

Small-scale commercial preservation of acid foods



Food Science Australia Fact Sheet

Revised March 2000

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Acid foods

Acidity is an important factor affecting the growth and survival of bacteria and other micro-organisms in foods.

Food with high acidity can be safely processed by a small manufacturer. Low acid foods usually require more complex processing equipment and specially trained staff.

The production of shelf stable acid foods, that is heat treated foods which may be safely stored at room temperature, appears to be growing in popularity. Frequently these are mixed foods well received at a domestic or catering level which a manufacturer wishes to launch commercially. Example are vegetables, relishes, mushrooms marinated in vinegar, and pickled seafoods including octopus and mussels.

Most foods naturally contain acids. Depending on the type and amount of acid present, they are called high acid or low acid foods (see the figure below). The amount of acid present, and therefore the foods ability to support the growth of food poisoning bacteria, is measured by the pH of the food. The pH scale extends from 0 to 14. A pH of 7 is neutral; a pH above 7 is called alkaline. Very few foods have a pH above 7 but many staple foods have a pH in the range 4.5 to 7.0. The pH value of 4.5 is critical in food processing because below this pH, *Clostridium botulinum*, the most dangerous and most heat resistant of the food poisoning bacteria, is unable to grow.

The pH scale (a measure of acidity)

pH values

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Strongly acidic Strongly alkaline

ACID FOODS (pH less than 4.5)				LOW ACID FOODS (pH between 4.5 & 7)			
apples				banana*	meat		
apricots	pears			pawpaw*	poultry		
cherries	plums			mango*	seafood		
lemons	pineapple			melons*	vegetables (
oranges	raspberries				- asparagus	- mushrooms	
peaches	tomatoes*				- beans	- peas	
pickled vegetables					- beetroot	- peppers	
					- carrot	- sweet corn	
					- garlic	- etc.	

* These products have a pH of about 4.5 and should only be bottled with the addition of citric acid

In the previous figure, those foods with a pH value greater than 4.5 are termed low acid and require pressure cooking to make them shelf stable.

Those with a pH less than 4.5 are called acid foods and may be safely processed at temperatures around 100°C - the boiling point of water. Pressure equipment is not required.

Low acid products can be made acid by adding sufficient food acids such as vinegar (acetic acid) or citric acid to reduce the pH to below 4.5.

Shelf stable acid products have been successfully produced in very large quantities. Canned and bottled fruit and tomato products dominate this group of foods while various pickled and fermented foods such as gherkins and olives are familiar items of trade. It is not the purpose of this leaflet to discuss the processing of major items of commercial production such as fruit and tomato products. Rather it is to point out to potential manufacturers the microbiological problems they face when trying to transfer successful kitchen procedures to a product which will be stable on supermarket shelves.

Spoilage of processed acid foods

Under some conditions some food poisoning bacteria have been shown to grow in foods with a pH below 4.5. However many years' commercial experience indicates that provided the equilibrium pH of a food or food mixture is below 4.5, the risk of food poisoning is virtually eliminated. There are, however, numerous harmless micro-organisms that may spoil these foods if processing is not sufficient or if the closure of the container leaks. These include non-sporing and spore forming acid tolerant bacteria, yeasts and moulds.

Non-sporing bacteria

The most important group of bacteria which spoil acid foods are the lactic acid producing bacteria usually *lactobacilli*. Many produce gas and are capable of vigorously fermenting a wide range of foods. They are very acid tolerant and are capable of growth at pH values below 3.5. While able to tolerate more heating than most yeasts and moulds, lactobacilli can be controlled by moderate heat treatment at temperatures in the range of 85°-90°C.

Yeasts

Due to their low heat resistance, yeasts should not pose a problem in heat-processed acid foods although they can be a serious problem if they gain entry to the product after heating is completed. Some yeasts can grow at pH values around 3.0 but fortunately are killed by temperatures greater than 85°C.

Moulds

Moulds vary greatly in heat resistance but again the greatest risk with spoilage of acid foods is if they gain entry after heating is completed. Most vegetative and sporing forms of mould will be controlled in acid foods by temperatures greater than 85°C. A few moulds are extremely heat resistant and it is not practical to nominate processes which will kill these moulds in all acid foods without causing heat damage to the food itself. Commercially, one attempts to ensure that contamination with these moulds is avoided or raw material likely to be contaminated, e.g. some fruit pulps, is checked for their absence before use.

Spore-forming bacteria

Some bacteria form heat resistant bodies as part of their normal life cycle. These heat resistant bodies are called spores and are important in determining the heating procedure necessary to produce a food which will not spoil.

The best way to minimise the risk of spoilage of acid preserves by this type of organism is to maintain the pH as low as possible and preferably not greater than 4.0. Some manufacturers are reluctant to alter their formulations to reduce the pH and this means a more severe cook is required if the pH is in the 4.0- 4.5 range and particularly if the pH is near 4.5.

