Ministry for Primary Industries
Manatū Ahu Matua

# How to Determine the Shelf-life and Date Marking of Food

## A Draft Guidance Document

MPI Discussion Paper No: 2012/27

ISBN No: 978-0-478-40483-8 (online)
ISSN No: 2253-3907 (online)

December 2012

New Zealand Government

*Growing and Protecting New Zealand*

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# How to make a submission

The Ministry for Primary Industries (MPI) has revised and updated *Information Booklet for the Food Industry − A Guide to Calculating the Shelf-Life of Foods*: http://www.foodsafety.govt.nz/elibrary/industry/Guide_Calculating-Contains_Background.pdf

The draft revised guide *How To Determine The Shelf-Life And Date Marking Of Food* is intended to help manufacturers and processors of food to determine the shelf-life of their food products and to apply appropriate date marking. The draft revised guide describes:

- how shelf-life is defined;
- the causes of food deterioration and spoilage;
- why food may become unsafe during storage;
- how to decide whether a 'best before' or 'use by' date mark is required;
- the information needed to work out what the shelf-life is; and
- how to ensure the safety of chilled foods.

For the purposes of this draft revised guide chilled foods have been defined as those that require storage at 5˚C or less to maintain their suitability and safety.

Standard 1.2.5 in the Food Standards Code (current edition) Date Marking of Packaged Foods sets out the date marking provisions and applies to packaged foods with a shelf-life of less than two years. Date marking can be either a "use-by" or a "best-before" date and these requirements apply to food sold in New Zealand. The shelf-life of a product begins from the time the food is prepared or manufactured. Date marking is required on all packaged foods with a shelf-life of less than two years (with the exception of infant formula where date marking is required irrespective of the length of the shelf-life).

The FSANZ Date Marking User Guide to Standard 1.2.5 – Date Marking of Packaged Food outlines the requirements. The FSANZ User Guide can be used to decide whether a "best-before" or a "use-by" date is appropriate for a food: http://www.foodstandards.gov.au/foodstandards/userguides/datemarking.cfm

It is intended that this MPI draft revised guide provides further background information to the FSANZ User Guide.

You are invited to comment on the draft revised guide *How To Determine The Shelf-Life And Date Marking Of Food.*

Please send any comments on the draft to the address below by 5:00pm,
Thursday 31 January 2013.

Submitters are asked to include the following information with their submission:

- the name and title of the submitter;
- organisation's name where applicable;
- submitters address and contact details (phone, fax and e-mail if available);
- the title and number of the clause(s) commented on where appropriate.

Submissions should be addressed to:
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All submissions are subject to the Official Information Act 1982. Therefore if you consider that all or part of your submission is commercially sensitive or should be treated as confidential, please state this clearly when making your submission.

Judy Barker
Manager (Animal Products)
Animal and Animal Products Directorate

# 1 Scope

This guide is intended to help manufacturers and processors of food to determine the shelf-life of their food products and to apply appropriate date marking. It describes:

- how shelf-life is defined;
- the causes of food deterioration and spoilage;
- why food may become unsafe during storage;
- how to decide whether a "best before" or "use by" date mark is required;
- the information needed to work out what the shelf-life is; and
- how to ensure the safety of chilled[1] foods.

# 2 Shelf-life definition

The shelf-life of a food is the period for which it remains safe and suitable for consumption. This means that the food has not deteriorated in quality or spoiled in any way that the consumer would find unacceptable. There should be no formation of toxic products within the food and no loss of significant nutrients below the levels listed on the label. The food must stay safe to consume i.e. should not cause food-poisoning because of the growth of pathogens or the production of toxins in the food during storage.

# 3 Changes that may occur during processing and storage

## 3.1 RATE OF SPOILAGE

Food is perishable by nature. Changes will take place naturally in all food while it is being stored by the processor, retailer and the purchaser. The changes can be rapid as with spoilage of raw meat and fish or they can take place over a period of days or weeks e.g. bread becomes mouldy, biscuits become stale and soft, and processed meats become smelly and slimy. For some foods, e.g. canned and very dry foods, the deterioration in the quality may not become apparent until after months or even years of storage.

## 3.2 EFFECT OF PROCESSING ON SURVIVAL OF MICROORGANISMS INCLUDING PATHOGENS

The processing of a food may eliminate or at least reduce the number of microorganisms present. This will usually extend the shelf-life of the food by reducing the numbers of spoilage microorganisms present. It is important to be aware that many processes applied to food e.g. washing fresh produce or pasteurising liquids will not eliminate all the microorganisms present and a few may survive processing. This applies especially to those bacteria that make heat-resistant spores. This means that most processed food is not sterile and will still show spoilage, but at a slower rate than unprocessed food. It is also important to be aware that any pathogens present in the unprocessed food or ingredients will usually have only been reduced to a safe level by the processing. So although they may be below detection levels in the food, if they grow in the food during storage, the food could become unsafe to consume after a period of time.

There are some bacteria that produce spores that are very resistant to heat processing and therefore may not be eliminated during processing. This includes both spoilage bacteria and pathogens. Where these spores could be present this will need to be taken into account when

[1] Chilled foods are those that require storage at 5˚C or less to maintain their suitability and safety.

establishing the shelf-life. Fungal spores on the other hand are easily destroyed by heat processing (see Table 1 for more information).

While most processing will decrease the numbers of pathogens present in the raw materials and ingredients, some food preservation processes will include steps that have the potential to increase pathogens numbers. This applies in particular to fermented foods such as cheese and salami. If the raw materials have not been treated to eliminate pathogens e.g. pasteurisation of milk, the conditions required for the fermentation to take place will also allow pathogens to grow. To ensure the safety of these foods it is necessary to ensure that the pathogen numbers in the raw materials are as low as practicable and that there are adequate hurdles in place to inhibit and eliminate surviving pathogens, e.g. acid development, salt, nitrites and nitrates.

Although processing would be expected in most cases to reduce the number of microorganisms present and make food safer, it may provide the opportunity for further contamination to occur. This is because some pathogens can become established in the processing environment and become a source of post-processing contamination after the processing has finished, before and during packing. The same problem can arise with post-processing contamination with spoilage microorganisms.

## 3.3 HOW CHILLED STORAGE IMPACTS ON SHELF-LIFE AND FOOD SAFETY

The shelf-life of many foods can be extended through chilled storage. Low temperatures slow down chemical changes and the growth of many spoilage and pathogenic bacteria, moulds and yeast. However there are some pathogenic bacteria that are able to grow readily at low temperatures. In some situations, while the levels of these cold-tolerant pathogens present may be considered safe at the start of the shelf-life, a longer shelf-life could give time for the pathogens to grow. This will have a major impact on the shelf-life of the food and the date marking requirements. Pathogenic bacteria that can grow in chilled foods that are a major concern for some foods are discussed in Section 7.0.

## 3.4 CHEMICAL CHANGES CAN OCCUR DURING STORAGE

Just as microorganisms can grow during storage, other changes in the composition of the food may occur. This deterioration may make the food unacceptable to the consumer as they will consider that it has spoiled and the quality does not meet their expectations. In some cases the changes in the food may make it unsafe due to the nature of the compounds formed during the breakdown. In some cases essential nutrient components will be reduced below the level that the consumer expects to be present. This will be important if the food is being consumed to ensure an adequate intake of a particular component, such as a vitamin. This will have an impact on the shelf-life labelling requirements.

## 3.5 FACTORS THAT IMPACT ON SHELF-LIFE

Information on the causes of food deterioration and spoilage and therefore what determines a product shelf-life can be found in Section 6. By understanding what are the most important factors impacting on the shelf-life of a food, it may be possible to manipulate these factors to extend the shelf-life. Conversely alterations to the composition, formulation, processing and packaging may inadvertently lead to a decrease in the shelf-life or make the food more susceptible to the growth of spoilage and/or even pathogenic microorganisms. It is important to review any changes that are made to formulations or packaging for their potential to have an adverse effect on shelf-life. This will be especially important if the safety or shelf-life of a food is reliant on a number of interacting factors or hurdles

# 4 Shelf-life and date marking requirements for packaged foods

## 4.1 REGULATORY REQUIREMENTS

Standard 1.2.5 in the *Food Standards Code* (current edition) details the date marking required for packaged food. This will apply to food sold in New Zealand. Date marking can be either a "use-by" or a "best-before" date. The shelf-life of a product begins from the time the food is prepared or manufactured.

Date marking is required on all packaged foods with a shelf-life of less than two years (with the exception of infant formula where date marking is required irrespective of the length of the shelf-life).

