A Guide to **Calculating the Shelf Life** of Foods

Information Booklet for the Food Industry

NEW ZEALAND FOOD SAFETY AUTHORITY

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Information Booklet for the Food Industry

Foreword

The New Zealand Food Safety Authority (NZFSA) and Health Protection Officers regularly deal with enquiries on the shelf life and date marks on foods. This **Guide to Calculating the Shelf Life of Foods** contains background information on the factors that influence shelf life and a procedure to assist you to calculate the shelf life of foods.

Although the shelf life and date mark requirements are detailed in legislation, the guide provides assistance to meet these requirements and should be read in conjunction with the **Australia New Zealand Food Standards Code**.

Traditional sectors of the food industry have gained valuable experience in calculating the shelf life of perishable foods but with changes in legislation and the expanding range of ready-to-eat, short shelf life foods there are increasing numbers of foods requiring date markings and specific storage conditions.

The increased availability of ready-to-eat foods with extended refrigerated shelf lives has resulted in the need for the food industry to employ measures to minimise the potential for microorganisms such as *Listeria monocytogenes* and *Clostridium botulinum* to be present in foods in numbers that result in a hazard to health. This updated guide contains sections on points that should be considered when determining the shelf life of foods that are capable of supporting growth of these organisms.

Calculating a realistic shelf life and date mark for food helps ensure the safety and quality of food sold

Who is this Guide intended for?

This guide was written to assist anyone who is providing information on the shelf life of food. It provides relevant background information on shelf life and outlines several approaches that can be used to determine it.

Contents

What is shelf life?	4
Is the shelf life of food related to food safety?	4
What are the regulations relating to shelf life?	4
Who is responsible for calculating a shelf life?	5
Who influences the shelf life?	6
Factors influencing the shelf life of a product	7
What is a shelf life study?	8
Step by step determination of shelf life by the direct method	9
What are indirect methods?	13
What is challenge testing?	14
Appendix 1: Guidelines for microbiological examination of ready-to-eat foods	14
Appendix 2: Determination of shelf life of foods capable of supporting *Listeria monocytogenes*	18
Appendix 3: Extended shelf life foods and *Clostridium botulinum*	25
Appendix 4: Contacts	27
Appendix 5: Publications	28
Appendix 6: Further reading	29

What is shelf life?

Shelf life is a guide for the consumer of the period of time that food can be kept before it starts to deteriorate, provided any stated storage conditions have been followed.

The shelf life of a product begins from the time the food is prepared or manufactured. Its length is dependent on many factors including the types of ingredients, manufacturing process, type of packaging and how the food is stored. It is indicated by labelling the product with a date mark.

Is the shelf life of food related to food safety?

Shelf life testing describes how long a food will retain its quality during storage. Controlling the pathogen content (safety) of foods should be achieved by using a Hazard Analysis Critical Control Point (HACCP) system. Predictive modelling or challenge testing can be used to assess pathogen growth. However, food safety and product shelf life are inextricably linked. During the shelf life of a food it should:

- Remain safe to eat
- Keep its appearance, odour, texture and flavour
- Meet any nutritional claims provided on the label.

What are the regulations relating to shelf life?

The **Australia New Zealand Food Standards Code** defines composition and labelling requirements for all food sold in New Zealand.

The shelf life is defined in Standard 1.2.5, which requires that any packaged food with a shelf life of less than two years be labelled with a date mark.

The Code requires food to be safe up to, and including, the date marked.

One of the following options must be used:

- A "Use by" date. This is used for highly perishable foods that will present a safety risk if consumed after this date. A food must not be sold if it is past its "Use by" date, nor should it be consumed.
- A "Best before" date. This is used for foods other than those specified above. It is not illegal to sell food that has reached its "Best before" date.

- "Baked on" and "Baked for" date marks can be used on bread products with a shelf life of less than 7 days. The "Baked for" date must be no later than 12 hours after the bread was baked.

What does the date mark look like? The words "Use by", "Best before", or "Baked on" must be followed by a date or a reference to where on the package the date is located.
The date must have:

- At least the day and the month for products with a shelf life of up to three months e.g. Best before 24 Jan
- At least the month and the year for products with a shelf life over three months e.g. JAN 05
- The dates must be expressed numerically and chronologically (day month year) but the month can be expressed in letters. These must be uncoded.
- "Packed on" dates or packer's codes can be used but only in addition to the date marks described above.

The Code also states:

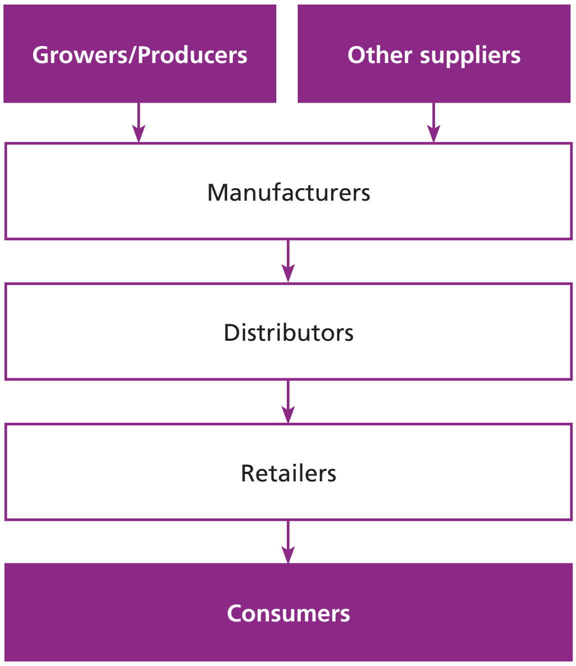
- Specific storage instructions must be included on the label where these are necessary to ensure the food will keep for the specified period indicated by the date marking.
- Storage conditions must be achievable in the distribution and retail systems and in the home.
- The seller must store the food according to stated storage instructions.

Consideration also needs to be given to providing directions for use and storage after opening. This is particularly important for foods preserved by modified atmospheres or under vacuum where the sealed packaging has a significant influence on the product's shelf life. For example, sliced ham in vacuum packaging may have a one month refrigerated shelf life, however, once the package is opened it should not be held for longer than 3-4 days.

Who is responsible for calculating a shelf life?

Anyone who packages and sells food that is required to be date marked is legally responsible for calculating how long their product can reasonably be expected to keep, without any appreciable change in quality. The food label is required to detail the shelf life and the storage instructions to meet that shelf life.
In most cases, this is the responsibility of the food manufacturer, but it can also be repackers, secondary processors, food retailers and supermarkets.

Who influences the shelf life?



Everyone in this food production chain has an influence on food quality and safety. It is not possible to be confident that food is safe unless a food control plan is in place that identifies and controls hazards throughout the food chain. The role of each person in the food chain should be considered.

