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Microbiological quality of chilled pasteurised food products

Over the past 20 years or so, the chilled foods industry has been using two target pasteurisation processes for products such as chilled soups, sauces, ready meals and cooked meats to assure safety. These processes separate chilled foods into two generic categories: short shelf life products and long shelf life products (>10 days). Short shelf life products are pasteurised at 70°C for 2 minutes, whilst long life products are treated at 90°C for 10 minutes. These processes ensure product safety and aim to achieve a 6 log reduction in the food pathogen likely to be of most concern to these products, namely *Listeria monocytogenes* and *Clostridium botulinum*. As an option to achieving these target pasteurisation treatments, chilled foods can be formulated to recommended parameters in terms of pH and aw to prevent growth of these pathogens should they be present. This document looks at these two sets of controls and provides a decision tree to help manufacturers decide which controls apply to their food products.

In addition, it is recognised that there are other microorganisms which may be capable of surviving the target pasteurisation temperatures and growing in the food products during chilled storage, for example, psychrotrophic strains of *Bacillus* and *Clostridium*. This white paper describes the survival and growth characteristics of relevant bacterial species in order to understand their potential effect on product quality and shelf life of chilled pasteurised food products. In addition recent data obtained on a Campden BRI member-funded project is presented (see www.campdenbri.co.uk/research/shelf-life-chilled-foods.php).

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Shelf-life categories

Over the past 30 years there has been continued attention given to the safety of chilled food products. There are various guidelines available to ensure the safe manufacture of chilled foods and these typically consider the microbiological risks based on the duration of their shelf life. There are 2 main categories to consider with respect to shelf life: short shelf life, i.e. ≤10 days and long shelf life, i.e. >10 days.

(i) Short shelf life foods ≤10 days

The minimum heat process currently recommended to assure safety from *Listeria monocytogenes (Lm)* in pasteurised chilled foods with a shelf life of more than 5 days is 70°C for 2 minutes (or a time/temperature that give equivalent lethality). Where this is not achieved then the Food Business Operator (FBO) has to demonstrate the potential or not for *Lm* to grow in the food during its shelf life. If a food meets one of these criteria then it is not necessary to assess the growth potential of *Lm* as it is considered unlikely to be able to grow.

- Heat treatment 70°C/2minutes or other effective process step able to achieve adequate elimination of *Lm* where recontamination is not possible, e.g. treatment to be given in final pack
- pH <4.4
- aw <0.92
- pH <5.0 **and** aw<0.94
- products with a shelf life of <5 days

If the above criteria are not met then the FBO should be satisfied that the product formulation and storage will not allow growth of *Lm* should it be present. This can be done by durability studies, predictive modelling or challenge testing.

If the intended product shelf life exceeds 10 days then the criteria recommended for long-life products should also be considered.

(ii) Long shelf life >10days

For long life chilled foods, the organism of most concern is psychrotrophic *Clostridium botulinum*. This organism is not considered likely to grow and produce toxin in most chilled foods stored below 8°C within 10 days. However, growth and toxin formation could potentially occur after 10 days if the organism were present. Therefore, the FBO should ensure that this organism is inactivated by the heat treatment or inhibited by the formulation of the product in products given a shelf life in excess of 10 days.

In order to have a shelf life of >10 days, a chilled food product should have at least one of the following:

- Heat treatment 90°C/10 minutes or other effective process step able to achieve adequate elimination of *C. botulinum* where recontamination is not possible, e.g. in final pack
- pH <5.0
- aw <0.97
- aqueous salt level of 3.5% or higher

If none of the factors are present then it is the responsibility of the FBO to demonstrate that the combination of factors present in the food will inhibit the growth of and toxin production by *C. botulinum*. This can be achieved by predictive models or challenge tests.

If none of the above is achieved, then such products should have a shelf life not exceeding 10 days.