It is a matter of judgment if the heat process given to acid foods should be designed to take account of spore-forming bacteria. The decision has to be made on the basis of the pH of the product and the association of spore formers with raw materials used in the product.

Processing conditions for acid products

Sauces, purees and jams

Many of the products which come into this category are quite thick and heat rather slowly. This type of product is traditionally processed in the food industry by heating outside the final container and it is then filled sufficiently hot into the final container to sterilise the container and closure. It is this procedure which is recommended for products which are relatively uniform in consistency, e.g. tomato-based pulps, jams and sauces.

Products should be filled as hot as possible into the final container. To achieve an effective process for products with a pH below 4, the fill temperature should be not less than 85°C and preferably between 90° and 95°C. In most cases the container will be glass and should be prewarmed to not less than 60°C before filling. This will avoid the risk of breakage through heat shock. If metal cans are used then obviously pre-warming is not necessary. Small processors should always consider this option, although for marketing reasons most prefer glass containers.

After filling, the containers are immediately closed and should be held for at least 3 minutes in air before water cooling. Unless the product suffers serious heat damage during extended cooling, it is preferable to air cool products packed in this manner to give an extra safety margin. While the containers are held in air, they should be in an inverted or at least horizontal position. The heat and acidity of the hot-filled product are relied upon to sterilise the container and closure -- hence the need to invert the closed container or, if this is not practical, to lie the containers horizontally for 3-5 minutes.

Plastic containers in general do not seal well enough for hot fill operations to be successful and most common plastics distort at the high temperatures necessary to complete the process. They should therefore not be used for hot fill operations unless the product is to be stored under refrigeration.

If there is any doubt about the temperature at which the product is being filled maintaining a temperature of 85°C at the time of filling, then a subsequent process for a few minutes in a boiling water bath is recommended. Temperatures during hot filling or processing should be checked regularly either by thermocouple measurement or by taking stab temperatures with a suitable probe thermometer (not mercury-in-glass or other breakable type).

Food pieces in syrup or brine

Acid products which contain food pieces in syrup or brine can also be processed by the hot fill procedure. However this is not always practical, uneven distribution of solid and liquid being one problem. It is necessary to ensure that the proportion of food pieces to liquid remains the same each time a batch of food is manufactured and processed. If more than small variations in the proportion of solid to liquid occur, then the heating characteristics of the mixed food can change from batch to batch. In these cases processing in a boiling water bath is necessary. The product can still be pre-heated if convenient so that only a short time of heating in the container is necessary to achieve a minimum temperature throughout the pack of 85°C.

Regular checking of internal temperatures is necessary. If glass jars or bottles are used the caps may be left a half-turn short of full closure, the closure being completed at the time the cook is terminated. Thermocouples should preferably be used to record internal temperatures. If this is inconvenient, then stab temperatures may be taken using a suitable probe thermometer.

The temperature should be measured as close as possible to the geometric centre of the jar. Where pieces of food are present, e.g. pickled seafoods, temperatures will vary greatly between solid and liquid phases. The thermometer probes should be placed in the middle of a large piece of the food at the desired point in the container. A sufficient number of containers should be tested to cover possible variations.

For foods and food mixtures processed in this way, with a pH of 4.0 or lower, the slowest heating point in the container should be held at a temperature of not less than 85°C for at least two minutes. Inversion of containers processed in this way is not necessary although air cooling is to be preferred for those products which will not suffer serious heat damage.

When the pH of an acid food is in the range 4.0 to 4.5, the risk of spoilage from spore-forming bacteria must be taken into account. The National Food Processors Association (U.S.A.) recommends processes for these foods of not less than 5 minutes at 93°C for foods with a pH between 4.0 and 4.3, and not less than 10 minutes at 93° when the pH is above 4.3.

Foods packed in oil

A number of the foods which come into this category have oil added to them as part of a traditional recipe. The oil is usually added in addition to vinegar in products such as eggplant in vinegar, pickled capsicum or pickled octopus.

It is important to note that the oil has no preservative effect on the food although it may help protect the colour of some foods. The equilibrium pH of the food must always be below 4.5. It is desirable to pour off as much oil as possible before blending solid and liquid components to measure the pH of the mixture.

Measurement of pH

pH is an important factor in the processing of many foods. It is a critical factor when a heat process is being based on those organisms which can grow at the pH of the food.

While narrow range pH papers may be useful during product development, measurement of pH during production runs must be made on a properly standardised glass electrode pH meter. A number of acceptable commercial units are available. We can provide names of suppliers if required.

It is the equilibrium pH of the food after processing that is of particular importance. Products consisting of solids suspended in brine, syrup or oil should be blended to a puree in an electric blender before a pH reading is taken.

Further reading:

Hersom, A.C. and Hulland, E.D., **Canned Foods: Thermal Processing and Microbiology**, 7th Ed., Churchill Livingstone, 1980.
National Canners Association Laboratory. **Manual for Food Canners and Processors**, vol. 1., Avi Publishing Co., 1968.

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