Reflections on the microbiological monitoring of seafood products

Quality control in foods, including seafood, tends to centre around education and training, risk management strategies such as HACCP, inspection of facilities and processes and microbiological testing.

In this article we will focus on the last of these and consider its value and limitations. Enumeration of bacterial numbers is often used as a retrospective assessment of microbiological quality or as a means of assessing the presumed safety of products.

The first aspect of microbiological testing to consider is the number, size and type of samples to be collected. With fish and seafoods it is virtually impossible to get a sample that is truly representative of the whole batch or lot. So, microbiological testing is often giving us an indication of possible status, rather than the status of a product.

Thus, several factors need to be taken into account when devising a testing programme. These include the reason why we are testing, the nature of the product to be tested and the nature of the testing to be performed. Some testing is just looking for the presence or absence of an organism such as salmonella. In this case, the sampling plan is defined in terms of the number of samples to be taken (n) and the maximum number of these which can be positive (c).

Then the testing regimen can be described as n=5, c=2, that is five samples have to be tested and no more than two of these can fail (yield the undesirable bacterium). This is often known as a '2-class sampling plan'.

In a '3-class plan sampling plan' acceptable counts are differentiated from marginal ones and a third figure (M) is introduced. Then we might say, n=5, m=3, and M=1. In other words, we test 5 samples and fail the batch if either more than one product exceeds the count M or more than 3 fail the count m, when M is the boundary between marginally acceptable and unacceptable and m separates acceptable and marginally acceptable counts.

The more samples we test the greater the likelihood that we can have confidence in the test results. Even so, even if we have a very rigid scheme, for example n=60 and c=0, there is still a 30% risk of accepting product in which 2% of sample units (packs) are positive! Thus, the most elaborate of end product testing protocols can never guarantee product safety!

For this reason, we should never guarantee the microbiological negativity of a product but just state the testing that has been done and whether it did (or did not) yield any positive results.

Taking this a stage further, it is logical to increase the number of samples taken depending on the degree of hazard of the food. All this can be summarised for fish and seafood by the data in Table 1, known as the ICMSF 1986.

However, in the 1990s it was concluded that this approach did little to provide safety to the public and that it was not practical to address this by just raising the number of

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Table 1. Sampling plans and recommended microbiological limits for seafood (ICSMF 1986). Hazard ratings 0-3 reflect no hazard; 13-15 reflects a severe direct hazard. Class refers to class of sampling plan (see text).

Product	Test	Hazard	Class	n	c	Limit per g m	Limit per g M
Fresh and frozen; cold smoked fish	Total	1	3	5	3	$5x10^5$	10^7
	E. coli	4	3	5	3	11	500
Pre-cooked breaded fish	Total	2	3	5	2	$5x10^5$	10^7
	E. coli	5	3	5	2	11	500
Frozen raw crustaceans	Total	1	3	5	3	10^6	10^7
	E. coli	4	3	5	3	11	500
Frozen cooked crustaceans	Total	5	3	5	2	$5x10^5$	10^7
	E. coli	5	3	5	2	11	500
	Staph. aureus	8	2	5	0	103	-
Cooked, chilled and frozen crab meat	Total	2	3	5	2	10^5	10^6
	E. coli	6	3	5	1	11	500
	Staph. aureus	9	2	5	0	10^3	-
Fresh and frozen bi-valve molluscs	Total	3	2	5	0	$5x10^5$	-
	E. coli	6	2	5	0	16	-

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samples taken and greater emphasis on the use of HACCPs in production to give real time control during processing came to the fore. Nowadays, microbiological testing focuses more on detecting pathogenic bacteria and faecal indicators.

Types of bacteria

We will now look at some of the types of bacteria tested for and put their significances into context.

The total viable count or TVC is influenced by the temperature the agar plates are incubated at in the laboratory. High counts as a result of microbial growth in food are more likely to be associated with problems than high levels arising from recent contamination. Therefore, TVC is of no value when it comes to aesthetics or sensory qualities.

TVCs are also of little value in foods where there are large populations of non-spoilage lactic acid bacteria. Also an unknown bacterial kill can occur and in such a scenario the presence of a low TVC can be very misleading.

E. coli comes from man and vertebrate animals and in temperate waters fish and crustaceans do not contain E. coli at time of capture. Thus, E. coli is a useful indicator of post harvesting mishandling.

E. coli can occur in tropical waters or fish/seafood derived from such waters so, in the tropics, E. coli is not a reliable indicator of post harvesting contamination. E. coli is more sensitive to adversities than, say, enteric viruses and so their value as a faecal indicator must be questionable.

Faecal enterococci or streptococci are not a very reliable faecal indicator as many seafood products contain these bacteria as part of their normal flora and they can become 'resident bacteria' in processing facilities.

Staphylococcus aureus in small number are likely to have come from man, whereas high numbers are probably indicative of faulty hygiene or production practices.

Microbiological criteria (Table 2) should only be established where there is a need for them and when it can be shown to serve an effective and practical use.

When devising microbiological criteria due cognisance should be given to:

- The nature of the product.
- The product's microflora.
- Whether it presents a hazard.
- Processing effects, for example, cooking or mincing.
- The state in which the food is distributed.
- How it will ultimately be consumed (will it be cooked?).
- Are there reliable and practical methods of detection?
- Cost.

A microbiological standard should only be created when it can be shown that there is a relationship between a food and outbreaks of disease, exceeding the limits correlates to product decomposition or the standard will eliminate a health risk and/or reject products of dubious condition or that have been produced under dubious conditions.

Nowadays, all this needs to be coupled to an understanding of HACCP. In HACCP we put into processing systems that will control microbiological hazards.

A very effective control is cooking. If we use cooking as a CCP (Critical Control Point) we can use microbiological testing to verify the CCP.

Then we know that a certain temperature time combination on a particular oven kills off all the bacteria. After that we can measure time and temperature on that particular oven and if we achieve the levels we have previously confirmed to be effective by microbiological testing we know the product should be safe.

Time and temperature testing has the great advantage of being in real time and, so, if the predefined limits are not met, management can instantly define a corrective action such as extending or repeating the cooking.

In this example microbiological results could be obtained days later when the product is well down the distribution chain.

So, in 2011 microbiology is a little more about using microbiological testing to confirm effectiveness of CCPs and a little bit less about confirming end product status. ■

Table 2. Microbiological criteria.

- **Microbiological Standard** is a microbiological criterion that is defined in law and, as such, is a mandatory criterion.
- **Microbiological Guideline** is a criterion used to assess microbiological conditions during the processing, distribution and marketing of foods and is, therefore, an advisory criterion.
- **Microbiological Specification** is defined in purchase agreements between buyer and vendor and, as such, is subject to the law of contract.