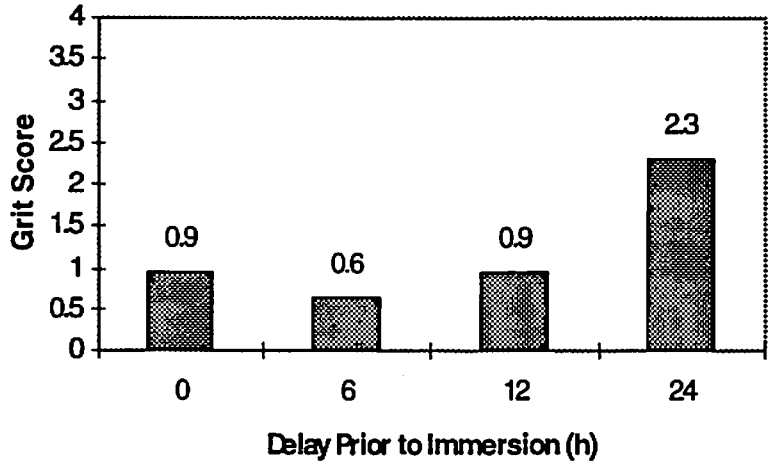

Figure 12b - Effect of delay prior to immersion on degritting

Extended delay prior to immersion had a significant effect on scallop activity and the final grit score. Scallops were most active when immersed immediately in seawater on the boat, and were still active when transferred from the boat tank to the degritting tank ashore. Those scallops with a 24 hour delay prior to immersion were markedly less active and had higher grit scores, suggesting that not all scallops could tolerate being kept out of water for this length of time, especially when held at 3°C.

5.3.2.3 Effect of the period of immersion on scallop activity and degritting

Table 22 - Effect of the period of immersion on scallop activity and degritting

Treatment number	Period of immersion (h)	Average scallop activity	Average grit score
7	9	1.8	2.3
2,5,13,15	12	3.8	1.1
8,10,18	15	3.6	1.7
3,6,9,11,14,16	24	3.6	1.1
4,12,17	36	3.9	0.6