The definitions in Standard 1.2.5 are:

**best-before date**, in relation to a package of food, means the date which signifies the end of the period during which the intact package of food, if stored in accordance with any stated storage conditions, will remain fully marketable and will retain any specific qualities for which express or implied claims have been made.

**use-by date**, in relation to a package of food, means the date which signifies the end of the estimated period if stored in accordance with any stated storage conditions, after which the intact package of food should not be consumed because of health or safety reasons.

These definitions will mean that during shelf-life the food must:

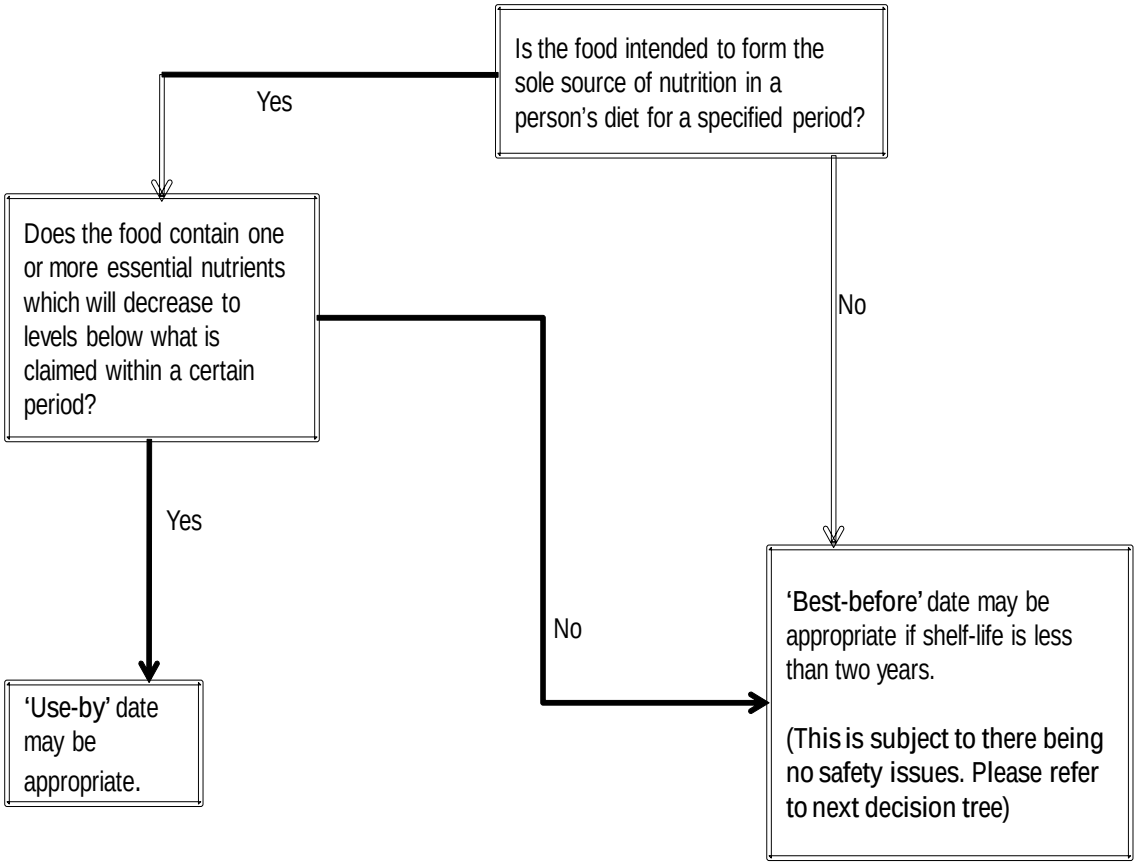
- comply with any label declaration of nutrition data i.e. if the food is claimed to be a source of a vitamin or other nutrient, the amount present should not fall significantly below must not go below the level stated. If there is potential for the level to decline below the stated level and if this could be *harmful to health*, a "use-by" date will be required. **In this case a "use-by" date marking is required for health reasons.**
- remain safe i.e. the level of pathogenic microorganisms present must not increase to a harmful level. If there is a potential for pathogenic microorganisms to grow in the food during storage so that the level present could cause *food poisoning*, a "use-by" date will be required**.** Toxic products must not form in the food due to chemical changes**. In this case a "use-by" date marking is required for safety reasons.**
- retain desired qualities of sensory, chemical, physical and microbiological characteristics i.e. has not deteriorated to an extent that consumers find *unacceptable*. **The shelf-life will be indicated by a "best-before" date.**

The *FSANZ Date Marking User Guide to Standard 1.2.5 – Date Marking of Packaged Food* outlines the requirements. The FSANZ User Guide can be used to decide whether a "best-before" or a "use-by" date is appropriate for a food:

http://www.foodstandards.gov.au/foodstandards/userguides/datemarking.cfm)

**The following sections of this guide provide information to assist food processors to understand the factors that impact on a product's shelf-life and how to ensure that the shelf-life and date marking assigned have a scientific basis. You should be able to explain how a date mark has been arrived at and have the evidence documented in the event of concerns about the appropriateness or safety of the date marking applied.**

Figure 1: Decision tree: Applying a 'use-by' date for health reasons




## 4.2 WHEN A "USE-BY" DATE IS NEEDED FOR HEALTH REASONS DUE TO NUTRIENT LOSS

There are some foods where essential nutrients could be lost with time due to their deterioration. For example a number of vitamins are sensitive to oxygen including vitamin C (ascorbic acid) and vitamin B (thiamine). If the food is an important source of that nutrient for consumers, such that they could suffer an adverse health effect if they were not receiving the stated intake, then a "use-by" date would be needed. This is not a common situation but could be important if the food is intended to be the sole source of nutrition for a reasonable time.

The decision tree (figure 1), taken from the *FSANZ Date Marking User Guide to Standard 1.2.5 – Date Marking of Packaged Food*, shows how to decide when a "use-by" date is required for health reasons.

## 4.3 WHEN A "USE-BY" DATE IS NEEDED FOR SAFETY REASONS BECAUSE OF THE POTENTIAL TO CAUSE FOOD POISONING

### 4.3.1 Why there may be a food safety concern

Food may become unsafe during storage because of the formation of toxic substances or the growth of pathogenic microorganisms. It is relatively uncommon for constituents of the food break down or change so that toxic substances are formed e.g. oxidation of fats and oils. The potential for this to occur will usually be mitigated by the addition of substances that reduce the potential for the changes to occur e.g. antioxidants, packaging to reduce exposure to light which may cause changes, and storage instructions e.g. refrigerate or store in a dark space. However, where the potential remains for toxicity to develop, a "use-by" date is required for a safety reason.

### 4.3.2 Modern food processing and chilled storage has changed the risk

Before the advent of refrigerated storage and modern food technology, foods were preserved using simple processes such as drying, salting, pickling and fermentation, either on their own or in combination. As well as preserving the food, pathogenic microorganism would usually be inhibited from growing and in some cases killed or they would die off over time. Today milder forms of processing are often used, so that foods are not so dry, salty or acidic. This produces a product more acceptable to consumers but these products will not have the long shelf-life of the traditional product. Spoilage microorganisms and pathogens may now be able to grow during storage. Special packaging can be used to restrict this growth during storage, e.g. gas flushing, vacuum packing and chilled storage. However, it is important to be aware that this does not always assure an extended shelf-life. This is because the storage conditions may actually favour the growth of some microorganisms if they are present e.g. cold-tolerant spoilage and pathogenic microorganisms, and those that thrive in the absence of air.