GROWERS AND PRIMARY PRODUCERS… provide the raw materials. Variable quality of these can make production of a consistent final product difficult. Consistent quality can be maintained by developing raw material specifications.

OTHER SUPPLIERS… for example, of packaging materials or ice for chilling also have a responsibility to supply safe and consistent materials. They may also provide advice about different materials and their effect on shelf life.

MANUFACTURERS… are responsible for determining a suitable shelf life for their products. This should be based on a study that considers all stages of the production chain.

DISTRIBUTORS… transport the food product from the manufacturer to the retailer. It is essential that food is stored safely and securely in the warehouse, transported at the correct temperature, delays are avoided, and packaging is not damaged.

Consideration should also be given to the possibility of contamination of the food from other goods carried in the vehicle.

RETAILERS… store and handle the product immediately before it reaches the consumer. They must store products according to directions that the manufacturer supplies.

CONSUMERS… are the final link in the chain and it is important that they are provided with the correct information on storage conditions.

Factors influencing the shelf life of a product

How long a shelf life should my product have? There is no simple answer to this question. All foods spoil with time, but there is considerable variation in spoilage rates. Some of the factors involved in loss of quality are explained below.

MICROBIAL GROWTH… the growth of some bacteria, yeasts and moulds in food may lead to either food spoilage or food poisoning.

The time taken for microorganisms to affect foods will depend on their levels in the food when it is produced, as well as any further contamination the food may suffer during packing, storage and other handling. The temperature and time of storage, as well as the type of food, are also important factors. Moist foods will usually spoil faster than dry foods.

Definition of the end of shelf life is usually based on numbers of microorganisms present or on recommended guidance (FSANZ criteria are detailed later in this booklet). In other cases, the end of shelf life may be determined by sensory or biochemical deterioration.

NON-MICROBIAL SPOILAGE… there are many other ways in which quality and nutrients can be lost. They may not necessarily result in the product being harmful but can mean that it is no longer of an acceptable standard.

Moisture gain/loss can result in loss of nutrients, browning and rancidity. Dry foods can become vulnerable to microbial spoilage if they take on moisture.

Chemical change can result in off flavours, colour changes, browning and loss of nutrients.

Light induced change can cause rancidity, vitamin loss and fading of natural colours.

Temperature changes increase or decrease the speed of other forms of spoilage.

Physical damage to food can result in spoilage, for example bruising of fruit and vegetables. Damage to food packaging can make the food vulnerable to both microbial and non-microbial spoilage. For example, pin holes in cans or tears in plastic bags allow microorganisms to enter the food and moisture to be lost from the food.

Other

- Spoilage by rodents and insects
- Flavours and odours from storing food near other strongly smelling products
- Product tampering.

What is a shelf life study?

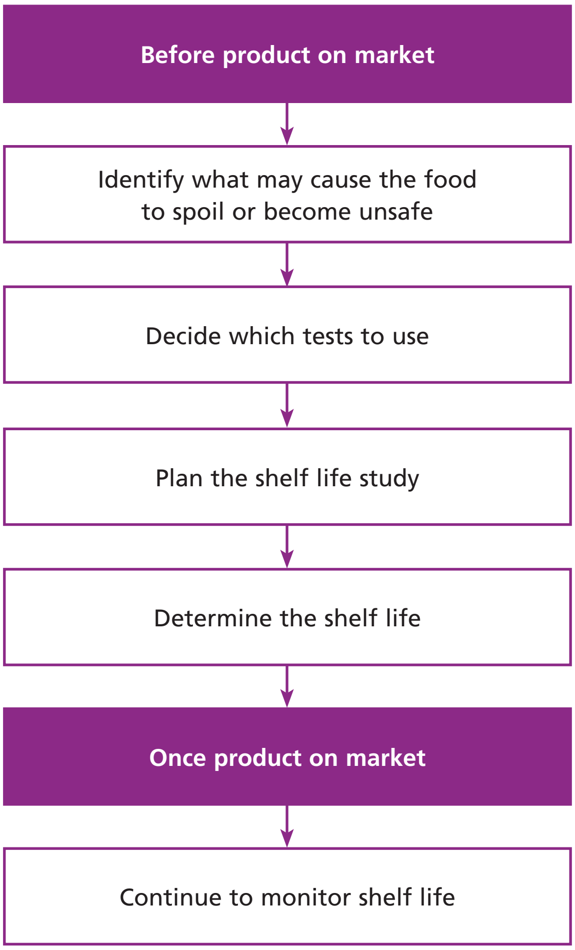
A shelf life study is an objective, methodical means to determine long a food product can reasonably be expected to keep for, without any appreciable change in quality. A separate study needs to be carried out for each type of product.

The two main methods used are:

1. Direct method This is the one most commonly used. It involves storing the product under preselected conditions for a period of time longer than the expected shelf life and checking the product at regular intervals to see when it begins to spoil. The exact procedure is unique for each product. Details of the steps required and types of decisions to be made are discussed in the following pages.

2. Indirect method This approach uses accelerated storage and/or predictive microbiological modelling to determine a shelf life. A brief outline of these is given later.

Steps involved in Calculating Shelf Life by the Direct Method



Step by step determination of shelf life by the direct method

There are a number of decisions that need to be made during the study, where it may be necessary to seek expert advice

STEP 1. Identify what may cause the food to spoil or become unsafe.

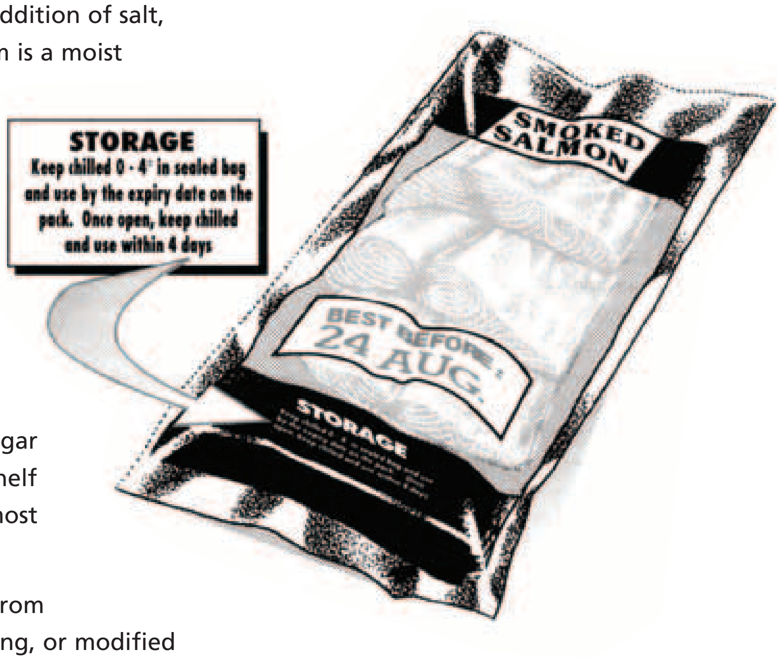
Each product will have its own set of factors that may limit its shelf life. Use the following lists as a starting point to help identify all the possible ways that the product may deteriorate in quality and/or safety. At the same time, identify the factors that help prolong the shelf life. Do not forget to consider the entire process, from the purchase of ingredients and packaging materials right through to the end use by the consumer. You may also need to consider the time of year, as some products will deteriorate faster in summer than in winter due to higher temperatures.

