NSW Food Authority

safer food, clearer choices

Shelf stable acid preserved foods

Factors affecting the shelf stability of acid foods

Condiments, sauces and salad dressings

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NSW Food Authority

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EXECUTIVE SUMMARY

Thermally processed acid foods have a good record of food safety and shelf stability. The parameters required to ensure safety and stability are well understood by the food industry.

Products that have the right combination of low pH, adequate levels of acetic acid, salt and sugars can be filled without a thermal process and still be safe and stable. Complexity is higher but technological and regulatory guidelines exist.

However, if products are not properly formulated there can be risks to food safety or shelf stability. In particular poorly acidified foods can lead to botulism and cold filled products with inadequate acetic acid can spoil. Both these problems can occur with vegetables packed under oil, especially where home production is involved.

Food Standard 2.3.1 requires that fruits and vegetables in brine, oil, vinegar or water, other than commercially canned fruit and vegetables, must have a pH not greater that 4.6. Compliance with this standard must be supported by Good Manufacturing Practice (GMP) especially when measuring pH. The US Food and Drug Administration (21 CFR 113; FDA, undated) provides guidance on GMP for acidified foods.

The NSW Food Authority recognises a number of criteria as evidence of the shelf stability of acid preserved foods:

- A thermally processed product with a pH below 4.6 and not subject to recontamination
- A product meeting CIMSCEE or 21 CFR 169 guidelines for stability
- A product formulated by a suitably experienced food technologist utilising a preservative at an appropriate pH
- A product passing a challenge test such as described by CIMSCEE. The challenge test must use appropriate organisms which have been acid adapted

Proprietary models for safety and stability also will be recognised if adequate disclosure can be made.

INTRODUCTION

Most foods on supermarket dry-grocery shelves are shelf stable products. Some foods such as dry pasta and rice are intrinsically shelf stable. Other foods rely on a range of technologies to ensure shelf stability. These include the elimination of microorganisms capable of growing in the food system by retorting or UHT processing or by adjusting the environment in the food so that it is not suitable for the growth of microorganisms. Control of water availability, pH reduction, the use of organic acids or preservatives and heat shocks are common methods to inhibit microbial growth.

Acid and acidified foods are well represented on the supermarket shelf. The determinants of food safety and shelf stability are long established. However, the US Food and Drug Administration (FDA, undated) lists a history of botulism attributed to inadequately acidified foods and notes that products processed by 29 firms were found to be inadequately acidified. [Botulism is caused by the anaerobic, spore-forming microorganism *Clostridium botulinum.* Although outbreaks of botulism are extremely rare, the consequences can be life-threatening.] The FDA concluded that the evidence demonstrated that certain manufacturers of acidified foods did not realise the importance of adequate pH control. This resulted in the development of a specialised regulation for acidified foods in Title 21 of the Code of Federal Regulation (21 CFR 114).

Despite the acidified foods regulation being published in 1979 two serious outbreaks of botulism were reported in the 1980s in Canada and the United States. Chopped garlic in oil was clearly identified as the source of botulism toxin (St Louis et al., 1988). In 1991 Australian authorities adopted similar precautions to 21 CFR 114 by regulating that this class of product must not have a pH greater than 4.6. This requirement is included in Food Standard 2.3.1 (FSANZ).

The concern about vegetables in oil and botulism remains current. The products are popular, home production is common and, according to Food Science Australia (2000), two false assumptions persist:

> *That the addition of oil has a preservative effect*
> This is incorrect. The only function of the oil is to prevent oxidation from air in the container which can lead to discolouration of some foods. By excluding air from the surface, one is establishing anaerobic conditions which actually favour the growth of some types of bacteria. Unfortunately, *C. botulinum* is one of these bacteria.
>
> *That some herbs and spices, and especially garlic, have significant anti-microbial properties*
> This is also incorrect. The preservative effect of these materials is slight and inconsistent as the botulism incidents in Canada and the United States prove.

A further concern is that even properly acidified vegetables in oil might not be shelf stable. Cold filled products stored at room temperature without a preservative are at risk of spoilage.

The purpose of this discussion paper is to outline the criteria used by the NSW Food Authority to assess the shelf stability of acid preserved foods.