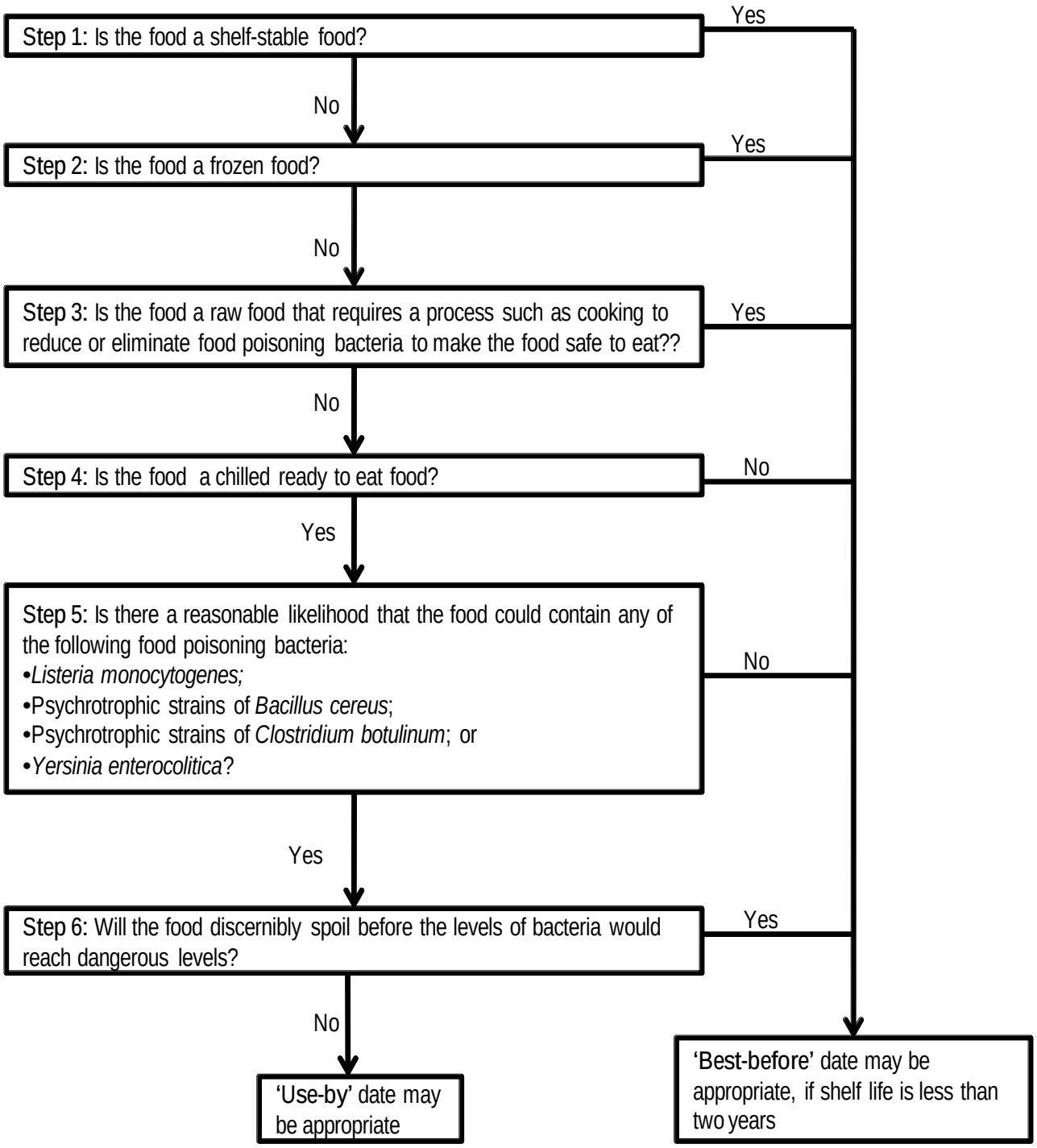
There are also a number of products, e.g. dips and sauces that if made in the home are normally consumed within hours of being made. However when these are produced under commercial conditions they will have an extended shelf-life, usually of several weeks. Extending the shelf-life may be achieved by a combination of factors relating to the formulation of the food and refrigerated storage. However these may not be sufficient to prevent growth of any pathogens present and so it may be necessary to either reformulate or package the food so that growth cannot occur or to ensure that there are no pathogens present e.g. treat the product in its final packaging or monitor the food and the processing environment constantly for the presence of pathogens.

Chilled foods storage may have the advantage of increasing the shelf-life of some foods where chemical and physical changes that occur during ambient storage will be slowed down and may cease.

### 4.3.3 Using the FSANZ decision tree to determine when a "use-by" date is needed

The decision tree below (Figure 2) is taken from the *FSANZ Date Marking User Guide to Standard 1.2.5 – Date Marking of Packaged Food*.

Once it has been determined that there are no health reasons for applying a "use-by" date because of nutrient loss (see Figure 1 decision tree : Applying a "use-by" date for health reasons), the Figure 2 decision tree can be used to work out whether a "use-by" is needed due to food safety reasons or a "best-before" is appropriate. To assist with the interpretation of the flow chart, each of the steps has been numbered and some explanatory text is provided below for each step


Step 1: Is the food a shelf-stable food?
Yes
No
Step 2: Is the food a frozen food?
Yes
No
Step 3: Is the food a raw food that requires a process such as cooking to reduce or eliminate food poisoning bacteria to make the food safe to eat??
Yes
No
Step 4: Is the food a chilled ready to eat food?
No
Yes
Step 5: Is there a reasonable likelihood that the food could contain any of the following food poisoning bacteria:
•Listeria monocytogenes;
•Psychrotrophic strains of Bacillus cereus;
•Psychrotrophic strains of Clostridium botulinum; or
•Yersinia enterocolitica?
No
Yes
Step 6: Will the food discernibly spoil before the levels of bacteria would reach dangerous levels?
Yes
No
'Use-by' date may be appropriate
'Best-before' date may be appropriate, if shelf life is less than two years

e.g. canning and retorting in the final package. Shelf-stable foods have a shelf-life of more than 2 years.

**Note that the exemption of foods with a shelf-life greater than 2 years i.e. shelf-stable does not apply to infant formula. Infant formula must have a date mark see Standard 2.9.1 Infant Formula Products Clause 17(2) of the (current edition) *Food Standards Code.***

*Step 2*
None of the pathogenic microorganisms and few spoilage microorganisms other than some moulds, associated with food can grow in frozen food.

However if it is intended that the food is to be thawed before consumption, proceed to step 3.

Note that if there is an extended time between the thawing of a food and it being consumed without further cooking, any microorganisms present may then be able to grow to harmful levels. There is usually a lag phase, i.e. a delay, between the time the food is thawed and any microbial growth taking place, so food that is consumed soon after thawing should not cause a problem. If a significant period of chilled storage is required for the thawed product, it is important that an appropriate new shelf-life is given to the food. The shelf-life assigned to the frozen product is no longer relevant. See Section 8 for information on how to determine the new date mark.

*Step 3*
For foods that will be cooked thoroughly by the consumer and which are labelled clearly to show that cooking is required and they are not ready-to-eat (RTE) appropriate preparation and storage should reduce any pathogens present to safe levels. For these foods a “best-before” date would be most appropriate.

*Step 4*
Some bacterial pathogens are able to grow in chilled foods i.e. foods stored below 5˚C. So if some of these bacteria have survived processing or are introduced into the food at the end of processing, for example during preparation of consumer packs, they may be able to grow and in some cases produce toxins during chilled storage of the food. This food when consumed could cause food poisoning.

*Step 5*
Could any of the four cold-tolerant bacteria listed in the flow chart be present at the start of the product’s shelf-life?

For more in depth information on each of the pathogens refer to Section 7 and to the Pathogen Data Sheets on MPI’s website http://www.foodsafety.govt.nz/science-risk/hazard-data-sheets/

While processing may inactivate pathogens, in some situations low levels of the pathogens may remain at the end of processing. For example for the spore formers (*Clostridium botulinum* and *Bacillus cereus)*, the process may not be sufficiently severe to kill any spores present, only the more vulnerable vegetative cells. The product will be safe to consume as long as the spores are not able to germinate and grow to unsafe levels during chilled storage.

Whilst *Listeria monocytogenes* does not form spores and is usually eliminated during processing, there is often the potential for recontamination with this pathogen if the food is exposed to the environment after processing. Also some processes are not sufficient to eliminate *Listeria monocytogenes* if present e.g. some fermentations and foods eaten with only minimal preservation e.g. RTE cold-smoked fish.

Review of the process using hazard analysis will assist in identifying the potential for any of these pathogens to be present. For more information on using HACCP, use this link http://www.foodsafety.govt.nz/industry/general/haccp/using-haccp.htm

**Important note**

- For food produced in New Zealand using locally produced ingredients, of the four cold-tolerant bacteria listed *Listeria monocytogenes* is the major food hazard currently of concern.

- Surveys and other scientific studies suggest that cold-tolerant *Clostridium botulinum* or *Bacillus cereus* are unlikely contaminants of ingredients or unprocessed food of New Zealand origin. However the same reasoning may not apply for ingredients or unprocessed foods from overseas. Although they are likely absent, importing countries may nevertheless require exporters to demonstrate that these pathogens would be controlled if present in the food.