PRODUCT RELATED SPOILAGE:

Raw materials. The quality, consistency, level of contamination and storage of raw materials will all affect the final product.

Product make-up. Which ingredients you use, and how they behave when combined, influences what type of and how many spoilage organisms can grow. Any changes to the proportions of ingredients, or the ingredients themselves, may affect the shelf life.

Water activity. This is the amount of water in a food that that is available to be used by microorganisms. Microorganisms need water to grow. Water activity can be reduced by the addition of salt, sugar and some other ingredients. Jam is a moist food but the large amounts of sugar it contains mean only a small amount of this water can be used by microorganisms.



pH. This is a measure of acidity or alkalinity. The pH will influence which microorganisms will survive and grow in a food. For example, fresh mussels have a very short shelf life whereas mussels in vinegar (acidic) marinades have much longer shelf lives as the acidic environment limits most microbiological growth.

Oxygen availability. By removing air from around food, or using vacuum packaging, or modified atmosphere packaging, the food's shelf life may be extended. However, some microorganisms can grow in environments without oxygen so production processes need to control these microorganisms as well.

High standards of hygiene are still important as these packaging methods only limit the growth of spoilage organisms that need oxygen - they do not kill them or limit the growth of organisms that grow in the absence of oxygen; for example the bacteria that cause slime, botulism or listeriosis.

Chemical preservatives. When used correctly preservatives help to control the growth of microorganisms. Some have more than one role; for example sulphites slow spoilage and also prevent browning in dried fruits. The types and amounts of preservatives that can be used are detailed in the **Australia New Zealand Food Standards Code.**

PROCESS RELATED SPOILAGE:

Processing. Processes include anything from mixing, salting, smoking, fermenting, heating, cooling and chilling to dehydration, freezing and heat sterilisation. The choice of process can alter the shelf life of the final product. For example, UHT milk is a sterilised product and has a longer shelf life than pasteurised milk as the heat treatment is much greater.

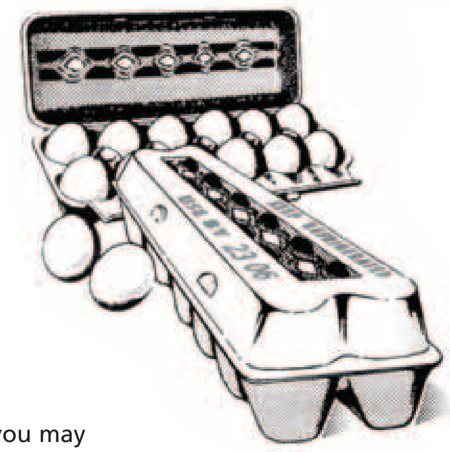
To achieve a consistent product with the same appearance, flavour, shelf life, etc., it is important that the ingredient quantities, quality and the processing steps are always the same. A written recipe or flow chart that gives exact details of what needs to be done at each step, particularly times and temperatures, will ensure this.

You cannot apply someone else's shelf life without knowing that all the steps in their process (i.e. growing, manufacture, distribution and sales) are the same as your own. Minor variations in the time or temperature can result in a failure to destroy spoilage and food poisoning organisms.

Packaging. Packaging must protect the product from contamination during all subsequent steps including distribution, sale and domestic storage. Packaging can also be a source of contamination if it is not produced and stored hygienically.

Storage. Temperature of storage is important as it can slow down the growth of the microorganisms that are important to food safety and quality. Other factors to consider are humidity, light, physical handling, placement near other products that could taint the food and protection from rodents, birds and insects.

Use temperature data loggers to ensure correct controls are maintained as fluctuating temperatures can affect the shelf life of perishable products.

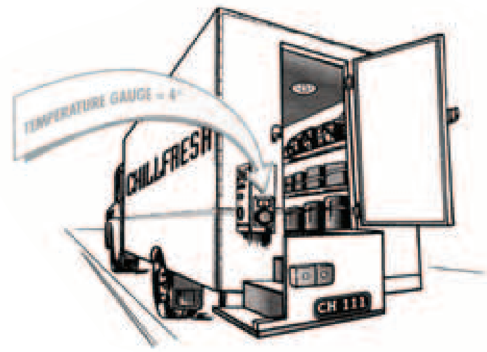


By now you should have identified all the possible ways the product could deteriorate and the factors involved should have been identified.

STEP 2. Which tests to use?

You need to select suitable tests for determining the safety and quality of the product.

All tests are not appropriate for all products. For example, you may test raw meats for numbers of lactic acid bacteria but you wouldn't test fermented raw meats (salami) for these organisms. It may also be important to test for food poisoning organisms such as *Listeria* in order to verify product safety.



If laboratory tests are needed, check that the laboratory is accredited for those tests with IANZ. If a laboratory is carrying out storage trials on your behalf you need to see records of storage temperature stability.

In general, tests can be divided into the following **four** categories:

1. SENSORY EVALUATION

Sensory evaluation assesses a food's smell, appearance, flavour, and texture. It can be used to monitor and record obvious changes that occur over time, and is therefore, useful when determining the shelf life of a food. The food should be assessed under the conditions at which it is designed to be stored and consumed.

Ideally, this should be done by a trained panel using recognised evaluation methods.

Always check the food is safe to eat before using a taste panel.

If possible, without destroying the texture or other properties of the food, freeze samples at the beginning of the study. These can then be used as a comparison at each testing session. If the food cannot be frozen, use a freshly prepared sample as a comparison.

2. MICROBIOLOGICAL

These tests can be used to evaluate both food quality and safety. Tests may be done to estimate changes in the number and type of spoilage organism (yeasts, moulds or bacteria) occurring over time. Table 1 in Appendix 1 provides examples of standard plate count levels that apply to various ready-to-eat food groups. If a specific food is not included in the table, use your judgement to determine where it would fit.

Identification of any food poisoning organisms present is important for food safety. Tests required will depend on the particular product. Microbiological standards and guidelines give guidance on the types of organisms and their number that can be considered acceptable, or unsafe, in a food. The following criteria apply to testing of foods in New Zealand:

- Standard 1.6.1 Microbiological Limits for Food
- Microbiological guideline criteria
- Guidelines for the microbiological examination of ready-to-eat foods

These documents are available on the FSANZ website *http://www.foodstandards.gov.au/*

It is unlawful to exceed limits set out in Standard 1.6.1. The other criteria listed above provide guidance to the food industry in setting acceptable levels of microorganisms. NZFSA recommends that industry set their own, more stringent, microbiological standards.