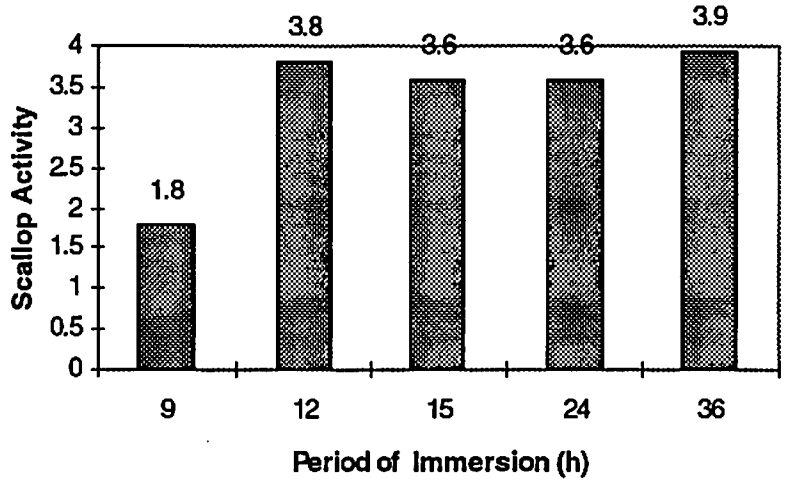

Figure13a - Effect of the period of immersion on scallop activity

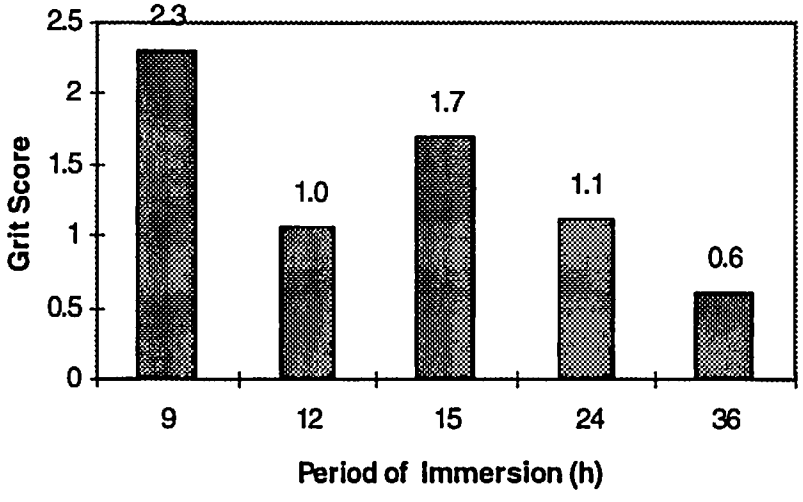

Figure13b - Effect of the period of immersion on degritting

The results show that scallops immersed for periods of up to 36 hours remained active in the tank, resulting in low grit scores. Data for the 15 hour immersion period was adversely effected by the scallops (in treatment 8) being held at 3°C for 24 hours prior to immersion. Similarly, all the scallops immersed for 9 hours had been kept at 3 °C for 24 hour prior to immersion. The indications are that, provided the conditions are suitable, the bulk of the degritting occurs within 12 hours of immersion.

5.3.3 Conclusions

1. It is confirmed that the holding temperature prior to immersion has a significant effect on scallop degritting. When held at chilled temperatures for extended periods, scallop activity is significantly reduced.

2. Delay of 24 hours prior to immersion significantly reduced scallop activity and the effectiveness of degritting, although delay of 12 hours did not have a significant effect.

3. It is confirmed that the bulk of degritting occurs during the first 12 hours of immersion, although the scallops remained active after 36 hours.

5.4 Trial 4 - Further Investigations of Scallop Degritting Using Artificial Seawater

This trial was undertaken to further investigate the effect of extended delays prior to immersion, the period of immersion and the use of artificial seawater. Pre-immersion samples were held at chill and ambient temperatures. All scallops were placed on trays in the purification tank and held at the same seawater temperature. Organoleptic assessment of the meats was carried out during extended chilled storage.

5.4.1 Procedure

Trial 4 was started on 12 September 1994 at the premises of Black Isle Mussels, Dingwall, using dredged scallops landed to Fraserburgh from a day boat. The scallops were held in ambient conditions on the vessel (15 °C).

Eleven combinations of treatments were examined as shown in Table 23 overleaf. The quoted delays prior to immersion are those after landing of the scallops rather than from bringing aboard on the vessel.

After landing and prior to degritting, the scallops were held at 3 °C (chilled) or 15 °C (ambient). Delays between landing and immersion for degritting were 15, 24 or 36 hours. Degritting was in artificial seawater in the lab-scale purification tank at 11 °C. The scallops were immersed for 6, 9, 12 or 24 hours. Within 2 hours of removal from the degritting tank the scallops were shucked and assessed for grit. The meats were then kept in chill conditions (0-2 °C) and assessed for organoleptic quality at intervals of up to 7 days.

The control sample was held at 15 °C, shucked and assessed for grit within 2 hours of landing without being immersed.

5.4.2 Results and discussion

The results of the effect of the various treatments on scallop activity and degritting are shown in Table 23. Average data for each treatment type is summarised in Tables 24

to 26 and Figs. 14-16. The effects of the various treatments on organoleptic quality are shown in Table 27.

5.4.2.1 The use of artificial seawater in degritting tanks

The scallops with the shortest delay times were active after several minutes, to the extent that the shells were open with the mantle full and the gill filaments straight and extended. The grit scores indicate that provided that the conditions are correct, scallops can be degritted successfully using artificial seawater.