DEFINITIONS

Acid foods

21 CFR 114 defines acid foods to mean foods that have a natural pH of 4.6 or below.

Acidified foods

21 CFR 114 defines acidified foods to mean low acid foods to which acid(s) or acid food(s) are added. The foods have a water activity greater than 0.85 and a finished equilibrium pH of 4.6 or below.

21 CFR 114 requires that acidified foods be thermally processed to an extent that is sufficient to destroy the vegetative cells of microorganisms of public health significance and those of non-health significance capable of reproducing in the food under the conditions in which the food is stored, distributed, retailed and held by the consumer. Permitted preservatives may be used to inhibit the reproduction of microorganisms of non-health significance (in lieu if thermal processing).

Note that 21 CFR 114 is an excellent reference for guidance on pH determination including the calibration of pH meters. It is essential reading for intending manufacturers of acidified products.

Shelf stable

The term 'shelf stable' is used in many branches of food science with differing but inherently similar definitions.

- Foods that by virtue of their form, formulation, or packaging can be stored for extended periods (eg months or greater) at ambient temperature without significant deterioration of quality (Australian Government, Department of Health and Aging)
- Non-perishable food with a shelf life of many months to years (FSANZ 2001)
- Those products that do not spoil under ordinary unrefrigerated temperature and humidity conditions, if the package integrity is maintained. These products are free of microorganisms capable of growing in or on the product at non-refrigerated conditions at which the product is held during distribution and storage (FSIS USDA 2005)

The Australian definitions reflect how the term is intuitively understood. Bullet point 3 above is relevant to processed foods including acid preserved food. The key elements of the definition are: no significant deterioration in quality when held at ambient temperatures for many months to years.

Commercially sterile foods

The term 'commercial sterility' is a defined term under 21 CFR 113.

Commercial sterility of thermally processed food means the condition achieved:

1. by the application of heat which renders the food free of:
    a. microorganisms capable of reproducing in the food under normal non-refrigerated conditions of storage and distribution, and
    b. viable microorganisms (including spores) of public health significance, or
2. by the control of water activity and the application of heat, which renders the food free of microorganisms capable of reproducing in the food under normal non-refrigerated conditions of storage and distribution.

Two further definitions are required to complete the understanding of the above:

1. Hermetically sealed container means a container that is designed and intended to be secure against the entry of microorganisms and thereby to maintain the commercial sterility of its contents after processing
2. Low-acid foods means any foods, other than alcoholic beverages, with a finished equilibrium pH greater than 4.6 and a water activity greater than 0.85

The a_w of 0.85 is significant because below this level foods can be rendered commercially sterile without the conventional canned-food sterilisation, which statistically achieves a 12 log reduction for a test organism which is more heat resistant than *C. botulinum*.

Hot pack

In this document 'hot pack' is taken to mean the use of an adequate thermal process either in the final container (eg retort or steam tunnel) or prior to packaging but with the product filled at a temperature that will control non-sporing bacteria, yeasts and most vegetative and sporing forms of moulds. Guidance may be found in Food Science Australia (2005). In summary:

> For acid foods processing at around 100°C is adequate and pressure equipment is not required. In most cases the product temperature when hot filling should not be less than 85°C and preferably between 90° and 95°C. The container is closed and then inverted or turned on its side for 2 or more minutes prior to cooling. Where possible foods are processed below pH 4.0 with extended processing times recommended for products above that pH.

ACID PRESERVED HERMETICALLY SEALED FOODS

Under 21 CFR 113 acid preserved hermetically sealed foods are not defined as commercially sterile, however they do satisfy the definition of shelf stable.