Some European countries are preparing standards that set microbiological criteria for *L. monocytogenes* at end of shelf life (Anon, 2004). A separate section has been included in this guide to provide assistance when determining the shelf life of foods capable of supporting growth of *L. monocytogenes* (Appendix 2)

3. CHEMICAL

Chemical tests can detect changes in the product's quality throughout its shelf life. Examples of instrumental chemical tests include pH, headspace gas analysis, free fatty acids and total volatile nitrogen.

4. PHYSICAL

These include tests for measuring product texture, examination of packaging, 'travel tests' and determining the best, worst and average retail conditions.

A 'travel test' helps to identify any hazards involved in transport and handling. It involves transporting the product through the expected distribution and storage chain. An examination of the product at various points, and at the end of the chain, is required. A data logger may be used to record the temperature at preset times for later analysis. Experimental design should attempt to mimic real life practices e.g. include predicted transport temperatures to retail outlets, during commercial control, consumer purchase and transport, and consumer storage.

By now you should have selected the tests to be used in the shelf life study.

STEP 3. Plan the shelf life study

Consider the following points when preparing your detailed shelf life study plan:

1. What tests need to be carried out?
2. How long will the study run for, and how often will the tests be carried out?
   Include the actual sampling dates in your plan. It is suggested that sampling be carried out at the beginning, at the target end point and at about three occasions in between. Another sampling should be carried out beyond the target to confirm the end point selection.
3. How many samples will be tested each time?
   At least triplicate packs of product should be tested at each sampling,
4. How many samples will be needed for the whole study period?
5. When will the study be run? Ideally it should be carried out in the season most likely to cause problems, usually summer. The study should be carried out more than once to take account of variability of the product.

The product, process and packaging should be the same as you intend to use for the final product. Keep written records of everything you use or do, as these can be helpful when interpreting results.

Now the study is fully planned and timetabled.

STEP 4. Run the shelf life study

During the study samples should be stored under the same conditions as your normal production samples, from manufacture through to consumption. If this is not possible the samples should be stored at a known temperature and humidity. These need to be checked and recorded regularly.

At the times set out in Step 2, samples are selected and tested as per the tests decided in Step 1. Do not forget to record the test results, and anything else you think may be helpful later.

STEP 5. Determine the shelf life

Eventually a point is reached when the product no longer meets the quality standard. Using all the information you have recorded and observed, decide how long the product can be kept and still be of an acceptable quality and safety. Maximum storage times for quality and safety may not be the same. The shelf life of a product should be which ever is shortest.

Look at the test results and if any of them don't make sense, repeat them. If the results still don't make sense or are variable, check that the ingredients, their quality and the processing are the same for all batches. Determine what is causing the variability; fix it, then repeat the sampling and tests.

Now you have an estimated shelf life that is based on ideal storage conditions, so you need to make allowance for the 'real world' where storage conditions may be variable, and product abuse can occur. The shelf life you select for your product should be reasonable, not ideal, and you should allow a safety margin. You can limit the possibility of product abuse to some extent by specifying the storage conditions for the product and limiting its distribution.

Now you have calculated the working shelf life.

STEP 6. Monitoring the shelf life

Samples should be tested for the factors that the shelf life study indicated were the most important for that product, e.g. acidity, loss of flavour, level of spoilage organisms etc. Samples could also be taken from various points within the distribution and retail system. If this testing shows that the preliminary shelf life is inappropriate, it should be adjusted.

It is also critical that the shelf life study is repeated after any changes have been made in the production or the processing environment.

A longer shelf life may be developed by identifying the limiting factors in the shelf life study, modifying them and repeating the study.

Investigating customer complaints relating to product failure before the expiry date may help to identify a recurring problem and indicate a need to recalculate the shelf life.

The records you made while designing and carrying out the shelf life study will assist you in the evaluation of customer complaints, trouble shooting, production and distribution problems and in reviewing the shelf life of the product. It is important that all test results are written down and that these records are kept in a safe, but accessible, place.

Continue to monitor the product to ensure it is safe and of good quality throughout its whole shelf life.

What are indirect methods?

Indirect methods attempt to predict the shelf life of a product without running a full length storage trial; hence, they can be useful for products with long shelf lives. The two most common indirect methods are:

1. ACCELERATED SHELF LIFE STUDIES

The trial period is shortened by deliberately increasing the rate of deterioration. This is usually done by increasing the storage temperature. The results are then used to estimate the shelf life under normal storage conditions.

2. PREDICTIVE MODELLING

Predictive models are mathematical equations which use information from a database to predict bacterial growth under defined conditions. Predictive models can be used to calculate the shelf life of a food. Information on the changes that occur in the product when it deteriorates, the properties of the product and packaging is required for the calculations. Most predictive models are specific to particular types of organisms.

Some examples of predictive modelling systems are the United States Department of Agriculture (USDA) Pathogen Modelling Program (available to download from the internet), Growth Predictor and FORECAST (a paid service by Campden and Chorleywood Food Research Association (CCFRA)).

Models are useful as a first step in the evaluation of a product's shelf life. However, information from modelling programmes needs to be verified by challenge testing or a shelf life trial.

Food safety and technology consultants should be able to assist with specific predictive modelling trials or problems. A list of consultants is available on NZFSA's website. See Appendix 4 for contact details.

What is challenge testing?

Challenge testing is used to assess whether a product formulation and storage conditions of a food can control the growth of pathogens, if present, during the designated shelf life.

The procedure involves inoculation of the product with relevant microorganisms and incubation of the product under controlled environmental conditions in order to assess the risk of food poisoning, or to establish product stability.

When should you use challenge testing?

In many foods, a combination of factors contribute to the preservation effect, none of which is sufficient to control the safety of the food on its own. Where the effect of such food control systems on specific pathogenic microorganisms cannot be predicted from the literature, it may be necessary to use challenge testing to evaluate the safety of the product.