Table 23 - Trial 4: Degritting treatments and results

Treat-ment No	Holding temp prior to immersion (° C)	Delay between landing and immersion (h)	Period of immersion (h)	Number in sample	Scallop activity scores	Grit scores
1	15	n/a	n/a	10	n/a	2.6
2	3	24	12	6	2.4	2.7
3	3	24	24	5	2.4	1.8
4	3	36	9	5	0.7	3.2
5	3	36	6	8	1.8	3.0
6	15	15	9	5	3.4	0.8
7	15	15	24	5	4.0	0.0
8	15	24	12	5	2.3	1.6
9	15	24	24	14	1.0	2.3
10	15	36	9	10	2.9	2.7
11	15	36	6	5	2.7	1.4

All scallops placed on trays.
Tank temperature was 11 °C in all treatments.

Key: n/a - notapplicable

5.4.2.2 Effect of holding temperature prior to immersion on scallop activity and degritting

Table 24 - Effect of holding temperature prior to immersion on scallop activity and degritting

Treatment number	Temperature (°C)	Average scallop activity	Average grit score
2 to 5	3	1.8	2.7
6 to 11	15	2.7	1.5

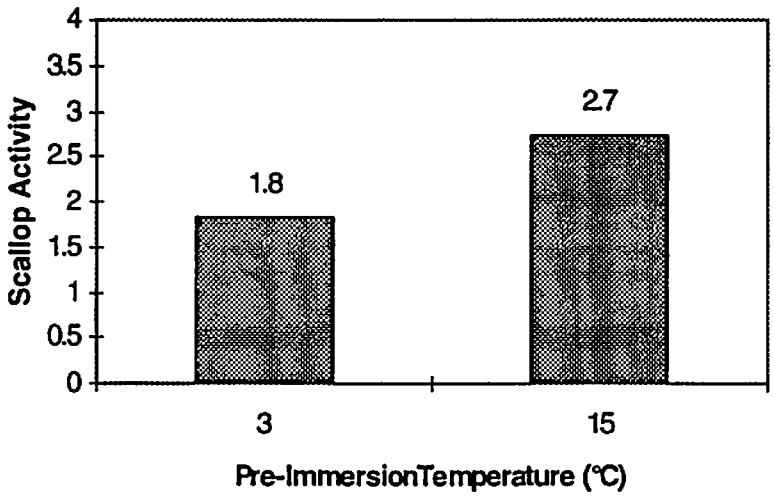

Figure 14a - Effect of holding temperature prior to immersion on scallop activity

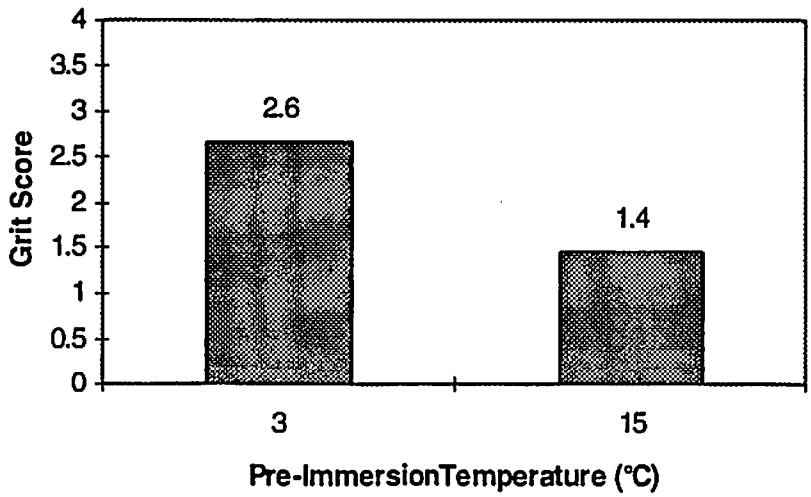

Figure 14b - Effect of holding temperature prior to immersion on degritting

The averaged results show that the holding temperature prior to immersion has a major effect on scallop activity and degritting. This effect is emphasised when treatments 2 and 8 are compared directly, which had grit scores of 2.7 and 1.6 respectively, the only difference in treatment being the temperature prior to immersion.

