Defining free of flesh shell

The current Animal By-products Regulation (ABPR) permits the use of shells from shellfish with the soft tissue and flesh removed (free of flesh) for certain defined technical uses. However ‘free of flesh’ is not defined and it is currently unclear which shellfish can be produced to this standard. At present ‘free of flesh’ is taken to mean free of visible signs of flesh i.e. is a visual inspection. However, there are concerns from regulators about whether the current legal framework is effective and the extent to which it can be interpreted and implemented differently.

The ABPR is currently under revision and Member States can define ‘free of flesh’ and develop their own standards within the implementing regulation. It also allows for the development of guidance to clarify procedures and allow greater flexibility.

The review of ABPR provides an opportunity to exclude free of flesh shell from the scope of the Regulation. However, to do so, ‘free of flesh’ shell needs to be defined. This project was devised to assess shell cleaning processes and to undertake testing on a range of different shellfish to determine suitable criteria and tolerance limits.

Specific objectives

- To test specific shellfish against different shell cleaning methods currently in use, to assess whether they can be made ‘free of flesh’.
- To provide criteria that can be used to define free of flesh (FOF) shell.

Method

Seven shellfish species were assessed; *Nephrops norvegicus*, brown crab, king scallop, queen scallop, mussels, cockles and whelks.

The methods of further processing currently utilised to produce FOF shell are; Manual Processing; Washing only; Washing followed by Drying; Drying and an Acid Wash (caustic clean).

Representative processed samples of these shellfish types were obtained from industry. Samples of shellfish as they came off the production line and after they had been subject to a shell cleaning process were obtained wherever possible. However, some species/cleaning process combinations are not practiced in the UK and as such some cleaning processes were ‘emulated’ through laboratory testing to provide comparative data. No occurrence of mussel processing to remove flesh and produce FOF shell could be located in the UK and as such processing and FOF cleaning were ‘emulated’ for this species.

Particular care was needed in obtaining representative control samples to establish shell characteristics in the complete absence of flesh so a variety of methods were attempted to produce representative control samples.

Where possible producers of free of flesh shell were visited and information about their shell cleaning process obtained. This information was used to develop standardised cleaning procedures.

Each type of shellfish, treated by each type of process, was tested according to the following;

Tests undertaken	Method used
Visual	Scoring flesh presence from 0-100% in 5% increments based on the presence of flesh on up to x20 shell fragments Odour was simply recorded as 'none', 'slight' or 'strong,'
Leach Tests	adding a known shell mass to a set volume of liquor with the objective of transferring the flesh from the shell into the liquor where it can then be tested to provide an alternative means to assess FOF flesh content. A range of leach types were performed: -water -brine (20% w/v of salt) -caustic (various sodium hydroxide concentrations) -Trichloroacetic acid (TCA) -Dimethylsulphoxide (DMSO) -Protease enzymes (144 and 439)
Volatile solids	recognised to be representative of 'flesh' component, whilst the residual ash is considered the inorganic component including the shell
Nitrogen (N)	Total nitrogen is also a useful measure of flesh with a close correlation to protein content.

Results

The following tables provide a summary of the results for each parameter tested. The tolerance limit for tests was ≤1%.

Species	Visual and Odour Quality Results
Cockle	No flesh could be seen in the Processor A cooked FOF sample and the emulated caustic wash FOF sample, although a minimal level (5%) was observed in the emulated cooked FOF sample. In terms of odour a cooked FOF sample had a slight smell of mud but nothing reminiscent of flesh.
King Scallop	No flesh was observed on washed king scallop, FOF and cooked samples, and caustic washed FOF sample. Only slight odour on one of the emulated washed samples
Queen Scallop	20% and 25% flesh occurrence was observed in the washed FOF sample and the cooked FOF samples respectively, although it should be noted the mass of visible flesh and odour was minimal. No flesh could be seen in the emulated caustic wash FOF sample.
Whelk	Actual FOF whelk samples showed no observable flesh although a wash emulated sample did show retained flesh.
Mussel	0-5% flesh was observed on emulated washed mussel sample whilst the emulated caustic wash sample showed no observable flesh.
Crab	Emulated wash FOF crab samples exhibited moderate (5-25%) flesh although a caustic wash emulated sample did not show retained flesh.
Nephrops	Emulated wash FOF crab samples exhibited moderate to high (30-50%) flesh levels although a caustic wash emulated sample did not show retained flesh.

Species	Volatile Organic Results
Cockle	Organic contents (volatile solids) in cooked shell samples varied from 2.8% (emulated cooked FOF) to 10.3% which when corrected with the 'control' sample with 1.8% volatile solids yields a 1% and 9.3% flesh content for emulated and processors sourced sample respectively. These analytical results would tend to mirror the visual observations which showed that the processor sourced sample looked muddy. The organic content of the emulated caustic wash FOF sample was similar to that of the control and therefore considered negligible.
King Scallop	Organic contents (volatile solids) in all FOF samples were similar to that of the control (~1% flesh) and therefore considered negligible.
Queen Scallop	Organic contents (volatile solids) in all FOF samples were similar to that of the control (~1% flesh) and therefore considered negligible.
Whelk	The organic content analysis when corrected by the control all yielded FOF samples lower than the 1% flesh limit. However, the control sample exhibited high levels of contamination appearing to have higher volatile contents than the 'dirty' sample and must therefore be discounted. In consequence, the uncorrected sample results exceed the 1% limit and are considered marginal.
Mussel	The organic content analysis corrected by the control sample showed all FOF samples exceeded the 1% flesh limit with ~3-5% flesh.
Crab	The organic content analysis when corrected by the control all yielded high flesh levels between 5-21% far exceeding the 1% flesh limit.
Nephrops	It was not possible to correct the organic content using the control sample which appeared to be contaminated. Uncorrected results suggest high flesh levels between 28-41% exceeding the 1% flesh limit.