Appendix 1: Guidelines for microbiological examination of ready-to-eat foods

TABLE 1: EXAMPLES OF STANDARD PLATE COUNT LEVELS APPLICABLE TO READY-TO-EAT FOOD GROUPS

Food group	Examples of products	SPC Level to apply*
Meat	Brawn	2
	Cold meat and poultry	2
	Kebabs (without salad)	1
	Minced patties (cooked)	1
	Sausages, frankfurters, saveloys (pre-cooked	1
	Sliced meat (ham, corned silverside, luncheon, etc)	2
	Sliced salami and other fermented meats	3
	Smoked meats (pastrami, hot pork, chicken)	2

Food group	Examples of products	SPC Level to apply*
Seafood	Crustaceans (shrimps, prawns, crab meat – cooked)	1
	Crustaceans and molluscs (cooked and marinated)	1
	Fish products (battered, crumbed – cooked)	1
	Fish and molluscs (smoked)	2
	Fish-based and seafood paté	1
	Herrings, roll mop and other raw pickled fish	1
	Molluscs and other shellfish (cooked)	1
	Surimi, crab sticks, and flavoured fish paste products	1
Dessert	Cakes, pastries, slices and desserts (with fresh cream)	2
	Cakes, pastries, slices and desserts (without fresh cream)	1
	Cheesecakes (baked)	1
	Cheesecakes (unbaked)	3
	Cooked fruit	1
	Fruit salad (fresh)	3
	Tarts, flans and fruit pies	1
Savoury	Cheese-based bakery products	1
	Curried eggs, mashed egg	2
	Dumplings, dim sims, won tons. spring rolls	1
	Flan/quiche	1
	Hummus, dips	2
	Meat and savoury pies	1
	Paté, terrines (sliced)	2
	Samosa, curry puffs	1
	Satay	1
	Sushi	3
	Sausage rolls, hot dogs	1
	Fermented foods	3
Vegetable	Coleslaw	3
	Fruit and vegetables (dried)	1
	Fruit and vegetables (fresh)	3
	Mixed salads, tossed salads	3
	Rice and rice based salads (cooked)	2
	Vegetables and vegetable meals (cooked)	1
	Vegetarian paté	1
Dairy	Cheese	3
	Cream freeze	2
	Iceblocks, flavoured shaved ice, sorbets	2
	Ice cream on cone (dairy and non-dairy)	2
	Milkshakes	2

Continued overleaf…

Food group	Examples of products	SPC Level to apply*
Ready-to-eat meals	Pasta/pizza	1
	Meals (others)	1
Bread products	Sandwiches and filled rolls (with salad)	3
	Sandwiches and filled rolls (without salad)	2
	Sandwiches and filled rolls (with cheese)	3

*Application of Standard Plate Count (30°C/72hr) levels (see next page)

Level 1 – applies to RTE foods in which all components of the food have been cooked in the manufacturing process/preparation of the final food product and, as such, microbial counts should be low.

Level 2 – applies to RTE foods which contain components that have been cooked and then further handled (stored, sliced and mixed) prior to preparation of the final food or where no cooking process has been used.

Level 3 – SPCs not applicable. This applies to foods such as fresh fruits and vegetables (including salad vegetables), fermented foods and foods incorporating these (such as sandwiches and filled rolls). It would be expected that these foods would have an inherent high plate count because of the normal microbial flora present.

NOTE: If a specific RTE food is not included in the examples, use you professional judgement to decide where the product would fit based on the type of product and the processing it has received

The following table has been extracted from the FSANZ *Guidelines for the microbiological examination of ready-to-eat foods.* The full document is available at the following address: *www.foodstandards.gov.au/mediareleasespublications/publications/guidelinesformicrobi1306.cfm*

TABLE 2: GUIDELINE LEVELS FOR DETERMINING THE MICROBIOLOGICAL QUALITY OF READY-TO-EAT FOODS

Test	Microbiological Quality (cfu per gram)			
	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous
Standard Plate Count (30°C/72hrs)				
Level 1	$<10^4$	$<10^5$	$\geq 10^5$	
Level 2	$<10^6$	$<10^7$	$\geq 10^7$	
Level 3	N/A	N/A	N/A	
Indicators				
Enterobactericeae*	$<10^2$	$10^2 - 10^4$	$\geq 10^4$	
Escherichia coli	<3	3-100	≥100	**
Pathogens				
Coagulase +ve staphylococci	$<10^2$	$10^2 - 10^3$	$10^3 - 10^4$	$\geq 10^4$ SET +ve
Clostridium perfringens	$<10^2$	$10^2 - 10^3$	$10^3 - 10^4$	$\geq 10^4$
Bacillus cereus and other pathogenic *Bacillus* spp	$<10^2$	$10^2 - 10^3$	$10^3 - 10^4$	$\geq 10^4$
Vibrio parahaemolyticus#	<3	$3-10^2$	$10^2 - 10^4$	$\geq 10^4$
Campylobacter spp	Not detected in 25g			Detected
Salmonella spp	Not detected in 25g			Detected
Listeria monocytogenes	Not detected in 25g	Detected but $<10^{2}$‡		$\geq 10^{2}$##

N/A SPC testing for level 3 RTE foods are not applicable. This applies to foods such as fruits and vegetables (including salad vegetables). Fermented foods and foods incorporating these (such as sandwiches and filled rolls).

* Enterobacteriaceae testing is not applicable to fresh fruits and vegetables or foods containing these.

** Pathogenic strains of E.coli should be absent.

\# V.parahaemolyticus should not be present in seafoods that have been cooked. For ready-to-eat seafoods that are raw, a higher satisfactory level may be applied ($<10^2$ cfu/g).

‡ Foods with a long shelf life stored under refrigeration should have no L.monocytogenes detected in 25g.

\## The detection of *L.monocytogenes* in ready-to-eat foods prepared specifically for "at risk" population groups (the elderly, immunocompromised and infants) should also be considered as potentially hazardous.

Appendix 2: Determination of shelflife of foods capable of supporting *Listeria monocytogenes*

It is important, when determining the shelf life of a food, to consider whether a food is capable of supporting growth of *Listeria monocytogenes. L. monocytogenes* is considered the most dangerous pathogen in relation to chilled processed foods as it is capable of growing at refrigeration temperatures. Listeriosis, the most significant illness caused by this pathogen, has serious health consequences for susceptible groups of people, in particular, the very young, pregnant, elderly and people who are immunocompromised. Healthy people usually only suffer a non-invasive gastrointestinal illness, but they too may be affected by the more serious outcome.

There are no simple rules for defining when growth may occur as a number of factors including temperature, pH, acidulant, competing flora, storage time etc. may have an affect. Below is a list of growth characteristics of *L. monocytogenes.*

Characteristics of *L. monocytogenes*

- Capable of aerobic and anaerobic growth (e.g. in vacuum pack)
- Minimum pH for growth 4.3
- Minimum a_w for growth 0.92
- Minimum growth temperature –1.5°C
- Decimal reduction times (D*) $D_{60°C}$, 5-10 min
  $D_{70°C}$, approx 10 sec
- Poor competitors in mixed cultures. Refrigerated foods such as vacuum packed meats with low levels of competing organisms provide favourable conditions for *Listeria* to multiply.

(*Time to achieve 90% or 1 log reduction in numbers of an organism at a specified temperature)

When determining the shelf life of foods, special consideration must be given to high risk foods that:

1. Will support growth of *L. monocytogenes*
2. Are sold ready-to-eat
3. Are stored refrigerated
4. Are stored for long periods of time (>10 days)

To help you to determine which products are of greatest concern, you can review your products or processes against the following questions:

1. Is *L. monocytogenes* expected to be present in the raw materials?
2. Will the organism be destroyed by any of the processing stages?
3. Will the product be exposed to any post-process contamination?
4. Will the finished product allow growth of *L. monocytogenes* if present?
5. Does the product have a long shelf life, e.g. >10 days?
6. Will the product be subjected to a process by the customer which will destroy *L. monocytogenes*?