How to assess the safety of chilled foods

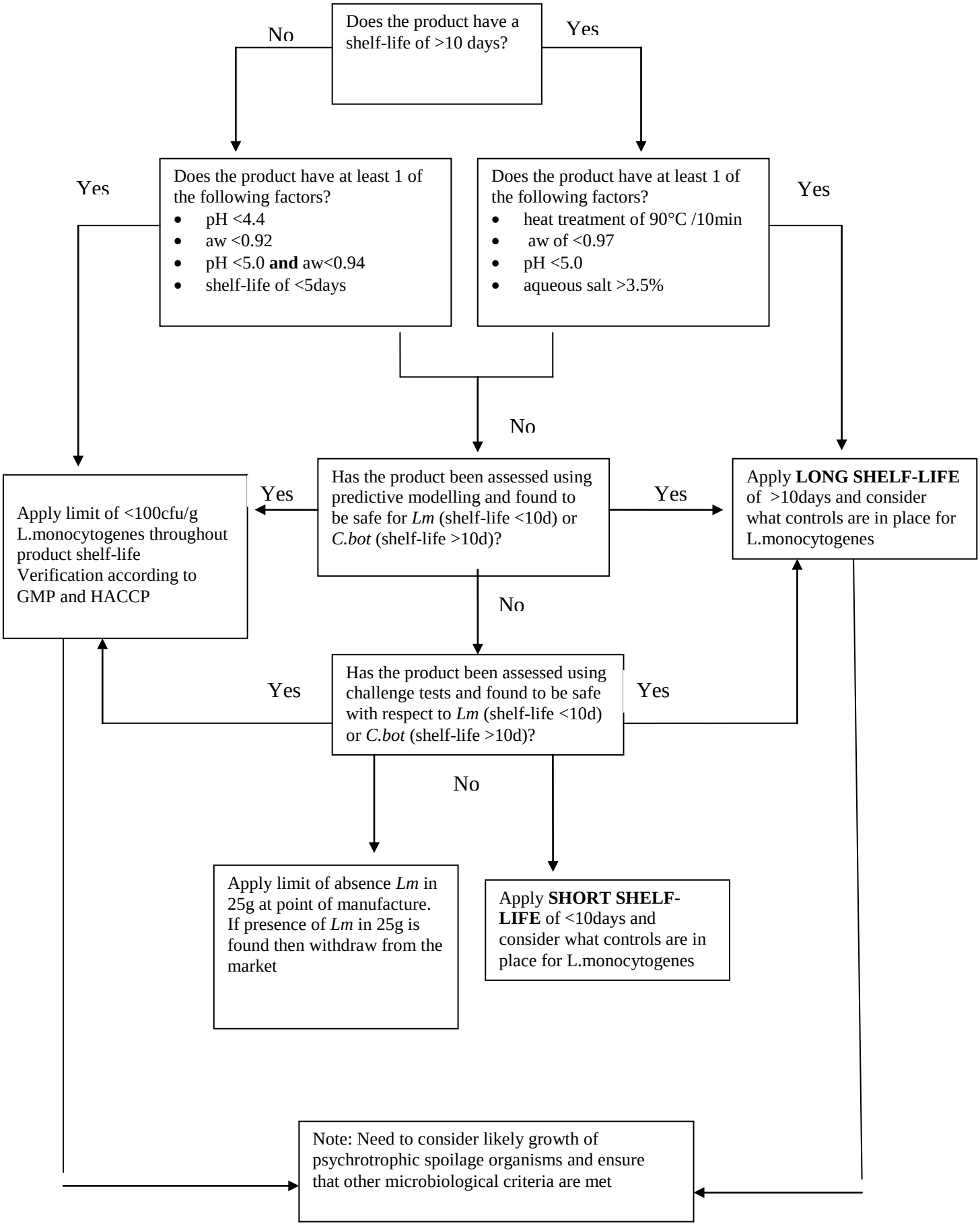
It can be confusing for the non-specialist to decide what category a RTE food falls within and what approach needs to be taken to assure the safety of the product. Figure 1 provides guidance for FBOs to decide which organisms are of most significance to their products and what evidence needs to be gathered to demonstrate the safety of the product.

When assessing the potential risks of a chilled food product using the decision tree, the process should be documented and a clear statement given on the choice of approach with respect to assessing safety (and quality) of the product.

The first branch of the tree determines whether or not the product has a long shelf life. Any long life products need to consider the *C. botulinum* controlling factors whilst shorter life products do not. The second branch considers whether the product meets any of the controlling factors for *C. botulinum* or any of the controlling factors for *Lm*.

Where none of the controlling factors are met then the products should be assessed for safety using predictive models, durability studies or challenge tests. The product should also be assessed for quality with respect to other organisms using appropriate shelf life studies.

Figure 1: Decision tree for assessing the safety of chilled food products



Microbiological quality of chilled foods

As well as the potential risks with *Listeria monocytogenes* and *C. botulinum,* there are other spoilage organisms which should be considered when setting the shelf life of chilled pasteurised foods.

Organisms of particular concern with respect to potential spoilage of pasteurised chilled products are psychrotrophic strains of *Bacillus* and *Clostridium* species. These organisms produce spores which may survive the various cooking steps and have the ability to grow at chill storage temperatures.

Psychrotrophic Bacillus species

The majority of reports of psychrotolerant *Bacillus* species in foods relate to the egg and diary industry and more recently vegetable products and starchy foods. Survival in these products occurs because the pasteurisation treatments given will inactivate any vegetative cells present leaving only bacterial spores, which will be present during subsequent storage. Many *Bacillus* species are mesophilic and will not grow at refrigeration temperatures. However, a number of species are adapted to grow at temperatures below 8°C.