- While *Yersinia entercolitica* does occur in New Zealand, it is unclear to what extent it is transmitted by the consumption of food. Overseas *Yersinia* has been linked with the consumption of food such as processed meat products. However, MPI believes that the process controls for Salmonella and or *Listeria monocytogenes* will be equally effective in controlling *Yersinia entercolitica.*

- MPI will continue to review available evidence including surveys of incidence and cases of illness associated with these four cold-tolerant bacteria in New Zealand

*How do you know if growth will or will not occur?*

- By identifying that the intrinsic compositional characteristics of the food (e.g. pH level and water activity in particular) would prevent growth occurring. See Section 7 and the hazard data sheets at http://www.foodsafety.govt.nz/science-risk/hazard-data-sheets/ for more information on what conditions the pathogens need for growth;
- Predictive microbiological modelling uses computer based models to predict the growth of some microorganisms (spoilage and pathogens) in foods with specific characteristics e.g. pH, salt content and water activity. There are limitations to the models in that they may not be able to model for all the characteristics that are contributing to restricting pathogens from growing and surviving in a food. Section 8.5.3 lists the most commonly used models and where information on how to use them can be found
- Challenge testing i.e. inoculating the food with appropriate strains of the pathogen and seeing if they can grow, and identifying the growth curve relative to spoilage (see step 6 on the flow chart and below). Protocols for challenge studies are shown in Section 8.5.4 of this guide. While challenge tests are the best method for determining whether or not growth will occur, they are expensive to do. However the cost would be off set by the assurances testing provides.

If challenge testing or predictive modelling predicts that growth will occur, consider risk management strategies that would reduce or limit growth such as:

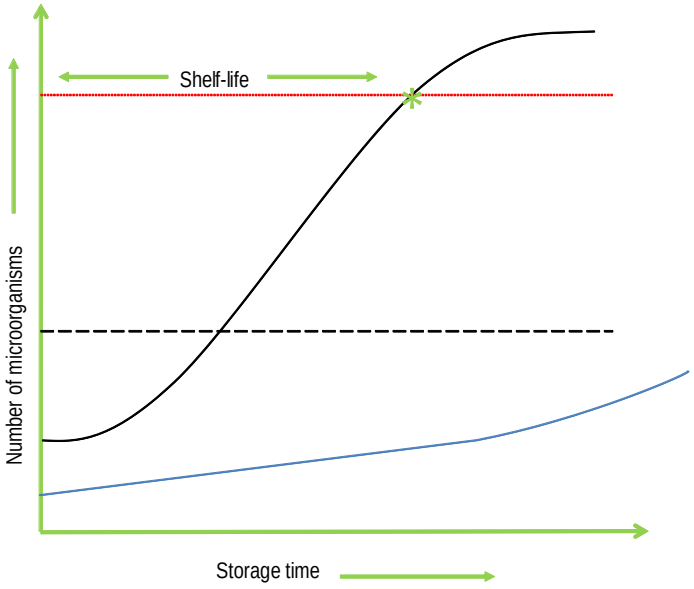
- frozen rather than chilled storage e.g. for ready-to-eat cold smoked fish especially if it is to be transported over long distance;
- increasing the use of micro-hurdles and other factors that would minimise growth such as reducing moisture or increasing salt or acidity;
- the addition of preservatives specific for the pathogen of concern; or
- an in-pack pasteurisation step. This will reduce the numbers of both spoilage microorganisms and vegetative pathogens present.

*Step 6*

If it is possible that a few cold-tolerant pathogen could be present in the food and could grow in the food during storage, a "use-by" date could be necessary. This however would only be the case if the level of these pathogens could make the food unsafe before the growth of spoilage microorganisms has made the food unacceptable. In Figure 3, three scenarios for the growth of spoilage microorganisms and pathogens in a chilled food are shown:

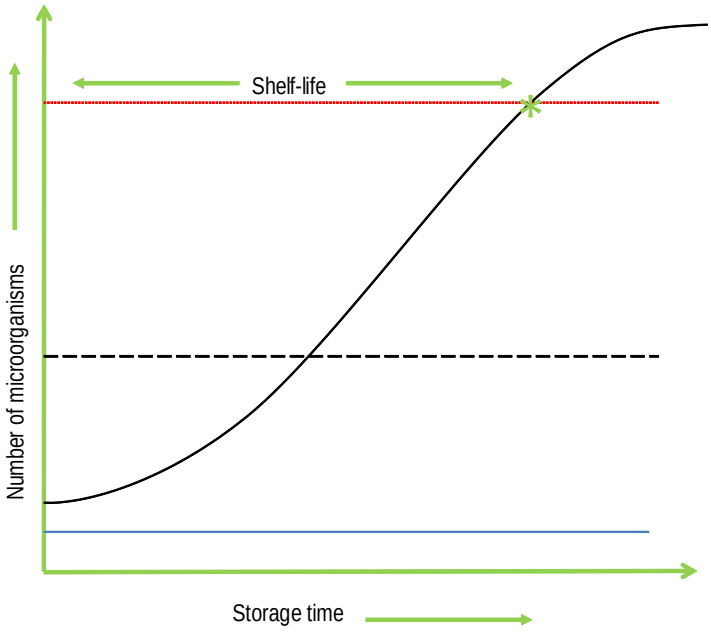
- Graph A: Pathogen increases during storage to unsafe levels and may produce toxins before spoilage has occurred. A "use-by" date is required.
- Graph B: Pathogen does not increase to unsafe levels during storage. A "best-before" date marking acceptable.
- Graph C: Pathogen increases during storage but the food has become inedible due to the growth of spoilage microorganisms some time before unsafe pathogen levels would have been reached. A 'best-before' date marking acceptable.

Graph B: Both pathogen and spoilage microorganisms grow during product storage




Interpretation: Spoilage occurs before pathogen levels become unsafe.
'Best-before' date appropriate.

Graph C: Pathogen does not grow during product storage




Interpretation: Pathogen levels do not increase during storage. 'Best-before' date appropriate.

# 5 Date marking when repackaging or changing the storage conditions and for composite foods

## 5.1 WHEN A DATE MARK NEEDS TO BE ALTERED

The date marking provided by the food processor applies only as long as the storage conditions are unchanged and/or the packaging remains intact. If a frozen product is thawed before sale, or if a bulk product is removed from the original packaging and then sliced before repackaging, a new date will be required.

The processor of the food is best placed to apply for changes to date marks on food in situations when storage conditions have been altered e.g. from chilled to frozen. When seeking permission to change date marks, evidence of the continued safety and suitability of the food e.g. shelf-life information must be provided to MPI. In addition to food processors, retailers and distributors can apply to alter date marks.

**Note that the date marks can only be altered with the permission of the relevant authority see Standard 1.1.1 Prohibition on Altering Labels Clause 11 of the (current edition) *Food Standards Code.***

When there are errors on a label such as a printing error, e.g. wrong year used by the processor, this can be approved by a Food Act Officer.

## 5.2 DATE MARKING FOR REPACKAGED FOODS

If food is taken from its original packaging it will not always have the same shelf-life as was given by the food's manufacturer. The shelf-life may be shortened because of the removal of protective packaging, the opportunity for contamination during repackaging or the product being damaged during thawing causing physical deterioration of the food and creation of an environment that encourages the spoilage microorganisms and pathogens that have survived freezing to grow. It is recommended that the manufacturer is contacted for information on how they expect the food to be stored and handled once it is out of its original packaging and what the new shelf-life would be.

When date marking repackaged food in a deli, e.g. ham sliced from a vacuum-pack of unsliced ham, and packs are prepared over several days, it will be important to ensure the shelf-life is calculated correctly for both the sliced ham and the bulk unsliced ham. For guidance on this see Deli Safe: Calculating shelf life (This link will be added when it becomes available). Repackaging foods and marking them with a (accurate) new date does not require permission from the relevant authority.

## 5.3 SHELF-LIFE OF COMPOSITE FOODS

When calculating the shelf-life of a food that is composed from mixing foods e.g. yoghurt based dip, the shelf-life that has been assigned to the various food components must be taken into account. The shelf-life of the new product should not exceed that of any of the ingredients unless it can be justified.

# 6 The factors that influence shelf-life

## 6.1 INTRINSIC AND EXTRINSIC FACTORS

Even if two products look similar, their shelf-life can be quite different. You will be able to arrive at an appropriate shelf-life for your food only if you understand the factors that influences its storage characteristics.