Examples of foods considered a high risk for *L. monocytogenes* include deli meats, frankfurters (not reheated), paté and meat spreads, smoked seafood, unpasteurised milk, high fat and other dairy products and soft unripened cheeses (FDA/CFSAN, 2003).

Surveys have found the times required for *L. monocytogenes* to grow through one log (a ten fold increase in numbers) in various ready-to-eat foods in the temperature range of 4-12°C are as follows:

Cold smoked seafood	43.2 h
Ready-to-eat crustacea	48 h
Vacuum packed deli meats	48 h

When considering the shelf life of high risk products you should consider whether you can put in place any of the following controls:

- Post packaging treatment of product to destroy *Listeria* (e.g. pasteurisation)
- Preventing contamination of foods that allow growth of *Listeria*
- Establishing acceptable storage times to preclude extensive growth
- Preventing *Listeria* growth in foods by addition of antimicrobial agents or use of modified atmosphere packaging (e.g. 100% CO_2)
- Providing advice to consumers to cook products thoroughly
- Providing advice to susceptible groups (e.g. label food as unsuitable for consumption by susceptible groups)

Growth of *Listeria monocytogenes* in Food

Below is a summary of the contents of 84 scientific papers describing the ability of *L. monocytogenes* to grow, or otherwise, on foods. There is a lot of data concerning various cheeses, vegetables and meat products, but not much on anything else.

These data have been extracted from a project conducted by ESR for the Ministry of Health in order to present health protection officers with some useful information on the kinds of foods that will support the growth of *Listeria monocytogenes* (MoH 1995).

Some notes regarding the data;

- In general the 'worst case' has been selected. For example if two isolates were tested, one grew and one didn't then the data for the one that did are included.

- Adaptation has been shown to occur. For example prior exposure to low pH can result in subsequent enhanced survival under acidic conditions. However the result is a change in the rate of death/growth and so it is a matter of degree. Therefore if *L. monocytogenes* is reported to die in a food then adapted strains still die, they just do it more slowly.
- 'Growth' means that they actually increased in numbers. 'Survival' means that there was neither a significant increase, or decrease, in numbers. 'Decline' means that numbers of the organism present actually decreased under the conditions in the food.
- Some products may appear in more than one place if, for example, *L. monocytogenes* grew on them at 10°C but not at 3°C.

N.B. The temperatures listed are those at which the experiments were conducted, and these have usually been at refrigeration or mild temperature abuse values. It would be fair to assume in most cases that a food found to support growth at 3 and 6°C will also do so at 4 and 5 and temperatures higher than 6°C .

[Annotations in square brackets refer to special conditions in which the foods were incubated]

TABLE 3: SUMMARY OF THE GROWTH OF *L. MONOCYTOGENES* IN FOODS

Foods permitting of growth	Temperature of storage (°C)	Foods allowing survival only	Temperature of storage (°C)	Foods where numbers fall	Temperature storage (°C)
		CHEESES			
Anthotyros	5, 12, 22				
		Blue	9-12		
Blue Lyme	6, 10	Blue Lyme	3		
		Blue Stilton	3, 10		
Brie	5				
Brie with garlic	3, 6				
Camembert	3, 6, 10, 15				
		Chaume	5, 10		
				Cheddar	8
				Cottage	5, 10, 20
				Emmantaler	10-22
English brie	6, 10	English Brie	3		
				Feta	4
		Full fat soft	5, 10		
Manouri	5, 12, 22				
		Mozarella	4		
		Mycella	5		
Myzithra	5, 12, 22				
				Parmesan	12.8
		Tilsiter	10-22		
White Lyme	6, 10	White Lyme	3		
White Stilton	10	White Stilton	3		

Foods permitting of growth	Temperature of storage (°C)	Foods allowing survival only	Temperature of storage (°C)	Foods where numbers fall	Temperature storage (°C)
OTHER DAIRY PRODUCTS					
Butter	4, 10, 13	Butter	-18		
Cream	3, 6, 9				
		Ewe's milk	-18, -38		
		Ice cream	-18		
Light butter	4, 20				
Milk, chocolate	4, 10				
		Milk, dried	25		
Milk, evaporated	7, 21				
Milk, skimmed	4, 8, 10, 22, 37				
		Milk, sweetened, condensed	7, 21		
Milk, pasteurised	3, 4, 6, 9, 22, 37				
Milk, UHT	3, 6, 9				
Milk, 1% milkfat	4				
				Yoghurt	4
MEAT AND POULTRY PRODUCTS, READY TO EAT					
Beef, corned	0				
Beef, cooked	5, 10				
		Beef jerky	25		
		Beef, minced	5		
Beef, roast	-1.5 [vacuum packed], 5, 10	Beef, roast	-1.5 [packed under 100% CO_2]		
Chicken	4.4				
Chicken breast	4, 7, 10				
Chicken loaf	3, 7, 11				
Chicken nuggets	3, 11				
Frankfurters	4				
Ham	0, 4.4, 7	Ham	0 [containing 170 ppm nitrate]		
Luncheon	7				
Pâté	4, 10	Pâté	4		
		Pepperoni	varied		
Pork	4, 10				
				Salami	4, 7
Turkey	4.4				
Turkey breast meat	2, 7	Turkey breast meat	4		
		Turkey loaf	3		
Wieners, beef	5				
Wieners, poultry	5				

Foods permitting of growth	Temperature of storage (°C)	Foods allowing survival only	Temperature of storage (°C)	Foods where numbers fall	Temperature storage (°C)
MEAT AND POULTRY PRODUCTS, UNCOOKED					
		Beef mince	4		
Beef striploin	5, 10 [vacuum packed]			Beef striploin	5, 10 [packed under 100% CO_2]
Hamburger	12	Hamburger	4		
Chicken	4, 10, 27 [in air and modified atmosphere containing oxygen]	Chicken	4, 10, 27 [in oxygen-free modified atmosphere]		
Chicken breast	6, 15	Chicken breast	1, 6 [modified atmosphere]		
		Liver mince	4		
Pork chops	4				
Turkey breast meat	2, 7	Turkey breast meat	4		
SEAFOODS, READY TO EAT					
Blue cod, smoked	-1.5, 3 [vacuum packed]	Blue cod, smoked	-1.5, 3 [packed under 100% CO_2]		
Cod fillets, smoked	4	Cod fillets, smoked	-20		
Crabmeat	1.1, 2.2, 5, 6	Crabmeat	-20		
Crayfish tail	4				
Mussels, cooked	5, 10				
Salmon, smoked	5, 10	Salmon, smoked	-20		
		Seafood Pâté	4		
Trout, hot smoked	8-10	Trout, hot smoked	4		
SEAFOOD, UNCOOKED					
Cod fillets	4, 20				
Crawfish	22, 30	Crawfish	-20, 6		
		Fish fillet	-20, on ice		
		Prawns	-20, on ice		