5.4.2.3 Effect of delays prior to immersion on scallop activity and degritting

Table 25 - Effect of delays prior to immersion on scallop activity and degritting

Treatment number	Delay prior to immersion (h)	Average scallop activity	Average grit score
6 & 7	15	3.7	0.4
2,3,8,9	24	2.0	2.1
4,5,10,11	36	2.0	2.6

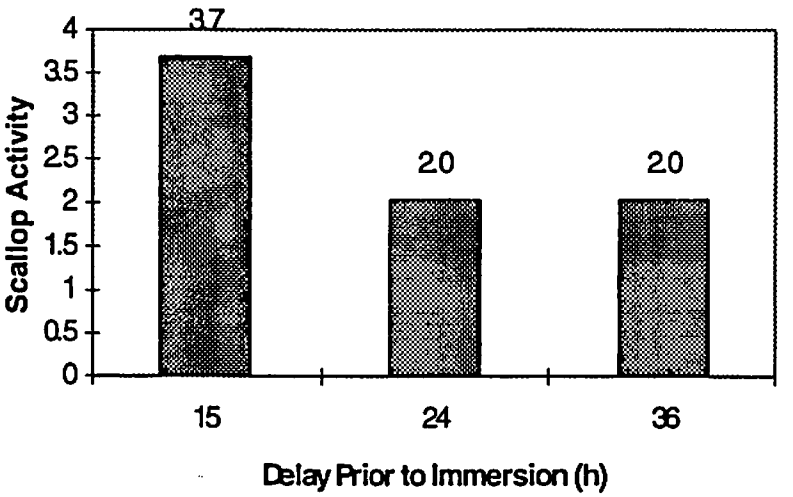

Figure 15a - Effect of delay prior to immersion on scallop activity

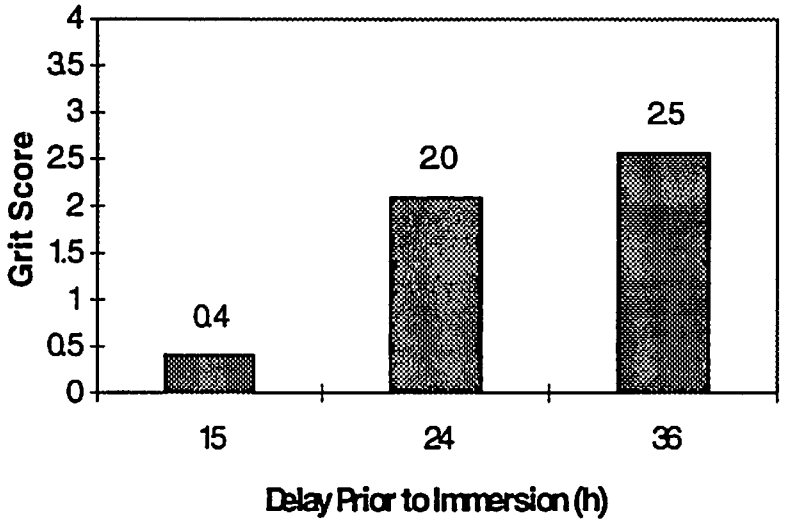

Figure 15b - Effect of delay prior to immersion on degritting

The averaged results show that the delay prior to immersion has a significant effect on scallop activity and the final grit score. Scallops with a 15 hour delay between landing and immersion were active in the tank producing scallops with a low average grit score, but at 24 and 36 hour delays, the scallops had low levels of activity and higher grit scores. This effect is emphasised when treatments 7 and 9 are compared directly, which had grit scores of 0 and 2.3 respectively, the only difference in treatment being the delay before immersion.

5.4.2.4 Effect of the period of immersion on scallop activity and degritting

Table 26 - Effect of the period of immersion on scallop activity and degritting

Treatment number	Period of immersion (h)	Average scallop activity	Average grit score
5 and 11	6	2.3	2.2
4,6,10	9	2.3	2.2
2 and 8	12	2.4	2.1
3,7,9	24	2.5	1.4

