

# Shelf-life evaluation to ensure the production of safe and stable food

by Dr Gail Betts, Section Manager, Campden BRI, Chipping Campden, Glos. GL55 6LD, UK.

The aim of food manufacturers is to produce products that meet customer expectations in terms of safety and quality. This is achieved by good product and process design and assignment of appropriate shelf-life and storage conditions.

The shelf-life of a product is defined as the time during which that product remains safe and retains the desirable attributes of product quality with respect to chemical, sensory and microbiological characteristics.

This encompasses the need to be free from undesirable foodborne pathogens and to maintain an acceptable level of spoilage organisms.

The assignment of an appropriate shelf-life can have a major impact on the success of a new product. If it is too short then the manufacturing costs are high and the profit margins low and if it is too long then there is the potential for food spoilage or growth of food poisoning organisms to occur.

It is therefore important to assign the shelf-life in a systematic and scientific manner, taking all relevant factors into consideration.

The shelf-life of a food product is influenced by many aspects of manufacturing, product formulation and storage conditions and the effect of these on the growth of target micro-organisms must be considered.

There are three different approaches that can be used to

assess the product shelf-life: shelf-life trials, challenge tests and predictive microbiology.

Each has a role to play in assuring the safety of the product shelf-life chosen.

## Shelf-life evaluation

Shelf-life evaluation is designed to answer the question: for how long does this product remain within the designated quality parameters during normal production and storage conditions?

Such tests only assess the growth of micro-organisms naturally present in the batch of product tested. As it is unlikely that pathogens would be present in product then shelf-life testing will not be able to assess the potential for growth of foodborne pathogens.

The shelf-life of food products is determined in a logical sequence of events:

- Kitchen/pilot scale assessment where the product and process characteristics are defined.
- Factory scale trials, where the majority of laboratory testing is done on batches of product produced under routine manufacturing conditions and where the shelf-life of the product is assigned. During this stage, product is stored under conditions to which it is likely to be exposed during retail distribution and examined for any changes in levels of target micro-organisms. Storage of samples should be done using a recognised protocol as shown in Table 2 for chilled food products.
- Full scale production, where any

**Table 1. Factors affecting microbial shelf-life.**

- Raw material quality
- Heat process
- Product formulation - pH (acidity), salt level or water activity and preservatives
- Distribution and storage
- Packaging, including gas atmosphere
- Consumer handling

Manufacturing stage	Storage temperature (°C)	Time
<b>Under commercial control</b>		
In-house storage at manufacturer	5 or 7 *	To be defined by manufacturer and/or retailer
Distribution vehicles storage depot	5 or 7	
Retail display	5 or 7	
<b>Outside commercial control</b>		
Consumer purchase	22	2 hours
Consumer storage	7	Remainder of life

*\* 7C ± °C should be used unless there is documented evidence to show a lower temperature can be achieved.*

**Table 2. Recommended storage regime for shelf-life trials and challenge tests for chilled foods (Betts et al 2004).**

changes to the shelf-life are monitored.

It should be noted that assigned shelf-life determined in these studies is only relevant to the product formulation and storage conditions used and cannot be extrapolated to other conditions.

## Challenge testing

Challenge testing is designed to answer the question: Will the product formulation and storage conditions control growth of pathogens (or spoilage organisms) during the designated shelf-life if they were present in the ingredients or contaminated the food during manufacture?

It involves the deliberate inoculation of a food with the relevant organisms followed by growth studies under controlled laboratory conditions. The advantage of this technique is that it provides data to answer the 'what if' questions that may not be answered during shelf-life studies, for example:

- What would happen if *Listeria monocytogenes* contaminated my product after cooking?
- What would happen if a preserv-

ative resistant yeast survived the processing?

## Predictive microbiology

Predictive microbiology involves the use of mathematical models to predict the likely growth of spoilage organisms or food pathogens in different product formulations or storage conditions. It provides a rapid answer for use in new product development and trouble shooting situations. Data can be obtained on the length of lag time; rate of growth; time taken to reach a target number of organisms and effect of different storage regimes.

In addition, many models can be used to predict the effect of fluctuating temperature profiles or changes in pH as may be seen during manufacture of fermented foods.

Predictions for a range of spoilage organisms are shown in Table 3.

## Case studies

The approach taken with shelf-life testing is dependent on the type of

*Continued on page 7*

Continued from page 5 product being assessed. The pH, Aw, heat process and storage temperatures will select for different target organisms and different end point criteria. Examples of the approaches used for two different food groups are shown inset below.

### Legislative requirements

There are two important areas in which challenge testing or predictive models can be used to help assess the safety of the designated shelf-life of chilled food products:

- Growth of *Clostridium botulinum*.
- Growth of *Listeria monocytogenes* in chilled foods.

For many years it has been recommended that chilled modified atmosphere packaged or vacuum packaged foods have a restricted shelf-life of up to 10 days unless they meet one of the recommended controlling factors required to inhibit the growth of *C. botulinum*.