Foods permitting of growth	Temperature of storage (°C)	Foods allowing survival only	Temperature of storage (°C)	Foods where numbers fall	Temperature storage (°C)
VEGETABLES AND SALADS, NORMALLY EATEN RAW					
				Cabbage, heat sterilised	5
Caesar salad	10	Caesar salad	4		
Carrot, cooked	5, 15				
				Carrot juice	30
Carrot, shredded	5			Carrot, shredded	4, 10, 15
Chicory endive	6.5 [vacuum packed]	6.5 [in air]			
Chicken salad with mayonnaise	4, 12.8				
Coleslaw mix	10	Coleslaw mix	4		
				Endive, broad leaf	10
Endive, curly leaf	3, 6, 10				
Kimchi	4 [improperly made]			Kimchi	21, 35
Lettuce, butterhead	10				
		Lettuce, lamb's	10		
				Macaroni salad	4, 12.8
				Mung bean sprouts	6.5
Soy milk	5, 22				
Tomatoes, cherry whole	10, 21				
				Tomatoes, chopped	10
		Tomato juice	5, 21		
				Tomato ketchup	5, 21
				Tomato sauce	5, 21
VEGETABLES, NORMALLY REQUIRING COOKING					
Asparagus	4, 15				
Broccoli	4, 15				
Butternut squash	4, 10				
Cabbage, shredded	5				
				Carrots, whole	5,15
Cauliflower	15	Cauliflower	5		
Onion	10	Onion	4		
Spinach	30				
Stir fry mix	10	Stir fry mix	4		
Swede	10	Swede	4		

Foods permitting of growth	Temperature of storage (°C)	Foods allowing survival only	Temperature of storage (°C)	Foods where numbers fall	Temperature storage (°C)
EGG PRODUCTS					
Eggs, whole pasteurised	4, 10, 12.8, 20, 30	Eggs, whole pasteurised	6.7	Eggs, whole pasteurised	2
Eggs, whole pasteurised plus 5% salt	12.8	Eggs, whole pasteurised plus 5% salt	2, 6.7		
		Egg white, pasteurised	2, 6.7	Egg white, pasteurised	12.8
				Mayonnaise	26.6
				Salad dressing	4
MISCELLANEOUS					
				Orange juice	4
		Ravioli, various fillings	5		
Rice pudding	5, 12, 22				

INITIAL NUMBERS AND SHELF LIFE

Some of the experiments reviewed measured growth of the *Listeria* already present in the foods as purchased (natural contamination). Usually initial counts were low and subsequent growth somewhat slower at refrigeration temperatures than expected from experiments where cells were added to foods. This ‘inoculum effect’ is quite well reported for *Listeria*.

Bacterial growth undergoes two phases, the lag phase and the exponential phase prior to attaining a maximum number. In the lag phase, bacteria take time to adapt to their new environment. At sufficiently low storage temperatures (which will vary with the food) this lag phase may be so long that, even if the organism were theoretically able to grow in a food, no growth will occur if the shelf life is short enough. The data produced from this review suggest that in a product such as minced beef, where the shelf life of the refrigerated product is quite short, no growth of *Listeria* is likely to occur before the product becomes grossly spoiled, and so, is unlikely to be sold or eaten.

In experiments where the storage period was shorter than the lag phase *L. monocytogenes* is reported as not being able to grow, but in other experiments where the storage period was extended the same food, or one much like it, may be recorded as allowing growth. This explains why similar foods sometimes appear in more than one place in the food list above.

Appendix 3: Extended shelf life foods and *Clostridium botulinum*

Clostridium botulinum produces heat resistant spores that can survive pasteurisation and some cooking temperatures. This organism produces a potent toxin in food. If there is a potential for spores of *C. botulinum* to be present in a food and the conditions allow spore germination and growth, the food is potentially hazardous to the consumer. Most outbreaks of botulism poisoning have involved canned or bottled vegetable products or meats where the spores were present in the raw food, heating has killed competitive organisms but the spores have survived and grown during storage.

Spores of *C. botulinum* must be expected to be present in raw foods harvested from the land or water. These organisms can be consumed without causing any harm. It is only when conditions allow growth and toxin production in a food that botulism poisoning will occur.

All people are at risk of botulism. Symptoms vary from a mild disease to an illness that can be fatal within 24 hours. Botulism has a high, (8%), case fatality rate and 80% of cases are hospitalised and require intensive supportive therapy.

Examples of foods involved in botulism outbreaks include:

- Canned and bottled vegetables (garlic in oil, marinated mushrooms, peppers, tomatoes and tomato juice, olives, roasted eggplant in oil etc)
- Vegetables (baked potatoes, garlic in oil, sautéed onions)
- Bottled fruits (pears, apricots, peaches)
- Fish and seafood (raw, vacuum packed, smoked, canned)
- Meats (cured, canned, fermented, pates, pies)
- Mascarpone cheese

C. botulinum types affecting humans fall into 2 groups

Group 1	Proteolytic strains (produce neurotoxins A, B and F)	
	Capable of anaerobic growth (e.g. in vacuum pack)	
	Minimum pH for growth	4.6
	Minimum a_w for growth	0.94
	Minimum growth temperature	10°C
	Decimal reduction times* at 121°C	0.2 min
	Recommended commercial heat treatment	3 min at 121°C
Group 2	Non-proteolytic (produce neurotoxins B, E and F)	
	Capable of anaerobic growth (e.g. in vacuum pack)	
	Minimum pH for growth	4.7
	Minimum a_w for growth	0.97
	Minimum growth temperature	3.3°C
	Decimal reduction times * at 90°C	1.1 min
	Recommended commercial heat treatment	10 min at 90°C

(* Time to achieve 90% or 1 log reduction in numbers of an organism at a specified temperature)

Chilled foods

There are concerns with chilled vacuum packed foods as there are types of *C. botulinum* that can grow at refrigeration temperatures as low as 3.3°C. Some foods have specific control factors that totally prevent growth, such as low pH or high salt, and therefore present no risk. In other foods a combination of preservative effects will be used to control the growth of *C. botulinum*.

The UK Advisory Committee on Microbiological Safety of Food recommended for chilled foods with a shelf life of >10 days that in addition to chill temperatures (<8°C), the following controls should be used singly or in combination (CCFRA, 1996):

- Heating to 90°C for 10 min
- pH of 5 or less
- Minimum salt level, 3.5%
- a_W <0.97
- A combination of heat and preservative factors that can be shown to prevent growth and toxin production of *C. botulinum*.