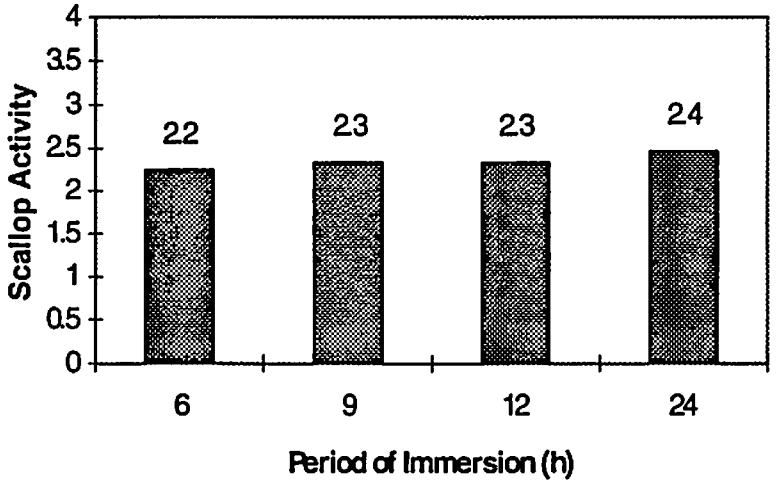

Figure 16a - Effect of period of immersionon scallop activity

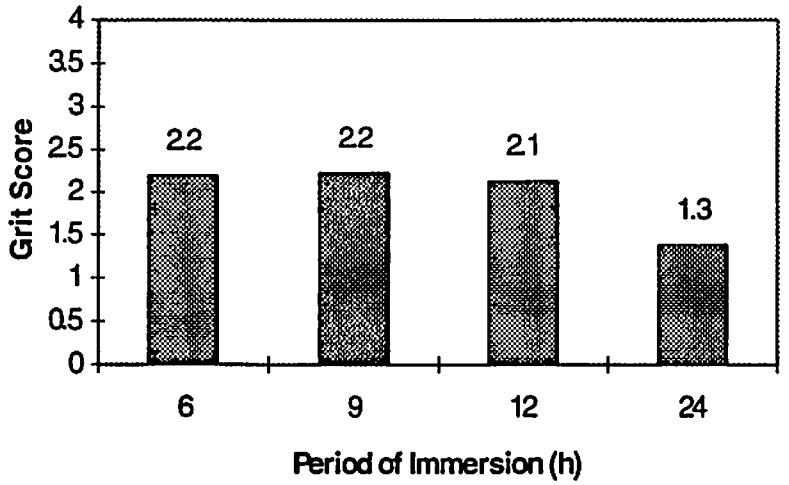

Figure 16b - Effect of period of immersion on degritting

The average results show that the period of immersion has some effect on the final grit scores but little effect on scallop activity. The averaged results are significantly affect by holding temperature and delay before immersion.

5.4.2.5 Effect of degritting on organoleptic quality

The data in Table 27, overleaf, is extremely variable with little consistent pattern, even with extended storage.

Table 27 - Organoleptic results of Trial 4

Treat-ment number	Holding temp prior to immersion (° C)	Delay between landing and immersion (h)	Period of immersion (h)	Organoleptic assessment after final chilled storage								
				1 day storage			5 days storage			7 days storage		
				Odour	Flavour	Texture	Odour	Flavour	Texture	Odour	Flavour	Texture
1	15	n/a	n/a	n	2.6	3.5	n	2.6	3.5	n	2.5	3.0
2	3	24	12	n	2.6		n	2.6	n	n	2.8	n
3	3	24	24	3.3	3.6	3.5	3.0	3.3	3.0	n	n	n
4	3	36	9	3.0	3.1	3.0	3.0	2.5	2.0	n	n	n
5	3	36	6	3.0	3.6	3.5	3.0	3.0	3.0	2.5	2.3	3.0
6	15	15	9	n	2.9	3.3	n	2.9	3.3	n	3.0	3.0
7	15	15	24	n	1.5	3.0	n	1.5	3.0	n	1.3	2.5
8	15	24	12	n	2.3	3.0	n	2.3	3.0	n	2.0	3.0
9	15	24	24	2.8	3.0	4.0	3.0	3.0	3.0	2.8	2.3	2.5
10	15	36	9	3.0	3.1	3.4	3.3	2.8	3.0	2.8	2.3	2.5
11	15	36	6	2.1	2.6	3.0	2.0	2.8	2.0	n	n	n

5.4.3 Conclusions

1. Scallops can be degritted in artificial seawater in purification-type tanks to produce scallops with little or no grit from gritty scallops.