Types of acid preserved foods

Food Type	Comment
Fermented and high salt (often hot pack)	Olives, sauerkraut, pickled cucumbers. Lactic fermentation under high salt conditions
Fermented and high salt (often hot pack)	Soy sauce, Asian fish sauces. Complex lactic fermentation under high salt conditions
Vinegared products (often filled with hot brine)	Pickled onions, gherkins
Products complying with the CIMSCEE Model (1985) or 21 CFR 169.	Mayonnaises, salad dressings, sauces (some). Inherently stable due to aqueous phase with low pH and adequate acetic acid, salt and sugars.
pH, acetic acid, hot pack, Refrigerate after opening	Sauces, ketchup, condiments
pH, hot pack, Refrigerate and use promptly after opening	Cook-in sauces, pasta sauces, salsas, fruit, fruit juices, marinades, commercial vegetables in oil
pH, preservative(s)	Fruit juice cordials
pH and high sugar, pasteurised Refrigerate after opening	Jams

Fresh herbs are intrinsically more perishable than other components of the products. As it is technically difficult to verify the pH or a_w of minor additives, commercially dried herbs provide a better assurance of safety. If a business prepares its own herbs it must verify that they are properly acidified prior to use.

Cold fill products

The combination of an effective thermal process that destroys vegetative microbial cells and pH sufficiently low to prevent spore germination ensures shelf stability. Where the thermal process is omitted then products that don't otherwise inhibit microbial growth will be subject to spoilage (eg by yeasts, moulds or *Lactobacilli*) and will not be shelf stable. Refrigeration is necessary to extend shelf life, the length of which has to be established by study.

Traditional mayonnaises, salad dressings and some sauces are cold filled and shelf stable. Microbial inhibition is attributable to low pH and levels of acetic acid approaching that of domestic vinegar. Salt and sugars also assist. The products are often formulated to meet CIMSCEE guidelines (1992) or requirements in 21 CFR 169.

Fruit cordials are cold filled and shelf stable. The pH of cordial is low, lower than most foods and much less than 4.6, and preservative(s) are used to prevent spoilage. This is consistent with 21 CFR 114 which requires acidified foods to be thermally processed or a preservative may be used to inhibit the growth of organisms that are not of public health significance.

Vegetables in oil

Most shelf stable vegetable in oil products sold in supermarkets are hot packed and hermetically sealed. Only one non-hermetically sealed product was located in national supermarkets. The manufacturer of the product reported that shelf stability is achieved by a combination of low pH, significant levels of acetic acid, hot fill of the aqueous portion and reduced a_w.

The nature of the testing used to determine shelf stability for the non-hermitically sealed product is not clear. If it didn't include comparison to CIMSCEE or 21 CFR 169 or a suitable challenge study (see below) then there is no certainty that the product is shelf stable. If acid tolerant spoilage organisms are not included in a challenge test then products with relatively small amounts of acetic acid at low pH can give the appearance of shelf stability.

During surveys undertaken during the development of the Plant Products Food Safety Scheme a number of cold fill vegetable in oil products were identified with most subject to refrigerated storage. However, anecdotal evidence suggests that ambient storage is common in home manufactured products sold through markets or tourist shops. Unless the products are demonstrably shelf stable they should be stored under refrigeration and labelled accordingly. An appropriate shelf life should be determined by study.

Other foods in oil

Feta cheese and vegetables filled with feta are being sold in oil. These products are found in refrigerated display cabinets in supermarkets and delicatessens but ambient storage is reported to be used in some other distribution channels.

Feta in oil: Feta cheese is subject to spoilage but has a useful shelf life when stored in brine under refrigeration. Product pH depends on the origin of the cheese, with European products reported to be above pH 4.6. The potential to spoil does not decrease when feta is packed under oil. The mixed product requires refrigeration to control spoilage. Any herbs added to the feta must be acidified prior to use.

Stuffed vegetables in oil: Capsicums stuffed with feta and packaged under oil have recently appeared in supermarket delicatessen cases. The product is not shelf stable. Refrigerated storage and shelf life determination are required. The capsicums will require acidification to meet the pH requirement of Food Standard 2.3.1.

Extensions to this product range should be supported by adequate product development studies. Interactions between components can be difficult to predict, especially where heat treatment is not used and enzymes and bacteria remain active. For example Harmon (1987) reports spoilage of anchovy-stuffed olives which resulted in a rise of pH from 4.3 to 5.25.