Foods stored at ambient temperatures

There are a number of factors that can contribute to the safety of long shelf life products that are stored at ambient temperatures.

1. You can incorporate a heat process to eliminate the hazard

- Heat to a high temperature to achieve a 'botulinum cook' i.e. 121°C for at least three minutes for canned or bottled foods.

2. You can use a combination of processes to control the hazard

Raw material control

- Select the best quality raw materials to ensure levels of *C. botulinum* are not excessive.

Heating to 90°C for 10 min

Formulate product to prevent growth of C. botulinum

- Addition of acid or fermentation (pH<4.6)
- Drying, salt (aw <0.97)
- Addition of preservatives

Advice to consumer

- Many products rely on effective handling by the consumer to ensure they remain safe until consumption. Label foods to inform consumer such as, "once opened keep refrigerated" or "consume within…".

Even though food-associated botulism is rare, because of the growth of novel food products, the increasing market for vacuum and modified atmosphere packaged chilled foods, and the availability of food ingredients from anywhere in the world, there is a need to consider *C. botulinum* in your hazard assessment when establishing the shelf life of a food.

Appendix 4:
Health Protection Officers Contacts

Public Health Office	Postal Address	Phone	Fax
Auckland Central Clearing House	PO Box 76 123, Manukau City Auckland *baskern@adhb.govt.nz*	09-262-1855	09-261-1626
Auckland District Health Board	Private Bag 92 605, Symonds Street, Auckland	09-623-4600	09-623-4645
Community & Public Health Christchurch Office	PO Box 1475, Christchurch	03-379-9480	03-379-6125
Community & Public Health Greymouth Office	PO Box Greymouth	03-768-1160	03-768-1169
Community & Public Health Timaru Office	Private Box 510 Timaru	03-688-6019	03-688-6091
Hawke's Bay District Health Board	PO Box 447, Napier	06-834-1815	06-834-1816
Health Waikato	PO Box 505, Hamilton	07-838-2569	07-838-2382
Hutt Valley District Health Board Lower Hutt Office	Private Bag 31 907 Lower Hutt	04-570-0044	04-570-9211
Hutt Valley District Health Board Masterton Office	Private Box 58 Masterton	06-370-5020	06-370-5029
Mid Central Health Palmerston North Office	P O Box 2056 Palmerston North	06-350-9110	06-350-9111
Mid Central Health, Wanganui Office	Private Bag 3003, Wanganui	06-348-1775	06-348-1783
Nelson Marlborough District Health Board – Blenheim Office	PO Box 46 Blenheim	03-520-9914	03-578-9517
Nelson Marlborough District Health Board – Nelson Office	PO Box 647 Nelson	03-546-1537	03-546-1542
Northland District Health Board	PO Box 742, Whangarei	09-430-4100	09-430-4492
Pacific Health, Rotorua Office	PO Box 1858, Rotorua	07-349-3520	07-346-0105
Pacific Health, Tauranga Office	PO Box 2121, Tauranga	07-571-8975	07-578-5485
Pacific Health, Whakatane Office	PO Box 241, Whakatane	07-306-0720	07-306-0987
Public Health South, Dunedin Office	PO Box 5144, Moray Place, Dunedin	03-474-1700	03-474-0221
Public Health South, Invercargill Office	PO Box 1601, Invercargill	03-211-0900	03-211-0899
Public Health South, Queenstown Office	PO Box 2180, Queenstown	03-422-2500	03-422-2505
Tairawhiti District Health	PO Box 119, Gisborne	06-867-9119	06-867-8414
Taranaki Health	Private Bag 2016, New Plymouth	06-753-7798	06-753-7788

FOOD SAFETY AND TECHNOLOGY CONSULTANTS

NZFSA provides a list of companies who offer food and dietary supplement labelling, food safety and food safety programme advice. Inclusion on this list does not imply endorsement by NZFSA.

http://www.nzfsa.govt.nz/processed-food-retail-sale/food-safety-consultants.htm

Appendix 5: Publications

The following website provides free public access to unofficial versions of New Zealand statutes (Public, Local, and Private Acts) and Statutory Regulations. *http://www.legislation.govt.nz*

More information can be viewed online at NZFSA's web site: *http://www.nzfsa.govt.nz/* or can be obtained from NZFSA's Policy Group, PO Box 2835, WELLINGTON.

The Australia New Zealand Food Standards Code can be viewed on the Food Standards Australia New Zealand website: *http://www.foodstandards.govt.nz* or can be viewed free of charge at NZFSA. Copies of the Code, or Amendments to the Code, can be purchased by subscription from:

ANSTAT
PO Box 447, South Melbourne
VIC 3205, Australia
http://www.anstat.com.au/
e-mail *foodcode@anstat.com.au*
Phone +61 3 9278 1144.

Microbiological Reference Criteria for Food. July 1995. Industry Guide that contains microbiological criteria used as a guide by regulators to assess when food can be considered unacceptable or unsafe. This is available from local health protection officers.

Appendix 6: Further reading

The following are a few references that you may find useful.

Anon (2003) Draft Commission Regulation on microbiological criteria for foodstuffs. SANCO/4198/2001, rev. 9. 15.1.2004.

Bell C and Kyriakides A (1998) *Listeria.* A practical approach to the organism and its control in foods. Blackie Academic and Professional, UK

Bell C and Kyriakides A (2000) *Clostridium botulinum*. A practical approach to the organism and its control in foods. Blackwell Science, UK

CCFRA (1996) A code of practice for the manufacture of vacuum and modified atmosphere packaged chilled foods with particular regard to the risks of botulism" Guideline No 11, GD Betts (Ed), Campden and Chorleywood Food Research Association, May 1996

CCFRA (2004) Evaluation of product shelf life for chilled foods", Guideline no 46, GD Betts, HM Brown and LK Everis (Eds) Campden and Chorleywood Food Research Association, 2004

FDA/CFSAN (2003) Quantitative assessment of relative risk to public health from *Listeria monocytogenes* among selected categories of ready-to-eat foods. FDA/Center for Food Safety and Applied Nutrition, USDA/Food Safety and Inspection Service, Centers for Disease Control and Prevention, September 2003. *http://www.foodsafety.gov/~dms/lmr2-toc.html*

FSANZ (2000) Australia New Zealand Food Standards Code. Food Standards Australia New Zealand. *http://www.foodstandards.gov.au*

IFST (1993) Shelf life of Foods – Guidelines for its determination and prediction. Institute of Food Science and Technology, London. ISBN 0 905367 11 1.

Man D (2002) Food industry briefing series: Shelf life. Blackwell Science UK. ISBN 0-632-05674-6.

MoH (1995) Growth of *Listeria monocytogenes* in Food. A report for the Ministry of Health., Project F95.

For further information please contact:

NEW ZEALAND FOOD SAFETY AUTHORITY