Species	Nitrogen content results
Cockle	Total N contents were low ranging from 670-1220mgN/kg (dry wt.) although once factored to protein and flesh this exceeds the qualitative 1% flesh presence limit (1-4% when control corrected).
King Scallop	Total N contents were very low ranging from <410-710mgN/kg (dry wt.) which when factored to protein and flesh is around the qualitative 1% flesh presence limit.
Queen Scallop	Total N contents were very low ranging from <410-870mgN/kg (dry wt.) which when factored to protein and flesh is around the qualitative 1% flesh presence limit.
Whelk	Total N contents were moderate ranging from 740-6970mgN/kg (dry wt.) which when factored to protein and flesh is around 2-20% flesh exceeding the qualitative 1% flesh presence limit
Mussel	Total N contents were moderate ranging from 3810-10250mgN/kg (dry wt.) which when factored to protein and flesh is around 15% flesh far exceeding the qualitative 1% flesh presence limit. However, control sample total N levels were significant possibly as a result of the marked brown periostracum layer. Coupled with the thin shells typical of rope grown mussels it is likely that residual organic and total N levels are elevated relative to bottom grown mussels where there will be a lower surface area : mass ratio.
Crab	Total N contents were high ranging from 13570-40480mgN/kg (dry wt.). However, theoretical assessment of the shell contribution to the total N indicate this may be >13,900mg/kg and may therefore account for all of the total N seen in the emulated caustic cleaned sample therefore indicating this may be FOF. A similar level of correction in more dirty emulated washed FOF sample indicates a corrected flesh level of ~10%. It is concluded that the residual total N levels are so large that caution should be adopted in assessing this result.
Nephrops	Total N contents were high ranging from 22970-36740mgN/kg (dry wt.). As with crab, theoretical assessment of the shell contribution to the total N indicate this may be >24,000mg/kg and may therefore account for all of the total N seen in the emulated caustic cleaned sample therefore indicating this may be FOF. A similar level of correction in more dirty emulated washed FOF sample indicates a corrected flesh level of ~20%. As with crab it is concluded that the residual total N levels may compromise the value of this assessment.

Total N results are problematic in terms of both their conversion into ‘flesh’ content and their residual content. As such visual inspection coupled with testing for volatile solids is recommended.

Species types were ranked in order of free of flesh status. The following table shows these rankings and their suitability for producing free of flesh shell. Free of flesh methods are available for cockles and scallops, whilst whelk and mussel have a marginal free of flesh status requiring further determination. Crab and *Nephrops* could not be produced free of flesh, although the caustic clean method was marginal and shows promise. It is apparent that molluscs are generally easier to treat to free of flesh status, using the defined criteria, compared to crustacea which present certain challenges.

Ranking	Ease of Flesh Separation	Free of flesh Status
1	Cockles	Good
2	King scallop	Good
3	Queen scallop	Good
4	Whelk	Moderate
5	Mussel	Moderate
6	Crab	Bad
7	*Nephrops*	Bad

Cleaning types were compared and grouped according to flesh removal mechanism. ‘Cook Separation’ (manually processing) was effective for certain species (cockle and queen scallop). ‘Washing’ was effective for scallop, while ‘Degradation’ by caustic washing provided the best overall performance for most species.

Samples of dirty scallop shell

Samples of free of flesh scallop shell

Conclusions and recommendations

- A tolerance level of up to 1% was used. It is virtually impossible to test below this limit due to the limitations of the tests and the residual background composition of the shell.
- Nitrogen is ineffective as an accurate test for flesh due to the present of high residual levels in the composition of the shell. The same applies for any compositional based test directly upon the shell (i.e. carbon, protein, nitrogen etc.)
- Visual inspection and volatile solids are deemed to be currently the most effective tests and are recommended for the purposes of defining ‘free of flesh’ shell.
- The enhanced leach, enzyme extraction method is indicated as a better quantitative method but needs further work / development.
- There are differences between molluscs and crustacea; molluscs being much easier to clean to FOF standards compared to crustacea. But with different levels of treatment, crustacea could theoretically be cleaned to free of flesh standards (but whether that is commercially feasible is a separate issue).
- Odour is not necessarily an indicator that flesh is present; it is intrinsic to processed shellfish.
- The most effective cleaning methods vary according to species; there is no one solution that fits all. Some methods are ineffective for all species.

Further work

Additional work is required to look at the efficacy of:

- a combination of processes
- biological treatment i.e. using a biological washing agent
- A leachate / enzyme test as a better method of testing.

Further information

- Copies of the full report are available on the Seafish website www.seafish.org
- Contact Michaela Archer – m_archer@seafish.co.uk or tel 01472 252332

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