- Heat treatment of 90°C for 10 minutes (or equivalent).
- Aqueous salt level of ≥3.5%.
- Water activity of ≤ 0.97.
- pH of ≤ 5.0.

If none of these factors are achieved in a food product, the safety of other levels of these factors or alternative preservatives can be demonstrated by inoculated challenge test or predictive models.

With respect to *L. monocytogenes*, chilled ready to eat products (RTE), other than those intended for infants or for special medical pur-

Model	Temperature (°C)	NaCl (% aq)	Equivalent Aw	pH	Other conditions
<i>Pseudomonas</i>	0-15	0.0-4.0	1.00-0.977	5.5-7.0	
<i>Bacillus</i> spp.	5-25	0.5-10	0.997-0.935	4.0-7.0	
Enterobacteriaceae	0-27	0.5-10	0.997-0.935	4.0-7.0	
Yeasts (chilled foods)	0-22	0.5-10	0.997-0.935	2.6-6.0	
Yeasts (fruit/drinks) (time to growth)	0-22	–	–	2.0-7.0	0-60% Sucrose 0-20% Ethanol Potassium sorbate 0-1000 (ppm)
Lactic acid bacteria	2-30	0.5-10	0.997-0.935	3.0-6.0	
Meat spoilage	2-22	0-6	1.00-0.964	4.6-7.0	Potassium nitrite 0-240 (ppm)
Fish spoilage	2-22	0-6	1.00-0.964	4.5-8.0	
Fresh produce	2-25	–	–	–	
Enterobacteriaceae death model	52-64	0-8	1.00-0.95	4.0-7.0	Predicts D value
<i>Bacillus</i> (time to growth)	8-45	0.5-10	0.997-0.935	4.0-7.0	

Table 3. Predictive models for spoilage organisms in Campden BRI Forecast system.

poses, should have no more than 100 cfu/g *L. monocytogenes* per gram present at the end of shelf-life (EU Regulation EC 2073/2005, as amended).

Food business operators producing RTE products able to support growth must therefore be able to demonstrate that the product will not exceed the limit of 100 cfu/g throughout its shelf-life. When this is not demonstrated, absence of *L. monocytogenes* applies at the end of the manufacturing process.

Challenge testing or predictive

models are two ways that manufacturers can demonstrate the safety of the assigned shelf-life with respect to the growth of *L. monocytogenes* in RTE foods following appropriate guidelines.

### Conclusions

The shelf-life of food products is influenced by microbiological, chemical and sensory considerations along, in some cases, with legislative requirements. It needs to be deter-

mined following sound scientific principles that can take into account all the relevant formulation, manufacturing, distribution and storage factors.

The shelf-life determined is unique to the product and storage conditions tested and cannot be extrapolated to other products or storage conditions.

Assigning the correct shelf-life can be the key to the commercial success of a new product and should be done in the early stages of new product development. ■

## Case study one

### Shelf-life of ambient stable acidified foods

This procedure is used by many manufacturers of acidified foods. Products are inoculated with a cocktail of acid tolerant yeasts, moulds and lactic acid bacteria.

If the levels increase during the trial then the product is considered to be unstable. However if the levels decrease then the products are considered to be stable for the duration of the ambient shelf-life (typically 18-24 months).

Two sets of data are shown in the tables below for different product types. It can be seen that the salad dressing has allowed growth of the target organisms.

It is therefore not stable and needs to be reformulated, whilst the chilli sauce formulation has shown a rapid decrease in levels of micro-organisms and is likely to be stable throughout the desired shelf-life.

Sampling time	Salad dressing		Chilli sauce	
	Yeast/lactic level (cfu/g)	Mould level (cfu/g)	Yeast/lactic level (cfu/g)	Mould level (cfu/g)
Day 0	1.30 × 10 <sup>3</sup>	ND*	1.30 × 10 <sup>4</sup>	ND*
Day 1	1.70 × 10 <sup>3</sup>	ND*	5	ND
Week 3	1.60 × 10 <sup>3</sup>	ND	<5	ND
Week 6	5.90 × 10 <sup>3</sup>	ND	<5	ND
Week 9	2.70 × 10 <sup>4</sup>	ND	<5	ND
Week 12	8.90 × 10 <sup>5</sup>	ND	<5	ND

\*ND is therefore <10

## Case study two

### Shelf-life of a chilled meat product

The shelf-life of this product type is short (typically 2-4 weeks) and is usually governed by levels of general spoilage micro-organisms.

Samples of product are stored according to the recommended storage regime and examined for levels of total viable count (TVC) and levels of indicator organisms such as enterobacteriaceae.

The levels are compared to published guidance in order to assign an appropriate shelf-life. For sliced meat products, the guidance recommends a maximum level of 10<sup>7</sup>cfu/TVC and 10<sup>4</sup>cfu/g enterobacteriaceae.

These levels are reached rapidly (see below) and therefore the shelf life of this product would be restricted to four or five days.