### 6.1.1 Characteristics of the food itself (i.e. intrinsic)

The intrinsic factors that impact on its shelf-life will include:

- *The nature and quality of the raw materials.* Good quality raw materials with low numbers of microorganisms present should result in products with a consistently acceptable shelf-life. If there is the potential for raw materials to sometimes be heavily contaminated, this needs to be allowed for during processing, e.g. extra wash of plant material when harvested in wet conditions, to achieve the same and consistent shelf-life. If the numbers of spoilage microorganisms or pathogens are highly variable this may impact on the process and consequently shelf-life. In this case consider setting microbiological limits (specifications) on raw materials.

- *Product formulation* including the use of preservatives. Note that mould and bacterial spoilage can be inhibited or slowed down by making removing moisture. It is also important to realise that substitution or removal of ingredients may allow the growth of microorganisms where previously it was inhibited e.g. sugar replaced by artificial sweeteners, changing the type of acid used, removal of nitrates and salt from processed meats.

- *Product structure.* While liquids and semi-solid foods will usually have a homogeneous composition, many ready-to-eat foods do not. Moisture and flavours will migrate between layers, and coatings and surface treatments will restrict or enhance the spoilage potential. For example herbs and spices on the surface of a pâté may grow mould, but a layer of aspic over the herbs will exclude air and prevent mould growth. In a pie an entire pastry crust will make the content anaerobic and allow for the germination and growth of bacterial spores such as *Clostridium perfringens* which are commonly associated with meat . However anaerobic conditions are less likely with a potato topping. It is important to be aware of the potential for anaerobic pockets to form within foods as this provides a suitable environment for heat-resistant bacterial spores to germinate. These may then cause either spoilage or food poisoning.

- *Oxygen availability and redox potential within the food.* This can have a major effect on which sorts of spoilage and pathogenic microorganisms will grow on the food. This also impacts on oxidation-reduction reactions which cause rancidity, loss of vitamins, browning, and flavour changes. Moulds need oxygen to grow and so are usually found on food surfaces but will grow in crevices within food if present

There is more information on intrinsic factors of specific foods at the following site http://www.fda.gov/food/scienceresearch/researchareas/safepracticesforfoodprocesses/ucm094145.htm

### 6.1.2 External factors (i.e. extrinsic) to the food

These will also have an impact on shelf-life and include

- *Processes applied to the food.* While canning processes can be used to inactivate the most heat-resistant organisms, milder heat processes will inactivate only some bacteria and a proportion will survive. The more there are in the raw materials, the greater the number of bacteria that will survive and shorten shelf-life. The more intense the process, the longer the shelf-life generally.

- *Cooling methods* applied to heat treated products. Some spoilage and pathogenic bacteria produce spores that may not only survive but may be activated during the heating process. If the food is not cooled rapidly after the heat treatment, these activated bacteria may increase rapidly in the warm food and cause spoilage and in some cases food poisoning. This is important for meat where *Clostridia spp.* can be a concern and in dairy processing and for baked goods where the problems are more likely to be due to *Bacillus spp.* Cooling can be hastened by techniques such as increasing the air flow, spreading the product to be cooled into a thin layer or blast chilling.

- *Type of packaging* including the gaseous environment. Packaging will have a primary role of protecting a food after processing but may also be used to extend the shelf-life. However if the gaseous environment is changed e.g. vacuum packing or gas flushing, this will favour the growth of certain pathogens and spoilage bacteria, while inhibiting the growth of microorganisms that require oxygen (including moulds).

- *Storage temperature* i.e. ambient, chilled or frozen. While frozen storage will stop the growth of all but a very few spoilage microorganisms, chilling will only slow growth. A number of spoilage microorganisms and a few important pathogens will actively grow as they are psychrotrophic (cold-tolerant), although their growth will usually be slower than would occur during ambient storage.

- *Conditions during distribution, storage, retail display and storage by the consumer.* At any point in the product's shelf-life, it may be exposed to conditions that will lead to the food showing signs of deterioration and a shortened shelf-life. These conditions include elevated or fluctuating temperatures, U.V. light, high humidity, freezer burn, etc.

Table 1 provides a brief overview of the impact that processes applied to food may have on the safety and spoilage of food.

Table 1: Impact of processing on food safety and shelf-life

| Processes applied to foods | Effect on microorganisms | | Impact on food safety | Impact on length of shelf-life due to spoilage |
|---|---|---|---|---|
| | Vegetative bacteria (either spoilage or pathogens), and mould spores and yeasts | Bacterial spores (cause spoilage or food poisoning depending on type) | | |
| Washing of raw materials e.g. plant material | Reduce numbers present | Reduce numbers present | May improve food safety by physically reducing pathogens but numbers may also increase if poor quality water is used, it is not changed frequently, too much fresh produce is washed at the same time. Cold tolerant bacteria may be able to grow during refrigerated storage | Variable. Washing may damage surfaces which would allow microbial growth and decrease shelf-life |
| Cooking – this includes baking | Reduce numbers to very low levels | No decrease and may be activated | Vegetative pathogens inactivated<br>Spores will survive and may germinate<br>Spores could germinate and make food unsafe if food not consumed or cooled immediately<br>Some pre-formed bacterial toxins will be inactivated | Extended, unless spores are able to germinate and grow post-cooking or baking |
| Cooling of cooked foods | - | Potential for spores to germinate and grow if cooling is slow | Spore-forming pathogens will germinate if cooling is not managed correctly and the food may become more unsafe than before processing | Decreased if cooling is not managed correctly and any spore-forming pathogens present can germinate |
| Pasteurisation of liquids or solids | Reduces numbers to low levels | No decrease | Significant improvement provided time/temperature applied is appropriate to the food type | Extended (provided that cooling is managed) |
| UHT / aseptic processing | Inactivates most vegetative bacteria and yeasts/moulds | Inactivates most spores | Foods become low risk | Significant extension |
| Canning and retorting | Inactivates all vegetative bacteria and yeasts/moulds | Eliminates almost all spores except for a few heat resistant spoilage types (however these are usually unable to grow in the anaerobic environment in the container) | Foods become low risk | Major extension |
| Micro-hurdles i.e. multiple factors such as high salt, lowering of pH, nitrates, high sugar, | Variable | No decrease | Combinations of hurdles will vary in ability to inactivate or inhibit growth of pathogens. | Extended |

| | | | | |
|---|---|---|---|---|
| fermentations, decreased moisture/drying | | | | |
| Addition of preservatives including some spices and herbs[1] | Prevents increases of a specific range of microorganisms | No decrease | Improves food safety by inhibiting growth of specific range of pathogens. | May provide some shelf-life extension by inhibiting spoilage;<br>May ensure shelf-life met by preventing growth of contaminants introduced into product during use |
| Salting, drying and pickling | Will prevent the growth of most pathogens and some spoilage microorganisms | No decrease | Vegetative forms of pathogens may survive for a while but will usually die off over time. | Extended as long as conditions remain unchanged |
| Packaging and gaseous atmosphere including excluding air with oil[2] | Will inhibit growth of many pathogens and spoilage microorganisms | Variable depending on gaseous requirements for pathogens that could be present | Pathogens could grow if conditions are suitable. Gaseous environment may favour pathogens by suppressing growth of spoilage organisms that would inhibit pathogens | Extended |
| Storage temperature | Chilled (<5˚C) – decreases growth<br>Frozen – stops growth of most | Chilled (<5˚C) – stops growth except for cold-tolerant<br>Frozen – stops growth of most and some will decrease | Chilled (<5˚C) – cold-tolerant pathogens will be a concern if able to grow<br>Frozen – stops growth of most and some will decrease | Extended |

[1] Herbs and spices used as preservatives must be free of pathogens and spoilage microorganism or they will adversely impact on the food safety and shelf-life of the food

[2] The gaseous environment created may however favour the growth of some pathogens and of spoilage microorganisms that do not grow in air or favour low oxygen environments. Of particular concern is *Clostridium botulinum* spores which may be present on some seafood and plant material harvested from locations where this bacterium is found. Not thought to be of major concern for material grown in New Zealand soil or locally sourced seafood.

## 6.2 THE CAUSES OF DETERIORATION AND SPOILAGE OF FOOD

### 6.2.1 Monitoring spoilage in product

Food may deteriorate or spoil due to a variety of reactions. Several of these reactions may occur simultaneously, or in a sequence, in a food. Each food will tend to have a number of typical spoilage patterns that will be characteristic of the food. However, changes in the food formulation, source of raw materials and processing conditions can lead to new types of spoilage. It will be important to be alert to any such changes as they may lead to shortened shelf-life and product not meeting its date marking. Keeping samples of each production run (retention samples) which are inspected at regular intervals that are relevant to the shelf-life of the product will help identify where product is failing to meet shelf-life expectations. If a product spoils before the end of its intended shelf life, consideration should be given to removing unsold product from the marketplace. Early recognition of shelf-life failures will also allow the cause to be identified so that remedial actions can be implemented.