2. It is confirmed that chilling prior to immersion significantly reduced the effectiveness of degritting.

3. Delays of 24 and 36 hours between landing and immersion significantly reduced the effectiveness of degritting.

6. General Discussion

Dredged scallops are gritty, typically with 90% of a haul having some grit in the shell (varying from traces to very gritty). They are usually sold for the bulk processing market. Grit contamination does not carry over to the processed product as most of the grit is within the shell and not in the muscle or roe, and the usual washing process is effective at removing this grit. However, scallops with high levels of grit within the shell spoil rapidly, have low cooked flavour scores, and are lower in overall quality than grit-free scallops. There may be several factors at work including tainting by mud and damage to the scallops internal organs by small shell pieces. Scallops which are known to be very gritty, particularly muddy, should be processed as soon as possible to limit the rapid quality deterioration which occurs.

Dived scallops are generally grit free, have a higher value than dredged scallops and are usually sold live at a premium price to markets such as high class restaurants.

The degritting trials have shown that it is possible for grit to be removed from live dredged scallops by their own filtering action when immersed in seawater in mollusc purification 'type' tanks under controlled conditions. In the trials, gritty and very gritty scallops successfully degritted themselves producing scallops with just traces of grit, some having the appearance of dived scallops. Degritting appeared to have no adverse effect on the eating quality of the scallops but because of the lack of an expert assessment panel on the trials sites, that aspect of the work cannot be considered rigorous.

The results are very largely similar to those of the previous work on degritting cockles (Ref. 13) and to the wide range of bivalve mollusc handling and purification work carried out by Seafish with a number of species. That work has demonstrated common characteristics and handling requirements for bivalve molluscs although the optimal conditions vary with species.

For scallops to degrit satisfactorily, they must be in good condition such that when placed in suitable seawater conditions they will quickly resume filter feeding activity. They must not be in a stressed condition. Scallops are not adapted to life out of water or to temperature changes other than gradual seasonal temperature variation. They are 'live' animals and must be carefully handled between capture and re-immersion, without being thrown about or dropped. Like many other bivalve molluscs, they are fragile and highly susceptible to handling damage by drops, shocks and temperature stresses. Terminally damaged scallops with shell or internal organ damage should not be placed in the tanks as damaged bivalve molluscs will not function and usually die when immersed, then spoil rapidly at the relatively high temperatures required for scallop degritting. These dead molluscs also harm the water quality, particularly in closed loop recirculation 'purification' type systems, which then affects the viability of the other molluscs in the tank.

For successful degritting, scallops should be held at a similar temperature to the seawater from which they were harvested and they should not be subjected to rapid and large fluctuations in temperature. Scallops for 'live' handling should not be directly iced or chilled prior to

immersion as this stresses them. This confirms previous studies showing the temperature sensitivity of scallops and that such thermal shocks will effect their viability in the tanks (Refs. 4 and 11). However, for scallops destined for processing without degritting or not to be kept 'live' then it is best to ice them down as dead animals.

A further significant factor affecting scallop degritting is the time delay between catching and immersion, as beyond 24 hours out of water even at optimum holding temperature little activity was observed in the scallops when immersed. This maximum time delay will probably limit scallop degritting ashore to a day boat fishery. Combination of delay and holding temperature stress magnifies the adverse effect on the scallop activity. At chill temperatures a delay of only 12 hours results in unsatisfactory degritting.

Degritting was successful throughout the range water temperatures in the tanks of between 11 and 19 °C although there is some indication of reduced activity at 11 °C. It is not known whether degritting would take place outside these limits but it is likely that at much above 19 °C as the oxygen holding capacity of the water reduces and the activity of the scallops increases, oxygen starvation and mortality would occur. At temperatures much below 11 °C there would be sufficient dissolved oxygen in the water but the scallop activity would be reduced and longer immersion times required. Because scallops have been shown to require high levels of dissolved oxygen (Ref. 4), a practical maximum seawater temperature of 18 °C is recommended.