A wide range of psychrotrophic *Bacillus* species have been isolated from cooked, chilled vegetable products, which is perhaps not surprising as sporeformers are often associated with soil and with the dried ingredients used in vegetable products. In one investigation, commercial preparations of broccoli, carrot, courgette, leek, potato and split pea were produced under normal processing conditions by a chilled food manufacturer. The vegetables were steam cooked, mixed with dairy ingredients and pureed. Courgette spoiled the most rapidly with TVC levels of $>10^7$ cfu/g reached within 7.5, 18 and 25 days at 9°C, 8°C, 6.5°C and 4°C respectively. The authors identified a range of psychrotrophic *Bacillus* species from the purees at 4°C, including *B. circulans*, *B. macerans* and *B. polymyxa*, whilst mesophilic strains dominated at temperatures of 10°C and higher, i.e. *B. licheniformis*, *B. subtilis* and *B. cereus*. *Bacillus weihenstephanensis* is another psychrotolerant sporeformer noted for its ability to grow at 5-7°C, It is able to spoil a range of chilled foods but has also been shown to produce cereulide, the emetic toxin produced by strains of *B. cereus*.

Psychrotrophic Clostridium species

Since the late 1980's there has been a known association of psychrotrophic *Clostridium* species with spoilage of raw and cooked vacuum packaged chilled meat products. A range of psychrophilic and psychrotrophic *Clostridium* species have the potential to grow at very low temperatures, in some cases down to -1.5°C, and in the anaerobic conditions used for meat storage.

Other food groups, e.g. dairy and vegetables, do not seem to be associated with these organisms. The range of psychrotrophic *Bacillus* and *Clostridium* species associated with pasteurised chilled foods is

shown below. For a full review of their growth characteristics see R&D report 366 - *Microbiological safety and quality of chilled pasteurised food products: A review.* (This is available free to members – send an e-mail to auto@campdenbri.co.uk with the subject line: **send RD366**)

Table 1

Bacillus spp	*Clostridium* spp
B. cereus	*C. algidicarnis*
B. mycoides	*C.estertheticum*
B. thuringiensis	*C. laramie*
B. circulans	*C.gasigenes*
Paenobacillus polymyxa	*C.frigidicarnis*
B. macerans	*C.lituseburense*
B. weihenstephanensis	*C.sordeli,*
	C.tertium
	C.algidicarnis

Data from on-going research project

Current work is underway at CampdenBRI, to investigate the growth of psychrotophic *Bacillus* species in relation to pasteurised chilled foods. Many *Bacillus* species were found to be able to grow at chill temperatures within 10 days, which has implications for the potential quality and safety of pasteurised chilled foods.

Table 2

Culture	5°C	8°C	12°C	15°C
B.lichenformis	NG	NG	12	5
B.pumilis	NG	7	5	2
B.weihenstephanensis	9	5	2	1
B.pumilus	12	5	2	1
B.pumilus	9	8	6	2
B.pseudomycoides	NG	14	7	1
B.amyloliquefaciens	NG	NG	NG	2
B.pyschrodurans	8	5	5	2

Furthermore, the current study is looking at the level of inactivation achieved by theoretically equivalent heat processes. A process equivalent to 10 minutes at 90°C is required for long life chilled pasteurised foods. Two equivalent processes often used are 85°C for 36 minutes and 80°C for 130 minutes. The data below (Table 3) show the amount of log reduction achieved by these three equivalent processes at a range of pH values. For some of the *Bacillus* species, e.g. *B. pumilus*, the level of inactivation achieved at 80°C was less than that achieved at 85°C or 90°C, even though the processes are theoretically equivalent. In addition, the inactivation levels achieved at pH5 were generally

greater than those achieved at pH 7, showing the interactive effects between heating temperature and product pH.

Table 3

	90°C/10 min			85°C/36 min			80°C/130min		
	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7
B.weihenstephanesis	4.43	4.47	4.41	3.43	3.47	4.41	4.43	3.47	4.41
B.pumilis	3.45	2.11	1.74	3.82	1.33	0.36	1.78	1.50	0.76
B.pseudomycoides	1.95	1.54	1.53	0.69	0.31	0.12	0.91	0.33	-0.37
B .pumilus	2.34	0.71	1.39	1.95	0.61	0.54	2.15	0.87	0.15
B.pyschrodurans	2.90	2.48	2.27	1.60	1.48	1.88	2.30	2.78	2.70
B.cereus	4.70	3.84	3.65	4.00	3.79	3.10	4.40	3.74	3.00
B.cereus	3.23	3.49	3.23	3.23	3.49	3.23	3.23	3.34	3.23

Further studies are on-going to look at the outgrowth of heated spores under different conditions of pH and water activity.

Conclusions

The shelf-life of pasteurised chilled foods is affected by foodborne pathogens and spoilage organisms. The pathogens are controlled by application of industry standard heat processes: either 70°C/2minutes for short-life products or 90°C/10minutes for long life products. These processes do not necessarily control spoilage by psychrotrophic *Bacillus* species.

On-going studies have demonstrated the potential for these bacilli to survive pasteurisation processes and grow at chill temperatures. Such studies are continuing to provide data on the effect of process temperature, pH, aw and atmosphere on growth of psychrotrophic sporeformers. Manufacturers of long-life pasteurised chilled foods should consider the potential risks from this group of organisms during product development.

We are continuing our studies in this area, so if you have concerns over your products and processes, please get in touch.

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