### 6.2.2 Transfer of moisture or water vapour

This means losing water (getting drier) or gaining water (becoming soggy) from the environment. As well as physical changes, there may be changes in taste or texture. When products become moister, microorganisms may start to grow and the food may then be subject to spoilage or to become potentially unsafe. In mixed foods, water may migrate between components leading to undesirable effects. For example water in salad vegetables may migrate into the dressing and dilute the acid making the salad more vulnerable to spoilage, e.g. by yeasts and growth of pathogens. Packaging may be used to restrict moisture loss, e.g. for leafy vegetables, or to prevent moisture gain, e.g. for breakfast cereals, or to keep ingredients separate e.g. for sauces and dressings placed in separate sachets.

### 6.2.3 Chemical changes

Most chemical changes in food are undesirable, with only a few being seen as desirable e.g. cheese maturing, ripening of fruit post-harvest. The undesirable changes can lead to unattractive colour changes (browning of cut fruit and meat), loss of vitamins, and changes in flavour and aroma.

The following are examples of some commonly encountered chemical changes:

- Enzymatic reactions. These reactions may proceed rapidly at room temperature. Most of the enzymes will be denatured by heat, so processes such as blanching of fruit and vegetables may decrease their activity. However some are not so heat sensitive, e.g. plasmin in milk will survive pasteurisation. Enzymes may be released from damaged meat or plant cells or they may be produced by microorganisms growing on the food.
- Oxidation of fats and proteins during storage in air can cause rancidity, off flavours, loss of vitamins, colour changes in meat, etc.
- Non-enzymatic browning (Maillard browning) which is a reaction between protein and sugars in food that not only causes a colour change but also leads to a loss of nutritional value (essential amino acids).

### 6.2.4 Spoilage due to the growth of microorganisms

Bacteria and fungi are common causes of food spoilage which will be seen from the development of slime, odours, ‘whiskers’, etc. The rate at which spoilage develops can be decreased by a variety of means such as:

- lowering the temperature of storage e.g. ambient to chilled or chilled to frozen;
- decreasing the initial microorganism load so there are less spoilage microorganisms present e.g. pasteurisation, washing with a sanitiser;
- lowering pH so that fewer spoilage microorganisms are able to grow e.g. addition of acidity regulators, pickling;
- reducing the water activity to make conditions unsuitable for growth of the spoilage microorganisms e.g. drying, salting;
- adding of preservatives that target specific spoilage microorganisms; and,
- modifying the storage conditions, e.g. vacuum packing, gas flushing so that spoilage microorganisms cannot grow. However it is important to then ensure that the changed conditions do not favour the growth of pathogens.

### 6.2.5 The source of spoilage microorganisms

Each food will have typical causes of microbiological spoilage. They will have come from the environment from which the raw materials were sourced or may be introduced during processing. Which microorganisms will grow and cause spoilage will depend on the characteristics of the food such as the pH, chemical composition, and water activity. Therefore spoilage microorganisms associated with vacuum packed meats will differ from those found in fresh meat. Moulds and yeasts are more tolerant of challenging growth conditions than bacteria, and so are more likely to be the cause of spoilage of semi-preserved foods such as salted fish and concentrated fruit juices. There are numerous textbooks that can be consulted to identify spoilage microorganisms specific to foods.

### 6.2.6 Spoilage microorganism as an indicator of food safety and acceptability

The presence of large numbers of any bacteria in a food is sometimes used as an indicator that food is unacceptable and past its "best-before" date and potentially unsafe to consume. However a high total viable count or presence of large numbers of a specific group of bacteria, e.g. coliforms need to be interpreted with care as this may not mean that the food is unsuitable for consumption. For example high counts of some bacteria such as lactic acid bacteria are usually harmless and may be a normal feature of the product. In the case of a fermented food such as salami or yoghurt they would be an essential component.

| |
|---|
| High counts of microorganisms will only be important if they are known to be indicative of spoilage, product abuse, inadequate processing or poor hygienic practices. |

### 6.2.7 Pathogens do not cause food spoilage

It is important to be aware that the bacteria that cause foodborne illness are rarely the cause of food spoilage. As such food poisoning is caused by food which appears not to be spoilt – and spoilt food does not cause food poisoning even though consumers may find the food offensive and consuming it may make them feel unwell.

Some of the foodborne illness bacteria will be carried passively by the food but in other cases the bacteria will multiply in the food and may produce toxins that are responsible for the subsequent illness when the food is consumed. Yeasts are rarely causes of food poisoning, but some spoilage fungi do produce potent and often carcinogenic toxins. Some bacterial and mould toxins are heat-resistant. This means that the fungi or bacteria that produced the toxins may be destroyed or removed by processing, but the food may remain unsafe.

# 7 Pathogenic bacteria associated with RTE chilled foods

In Figure 2, step 5 of the decision tree identified the four types of cold-tolerant bacteria that can be important to be aware of when determining a date mark .It will be important that if there are any of these pathogens present in the food at the end of processing, that the conditions under which the food is stored and the duration of the storage does not result in the bacteria growing to unsafe levels during the shelf-life of the food. A “use-by” date would be needed it this could occur to ensure that the consumer does not eat the food beyond this date.

Of the four cold-tolerant bacteria listed, the most relevant to New Zealand produced food is *Listeria monocytogenes*. For information on all the pathogens see the information provided below and the Pathogen Data Sheets
http://www.foodsafety.govt.nz/science-risk/hazard-data-sheets/pathogen-data-sheets.htm

Below is some information on each of these pathogens, why it is important that they ae controlled and how this control may be done.

## *7.1 LISTERIA MONOCYTOGENES*

**Illness that could result if present in food**
Food containing large numbers of *Listeria monocytogenes* may cause listeriosis when consumed, especially if the consumers are vulnerable, which includes women who are pregnant, the frail elderly and those whose immune system is suppressed. Listeriosis is fatal in up to a quarter of cases.

**How it gets into food**
*Listeria monocytogenes* is wide spread in the environment and so can be introduced into the food at any stage from raw ingredient to the end of processing if the opportunity exists. It will therefore be important to keep levels as low as practicable in raw ingredients and in the processing environment. It is a frequent contaminant of wet processing environments and forms biofilms inside and on the surface of all types of processing equipment. Drains are a common source.

Particular focus will need to be on preventing recontamination of processed foods. Where this is potential for recontamination it will be essential to complete the packaging of the food in a high care area where hygiene control is critical.

| Risk management options | Effectiveness in controlling *Listeria* |
|---|---|
| Pasteurisation | Susceptible to commonly used time/temperature combinations – see the appropriate pathogen data sheet for details |
| Raw materials and ingredient controls and specifications | For ingredients that could be heavily contaminated, apply incoming raw material specifications at levels that processing can eliminate; reject or apply additional controls to incoming raw materials harvested under conditions that could result in elevated levels e.g. milking animals with mastitis, vegetables harvested in bad weather. |
| Formulation of food | Will not usually grow in foods with pH <4.4, water activity <0.92; Combinations of hurdles will also be effective e.g. pH 5.0 with a water activity of <0.94; minimum salt level of 3.5% in the aqueous phase throughout the food |
| Gaseous environment of packaging | *Listeria* will grow both in air and in the absence of air (vacuum packaging); will grow at 30%$CO_2$ but not at 100%. |
| Presence of spoilage or other microorganisms, e.g. fermentative | Poor competitor so will not grow well in fermented foods and when spoilage organisms present |
| Cold storage | Chilled storage (<5˚C) only reduces growth rate; growth stops during frozen storage but will they will survive freezing |
| Preservatives | Many commonly used preservative will prevent growth but effectiveness should be confirmed. May be most effective when used with other inhibitory factors e.g. low pH, fermenting microorganisms |
| Pasteurisation of food in retail packs | For processed food, especially where competing bacteria have been eliminated, post-processing contamination is a concern. Pasteurisation in-pack will eliminate when this occurs |
| Processing environment | For foods vulnerable to contamination, a *Listeria* Management Programme with a well designed environmental monitoring programme will identify when there is potential contamination present (See *Listeria* Guidance for the control of *Listeria monocytogenes* in ready-to-eat foods Parts 1 and 3) (Weblink will be added when available) |

## *7.2 CLOSTRIDIUM BOTULINUM*

**Illness that could result if present in food**

Toxins released into the food during bacterial growth are powerful neurotoxins and may cause botulism which is very often a fatal illness.