Spoilage of acid foods

A number of organisms can spoil acid foods. The following examples are from AIFST (2001). Expert advice is recommended to deal with these problems:

- *Alicyclobacillus* species are thermotolerant sporeformers that grow at acid pH and produce taints, particularly in fruit products
- Heat resistant moulds are important for the beverage industry. These moulds are found in soil and orchard detritus can contaminate fruit that is harvested from on or near to the ground
- Preservative resistant yeasts are responsible for the spoilage of beverages containing preservatives

Confirmation of shelf stability

A number of criteria may be applied to assess shelf stability:

- A thermally processed product with a pH below 4.6 and not subject to recontamination
- A product meeting CIMSCEE or 21 CFR 169 guidelines for stability
- A product formulated by an suitably experienced food technologist utilising a preservative at an appropriate pH
- A product passing a challenge test such as described by CIMSCEE. The challenge test must use appropriate organisms which have been acid adapted
- Proprietary models for safety and stability will be approved if adequate disclosure can be made

Note 1: The results of microbiological testing of the food product are useful for verification of the assessment but they do not stand alone. Good results might provide a level of comfort about product stability but they are only a snapshot and do not necessarily address all spoilage risks. Results on products with low levels of acetic acid can be quite misleading.

Note 2: The history of the product alone does not confirm product stability. The history must be underpinned by a sound scientific evaluation.

CONCLUSION

Thermally processed acid or correctly acidified products have a long history of food safety. Their shelf stability is well understood as are the occasional spoilage issues. In contrast,

- botulism has been attributed to poorly acidified foods, and
- the factors affecting the shelf stability of foods that are not thermally processed are far more complex.

Unless demonstrated otherwise, cold pack acid preserved products will be considered to be perishable and dependant on refrigeration to extend shelf life.

REFERENCES AND FURTHER READING

AIFST (2001), Catherine J. Moir (editor in Chief), *Spoilage of Processed Foods: Causes and Diagnosis*, Australian Institute of Food science and Technology Incorporated. NSW Branch, Food Microbiology Group.

Australian Government, Department of Health and Aging, *Business Sector Food Safety Risk Priority Classification Tool (Version: 11 August 2006)* http://www.health.gov.au/internet/wcms/Publishing.nsf/Content/D0CBFFF254FD9290CA256F190003AC6F/$File/attall-17aug.pdf

21 CFR 113 *Thermally Processed Low-Acid Foods Packaged in Hermetically Sealed Containers,* http://www.access.gpo.gov/nara/cfr/waisidx_07/21cfr113_07.html

21 CFR 114 *Acidified Foods,* http://www.access.gpo.gov/nara/cfr/waisidx_07/21cfr114_07.html

21 CFR 169 *Food Dressings and Flavourings* http://www.access.gpo.gov/nara/cfr/waisidx_07/21cfr169_07.html

CIMSCEE (1992) *CIMSCEE code for the production of microbiologically safe and stable emulsified and non-emulsified sauces containing acetic acid*. Comite´ des Industries des Mayonnaises et Sauces Condimentaires de la Communaute´ E´conomique Europe´enne, Brussels, Belgium

FDA (Undated), *Guide to Inspections of Acidified Food Manufacturers*, http://www.fda.gov/ora/inspect_ref/igs/acidfgde.htm

FSANZ (2001). The National Food Business Notification System, http://www.foodstandards.gov.au/newsroom/publications/thenationalfoodbusin858.cfm

FSIS USDA, *HACCP for Shelf Stable Processes*, http://www.fsis.usda.gov/PDF/FSRE_SS_HACCP_Student.pdf

Food Science Australia (2005) Fact Sheet *Small Scale Commercial Preservation of Acid Foods*, http://www.foodscience.csiro.au/smallsca-text.htm

FSANZ Standard 2.3.1 Fruit and Vegetables http://www.foodstandards.gov.au/_srcfiles/Standard_2_3_1_Fruit_&_Veg_v94.pdf

Harmon (1977), *Spoilage of Anchovy-Stuffed Olives by Heterofermentative Lactobacilli*, Journal of Food Safety, 8 (3) 205-210.

St Louis, et al (1988) *Botulism from chopped garlic: delayed recognition of a major outbreak*. Annals of Internal Medicine, 108m 363-368.

NSW Food Authority

6 Avenue of the Americas
Newington NSW 2127
PO Box 6682 Silverwater NSW 1811
Phone 1300 552 406
Fax 02 9647 0026
www.foodauthority.nsw.gov.au