For effective degritting, scallops should be immersed in seawater for at least 10 hours and although some scallops were active after 36 hours in the tank, there is little additional benefit of immersing for longer than 24 hours. In optimum conditions of short delays and little temperature stress, then the immersion period required is short and it may also be possible for scallops to be kept in the tanks for long periods. However, it it is not known from this work whether scallops can remain viable in tanks for longer periods.

Some scallops were very active and 'swam' around in the tanks but there was no apparent need to constrain them and the majority of scallops remained in the same position, despite actively filtering. However, the cleanest degritted scallops were produced by suspending them vertically in nets. When held in this position, grit naturally falls out of the shells even if there is little activity. The advantage of suspending scallops would probably be outweighed by the practical difficulties and the time involved in hanging the scallops compared to simply loading them into trays.

Given the correct conditions, artificial seawater may be used for degritting, as scallops were observed to be active and their grit scores reduced just as well as those in natural seawater. It would therefore be possible for the degritting process to take place inshore or where there is no uncontaminated seawater available, provided that the delays, holding temperature and the water quality parameters are controlled.

Although degritting can be undertaken in purification tanks, some of the various control procedures required for purifying molluscs are not required if immersion is solely for the

purpose of degritting, i.e. is to improve product quality rather than ensure product safety. However, sufficient controls should be in place when operating degritting tanks to prevent the possibility of product contamination. Further advice is given in the Seafish Guidelines for Handling Bivalve Molluscs (Ref. 6).

The standard practice of soaking shucked scallops for 24 hours in chilled water typically results in a 30% weight increase and a loss of flavour (Ref .12). A by-product of the degritting process is that there is an even greater weight increase when the meats are soaked. Further work would be required in this area to understand the mechanism of weight gains during degritting and soaking. There are also important implications re product weight and labelling legislation, product quality, effects on drip loss, moisture content and water:protein ratio of the product.

7. Overall Conclusions and Recommendations

1. Dredged scallops are gritty with over 90% having varying levels of grit within the shell (ranging from traces to very gritty).

2. Grit is effectively removed by processing but in the whole scallop, detracts from appearance and results in accelerated spoilage. This is reflected in the lower value of dredged scallops.

3. Given the correct conditions, dredged 'live' scallops can be effectively degritted by their own filtering action when immersed for a period in seawater in purification type tanks.

4. For degritting to be effective, the scallops must have been carefully handled and remain viable:

   - physical and temperature shocks should be avoided. The scallops should not be thrown about.

   - the holding temperature between capture and re-immersion should be similar to the seawater temperature in which the scallops were caught. They should not be iced or chilled or overheated. A temperature range of 5-15° C is generally recommended for holding 'live' scallops.

   - delay between capture and re-immersion should be minimised. Allowing for the circumstances of commercial handling, a maximum delay of 12 hours is recommended.

   - dead or terminally damaged scallops should not be placed in the degritting tank.

5. For degritting to be effective, immersion in the degritting tank should be controlled:

   - the seawater should be clean, full salinity and oxygenated. The seawater can be natural or artificial.

   - the seawater temperature should be sufficient to stimulate the scallops but not so high that they exhaust themselves and run out of oxygen. A seawater temperature range of 10-18 °C is generally recommended for scallops.

   - the period of immersion should be sufficient for degritting but mortalities may occur during extended immersion. An immersion period of 10-24 hours is generally recommended for scallops.

6. These controlled conditions of immersion are best provided by a standard purification tank type system. Further guidance on this is given in the Seafish Guidelines for Handling Bivalve Molluscs (Ref. 6).

7. These constraints on degritting probably limit degritting ashore to the landings of day boats.

8. Degritting does not appear to affect the storage or eating qualities of the processed product is shucked soon after degritting, but may well result in reduced spoilage if unprocessed scallops are to be held 'in shell' for a period after degritting, although more controlled work is required to be precise about these aspects.

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