### *How it gets in to food*

The bacteria occur in the soil and so are commonly associated with plant material. They may also be found in association with seafood. Only some strains are of concern for refrigerated foods. These strains are identified as non-proteolytic Types B, E and F. While the cold-tolerant strains being discussed here have not been found in New Zealand, it is not possible to say that they do not occur. Ingredients and raw materials imported from other countries could carry the botulinum spores. Grows only in the absence of air (anaerobic) so only an issue in foods in sealed packaging from which air is excluded e.g. vacuum packaging, canning and retorting.

| Risk management options | Effectiveness in controlling cold-tolerant *Clostridium botulinum* |
|---|---|
| Heat treatment | Both spores and vegetative cells can be inactivated by some heat processing (unlike other types of *Clostridium botulinum* which produce heat resistant spores); toxin in food can be inactivated by heating |
| Raw materials and ingredient controls and specifications | Testing specifically for botulinum spores not possible, but may apply specifications for anaerobic spores; review sourcing of critical materials from countries where botulinum spores could occur |
| Formulation of food | Will not usually grow in foods with pH <5.0 but this may then encourage spores to form; minimum water activity for growth 0.97; minimum salt level of 3.5% in the aqueous phase |
| Gaseous environment of packaging | Will not grow in air ; will grow in the absence of air i.e. vacuum packaging, retorted and canned product; growth rate reduced in 100% $CO_2$ |
| Presence of spoilage or other microorganisms e.g. fermentative | Will be inhibited by the presence of fermentative microorganisms |
| Cold storage | Will not grow at temperatures <3˚C or during frozen storage |
| Preservatives | Nitrites/nitrates most commonly used preservatives in meat are effective only in combination with lowered pH and fermenting microorganisms |
| Pasteurisation of food in retail packs | Pasteurisation in-pack will not inactivate spores |

A useful source of information from the U.K. is the *Food Standards Agency guidance on the safety and shelf-lif of vacuum and modified atmosphere packed chilled foods with respect to non-proteolytic Clostridium botulinum*
http://www.food.gov.uk/multimedia/pdfs/publication/vacpacguide.pdf

## 7.3 *BACILLUS CEREUS* (PLEASE NOTE THAT THIS SECTION WILL BE UPDATED)

*Illness that could result if present in food*

*B. cereus*-associated foodborne illness occurs as two distinct intoxication syndromes: emetic and diarrhoeal. Recovery is rapid for both syndromes, usually within 12-24 hours of consuming food contaminated with large numbers of the bacteria. There are usually no long-term effects.

*How it gets into food*

Widely found in the environment and associated with raw ingredients including milk, so where they are a concern the levels need to be as low as possible. However only some strains of *B. cereus* and other related *Bacillus* species are cold tolerant and would be a potential issue for chilled RTE foods. [There is little evidence that these strains of *B. cereus* are widely found in New Zealand; in Europe there is evidence of them occurring in dairy products and a potential cause of food poisoning]

| Risk management options | Effectiveness in controlling cold-tolerant *Bacillus cereus* |
|---|---|
| Heat treatment | Both spores and vegetative cells an be inactivated by heat processing but spores will require elevated temperatures |
| Raw materials and ingredient controls and specifications | Spores associated with starchy foods and dairy ingredients. May apply specifications for aerobic spores; spores survive well in dry ingredients |
| Formulation of food | Will not usually grow in foods with pH <4.5 and water activity <0.91 |
| Gaseous environment of packaging | Will grow in presence or absence of air; i.e. in most MAP packaging but toxin production only when oxygen present |
| Cooling of foods post-processing | Spores that survive a heat process e.g. cook step will become vegetative sells and grow in numbers if the cooling stage is extended. Rapid controlled cooling therefore vital |
| Cold storage | Will not grow at temperatures <4˚C or during frozen storage |
| Preservatives | Vegetative cells inhibited by a number of preservatives e.g. sorbate and benzoate |
| Pasteurisation of food in retail packs | Pasteurisation in-pack will not inactivate spores |
| Processing environment | Can form biofilms in processing equipment and become difficult to remove; ensure cleaning programme capable of removing and preventing biofilm formation |

## *7.4 YERSINIA ENTERCOLITICA*

**Illness that could result if present in food**
Infection can cause diarrhoea and pain one week after consuming contaminated food. Symptoms may be mistaken for appendicitis. The illness is usually self –limiting but may be more severe and complicated in children under five years and other vulnerable consumers.

**How it gets into food**
The bacteria are transmitted from food animals and so can be contaminants of pork, beef, lamb and poultry. Crops such as fruit and vegetables may become contaminated from the environment or directly from animals and possibly birds.

| Risk management options | Effectiveness in controlling cold-tolerant *Bacillus cereus* |
|---|---|
| Heat treatment | Readily inactivated by heat processing including pasteurisation |
| Raw materials and ingredient controls and specifications | Associated with raw meat, including offal – contamination of carcasses may be reduced by certain practices; potential to be associated with plant material reduced by good agricultural practices |
| Formulation of food | pH variation variable and may grow in foods with pH4.2; does not grow if water activity <0.96 |
| Fermentation and drying | In meat products, survival will be inhibited in a well controlled and effective fermentation or drying process |
| Gaseous environment of packaging | Will grow in presence or absence of air; i.e. in most MAP packaging |
| Cold storage | Will not grow at temperatures as low as -1.3˚C |
| Preservatives | May be inhibited by preservatives but data limited |
| Pasteurisation of food in retail packs | Pasteurisation in-pack will inactivate |
| Processing environment | Evidence that contaminated water used in processing has been a source of contamination in some outbreaks |

# 8 How to determine the shelf-life of a ready-to-eat food

## 8.1 SHELF-LIFE STUDIES (DIRECT METHOD) FOR A "BEST-BEFORE" DATE

This requires the food to be stored for a period of time (i.e. longer than the expected shelf-life) while changes in the products characteristics are observed, tested and recorded. From this information a shelf-life can be estimated. The shelf-life will need to take into account possible variability between product batches and in storage conditions.

As the shelf-life will apply to the product available to the consumer, the actual shelf-life determinations must be made on product produced under commercial conditions. However it is recommended that during the development of new products, shelf-life studies are undertaken. This is to allow for making changes to the formulation, processing, etc during the development stage, if the shelf-life appears to be less than what is wanted or there are unacceptable variations between batches.

*Step 1: Setting up the study*

- Identify the type(s) of spoilage, loss of quality most commonly associated with the food. These will be mould and/or bacterial spoilage, changes in texture, smell, taste or appearance. Decide which of these are most important. One may dominate or several may be equally important.

- Identify the observations and tests that will be undertaken. These may be made by subjective sensory testing e.g. colour and texture changes, smell and taste. This may also be made by objective laboratory tests e.g. numbers of typical spoilage bacteria or yeasts, appearance of mould growth, presence of a chemical indicator of deterioration, such as D-alanine in fruit juice, rancidity, histamine in seafood, etc.

- From the literature, observation of similar products in the marketplace and past experience, identify the expected shelf life so that you know whether the testing is likely to take days, weeks or months.

*Step 2: Doing the study*

- *Decide on the storage conditions for the trial*. These should be the same every time the trials are done, so must be controlled and must reflect the normal conditions of storage for the product.

- *Consider including additional storage conditions* in the trial if these could have an impact on the shelf life in an intended market or due to the actions of the purchaser of the product e.g. optimum (storage for the whole shelf-life as on the label), realistic (e.g. short periods of elevated temperatures) and worst case (e.g. to mimic product moving from a temperate to a tropical market, poor temperature control in domestic refrigerators). Note that in each situation both temperature and humidity may need to be taken into account. Incubators and cabinets may be used to provide a constant environment for storing the trial samples. Refrigerators set at different temperatures e.g. 4˚C and 10˚C can provide insight into the impact of temperature on shelf-life.

- If the *product could be stored once opened* for more than a few days by the consumer, the impact of the changed environment needs to be factored into the studies, e.g. exposed to the air, move from ambient to chilled storage.

- Decide when observations will be made and tests will be done, e.g. daily or weekly. If the food has a fairly long shelf-life it may be sensible to start with less frequent observations and to increase the frequency as the expected end of shelf life approaches.

- Prepare log sheets on which to record the sequence of observations. Describe the observations to be made and provide a scale for recording the results. It is important that the trials are repeatable. Colour charts, pictures and descriptions of how to make the observations will be essential to ensure this. Trained panels should be used where tests are highly subjective, e.g. taste.

- Calculate the number of samples that will be needed for the trial. If the tests involve observation only, fewer samples will be needed than if the tests are destructive. It is important to examine at least three samples and preferably five or more at each observation point, so that within batch variability can be recorded;

- Obtain the required numbers of product samples. They should be randomly selected from a single batch of product and in consumer packs. Label the packs to allow easy identification and place into the storage conditions that have been selected;

- Do the study. Analyse the results. Calculate a shelf-life from the observations made. If there is a lot of variability in the results the study may need to be repeated and thought given as to how the variability can be reduced.

If the testing is to include tasting the food, it is important that there is confidence that the food would not be a potential source of food poisoning. If there is any doubt in this respect, do not do taste tests.

*Step 3 Setting the date mark; monitoring and review*

- **Determine the product date marking**. This should be no longer than the number of days before unacceptable deterioration usually occurs plus a safety margin. A safety margin is needed because the shelf-life is only an approximation and not a fixed value and will vary from time to time. The size of the safety margin needs to take into account the potential for the shelf-life to be easily compromised by less than ideal conditions for storage, distribution and use.

- **Ideally samples should be retained** from each batch of product. These can then be checked at the end of their shelf-life to confirm that the date marking is correct. In the event of customer complaints that the product has spoiled before the end of the shelf-life, the retained samples can be examined to see if the complaint is justified and an appropriate response made, e.g. review processing records, review date marking.

- **Repeat the shelf–life tests** if there are major changes made to the product composition, ingredients, processing or packaging to ensure that the shelf-life has not been compromised by the changes.

If you do not have suitable facilities or expertise to undertake shelf-life studies, seek help from commercial providers of this service.

## 8.2 INDIRECT METHODS FOR "BEST-BEFORE" DATE MARKING

The direct method discussed above can take too long for some products and can be costly. An alternative is to use indirect methods such as mathematical models to predict the shelf-life and then use this information in parallel with ongoing observation of how the product performs in the market place and the nature of customer complaints.

### 8.2.1 Products where chemical changes are critical

It is possible to use models and calculations to predict the shelf-life of some types of food products, such as pickles and sauces. These require technical expertise if they are to be applied correctly and so the appropriate experts should be consulted.

### 8.2.2 Products where microbiological spoilage is critical

Predictive models can be used to predict the growth, survival and non-thermal inactivation of microorganisms. Many of these models are for pathogens but there are some models for specific spoilage issues. The limitation of the models is that the conditions of the food must be the same as those in the model; otherwise they will not be applicable. The models require detailed knowledge of compositional factors such as pH and water activity which affect the growth of microorganisms.

For information on these models and to understand how they work and can be applied see the link below to the USDA Predictive Microbiology Modelling Portal.

'This portal is geared to assist food companies (large and small) in the use of predictive models, the appropriate application of models, and proper model interpretation. Our vision is that the PMIP will be the highway to the most comprehensive websites that brings together large and small food companies in contact with the information needed to aid in the production of the safest foods'. http://portal.arserrc.gov/.

## 8.3 WHEN THERE IS NUTRIENT LOSS OR UNSAFE CHEMICAL CHANGES AND A "USE-BY" DATE IS REQUIRED

This can be determined in the same way as for a "best-before" date (Section 8.1) but the focus on the study will be the characteristic of concern, e.g. the time taken for the level of a vitamin to go below the level indicated on the label. It will be important that these studies replicate the normal storage condition of the product.

## 8.4 WHEN THERE IS POTENTIAL FOR GROWTH OF A PATHOGEN AND A "USE-BY" DATE IS REQUIRED

If it is possible that there could be pathogens present in the product **and** they could grow during storage, it is important that growth studies are undertaken. The best information comes from challenge studies where the food is inoculated with a cocktail of several strains of the pathogen and then tested at intervals to establish a growth curve. A 'use by' date will be essential if the pathogen levels could reach unsafe levels before the food shows significant spoilage, e.g. the consumer would not eat it. (See the graphs in Section 4).

An alternative to challenges studies is to use predictive models. Entering the characteristics of the food into the model will predict whether growth will occur and provide a growth curve. While several of these models have been refined in recent years, it would always be recommended that a challenge study is also undertaken to confirm that the model reflects your product accurately.

Sections 8.5.3 and 8.5.4 show where to find information on challenge studies and predictive modelling.

Where there is potential for pathogens to be present and to grow in a food, it is recommended that the risk of the food being a cause of food poisoning should be managed by either reducing the potential for the pathogen to be present, e.g. in pack pasteurisation, or reformulation of the product so that growth does not occur.

## 8.5 USEFUL LINKS

### 8.5.1 Shelf-life and date marking in general

- MPI website link to Deli Safe: Calculating shelf life (add when available)

- *Guide to labelling requirements*
  http://www.foodsafety.govt.nz/elibrary/industry/nzfsa-food-labelling-guide/

- *FSANZ user guide to date marking*
  http://www.foodstandards.gov.au/foodstandards/userguides/datemarking.cfm

- *Validation of Product Shelf-Life. Guidance note* (Food Safety Authority of Ireland) (Includes a discussion of intrinsic and extrinsic factors influencing the growth of microorganisms) http://www.fsai.ie/WorkArea/DownloadAsset.aspx?id=10946

- *Code of Hygienic Practice for Refrigerated Packaged Foods with Extended Shelf Life CAC/RCP 46-(1999)* (Codex)
  http://www.codexalimentarius.net/download/standards/347/CXP_046e.pdf

- *Evaluation and Definition of Potentially Hazardous Foods* (USA)
  http://www.fda.gov/Food/ScienceResearch/ResearchAreas/SafePracticesforFoodProcesses/ucm094141.htm

### 8.5.2 Listeria monocytogenes

- *Shelf life in relation to L.monocytogenes Guidance for food business operators* (U.K.)
  http://www.chilledfood.org/Resources/Chilled%20Food%20Association/Public%20Resources/Shelf%20life%20of%20RTE%20foods%20in%20relation%20to%20Lm%20FINAL%20v1.1.1%2023%203%2010.pdf

- *Guidance on Listeria monocytogenes shelf-life studies* for ready-to-eat foods (EC)
  http://www.efsa.europa.eu/en/efsajournal/pub/599.htm

### 8.5.3 Clostridium botulinum

- *Guidance on the safety and shelf-life of vacuum and modified atmosphere packed chilled foods with respect to non-proteolytic Clostridium botulinum* (U.K.) http://www.food.gov.uk/multimedia/pdfs/publication/vacpacguide.pdf

- UK information sheet for manufacturers of vacuum packed chilled foods http://www.food.gov.uk/multimedia/pdfs/publication/vacpack0708.pdf

### 8.5.4 Predictive modelling

- Instructions on how to use predictive modelling and the main models can be found at http://portal.arserrc.gov/ Models available include:

1. ComBase http://www.combase.cc/index.php/en/
2. Pathogen Modeling Program http://www.ars.usda.gov/services/docs.htm?docid=6786
3. Growth Predictor & Perfringens Predictor http://www.ifr.ac.uk/safety/growthpredictor/
4. Seafood Spoilage Predictor Software, Danish Institute for Fisheries Research http://sssp.dtuaqua.dk/
5. Sym'Previus http://www.symprevius.net/

### 8.5.5 Challenge testing

- http://www.fda.gov/Food/ScienceResearch/ResearchAreas/SafePracticesforFoodProcesses/ucm094154.htm

- *Listeria monocytogenes Challenge Testing if Ready-to-Eat Refrigerated Foods* (Health Canada) http://www.hc-sc.gc.ca/fn-an/legislation/pol/listeria_monocytogenes-eng.php

- *Clostridium botulinum* Challenge Testing of Ready-to-Eat Foods (Health Canada) http://www.hc-sc.gc.ca/fn-an/legislation/pol/sop-cbot-eng.php

- *Challenge Testing of Microbiological Safety of Raw Milk Cheeses: The Challenge Trial Toolkit* http://foodsafety.govt.nz/elibrary/industry/challenge-trial-toolkit/index.htm
  This report provides information about the conduct of challenge trials for raw milk cheeses and is a useful background on the conduct of challenge trials in other foods, including the need to characterise the microorganisms used.