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Acidified Foods

Food Processing for Entrepreneurs Series

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This publication was designed to help you understand commercial food processing fundamentals so that you can perceive the relationships among microbiology, food characteristics, thermal processing (canning) and the safety of the food you consume.

Introduction

The production of safe canned foods is a precise science. Each food product in each type and size of container receives a thermal process sufficient to kill all the microorganisms capable of causing disease that may exist in the unprocessed food. However, we do not want the thermal process to be so severe that the quality of the food is destroyed. We are primarily concerned with the organism *Clostridium botulinum* in canned foods. *Clostridium botulinum* causes the deadly disease known as botulism. When this organism grows under conditions present in canned foods it can produce a neurotoxin that is one of the most potent poisons known. It has been postulated that one cupful of the pure toxin would be sufficient to depopulate the world. *Clostridium botulinum* is a mesophilic, spore-forming, anaerobic bacterium. Mesophilic means that the organism grows best at temperatures between 86°F and 98°F (30°C to 37°C). *Clostridium botulinum* will not normally grow and produce toxin at refrigerated temperatures, but will produce toxins at room temperature if other critical growth conditions are met. Anaerobic means that the organism grows best and produces toxin only if its environment contains little or no free oxygen. Spore-forming microorganisms react to adverse conditions by forming spores. Spores are a dormant stage of the microorganism that has the ability to survive a wide range of adverse conditions. They are somewhat analogous to plant seeds in that they will germinate and grow when conditions are favorable. Bacterial spores are very resistant to heat, cold and chemical agents. It may require several hours in boiling water to destroy the spores of *Clostridium botulinum*. This is why canned foods are often pressure-cooked. As the pressure of steam is increased the temperature increases, and the time necessary to kill bacterial spores is decreased. These spores will not grow or produce toxin in an acid environment (pH 4.6 or lower). Thus if a food is an acid food or is acidified it can receive a relatively mild heat treatment to preserve the product. Vegetative microorganisms are killed by mild heat, and spores will not grow and produce toxin in an acid environment. This milder heat treatment preserves much of the color, flavor and texture of the food that would be lost if the food had to receive the more severe heat treatment necessary to kill spores.

Food preservation using acid dates to antiquity. Foods such as sauerkraut, yogurt and pickles have been preserved by lactic acid produced by bacteria encouraged to grow in the food. The acid retards the growth of undesirable spoilage organisms and inhibits disease-causing microorganisms such as *Clostridium botulinum*. The acid serves as a preservative, extends shelf life and reduces the risk of illness without profoundly affecting the nutritional quality of the food. It is not necessary to ferment foods to preserve them. Acids such as vinegar or citric acid can be added to low-acid foods. Only those foods preserved by the addition of acid to low-acid foods are covered by regulations for acidified foods.

Acidified Foods – Definition

The United States Food and Drug Administration (FDA) has defined an "acidified food" as a low-acid food to which acid(s) or acid food(s) has been added to the product to produce a finished equilibrium pH of 4.6 or below and a water activity greater than 0.85. Foods such as fresh packed pickles, peppers and marinated vegetables are acidified foods. This definition excludes certain foods from coverage under the FDA regulations on acidified foods. Examples include jams, jellies, carbonated beverages; acid foods such as condiments, sauces and dressings that contain small amounts of low acid foods with a resultant pH that does not differ significantly from the predominant acid or acid food ingredient; naturally acid foods like tomatoes; and foods stored, distributed and shipped under refrigeration. Foods that are produced by microbial fermentation also are excluded from the definition. The United States Department of Agriculture (USDA) regulates the canning of meat poultry and egg products. USDA regulations stipulate that every component of the product must have a pH that is 4.6 or lower within 24 hours after processing.

Regulations governing acidified foods are found in the Code of Federal Regulations at 21 CFR for FDA regulated foods. Part 114 contains the acidified food regulations. Part 110 contains current good manufacturing practices, and part 108.5 deals with emergency permit control for acidified foods. Regulations for USDA regulated meat and poultry products are included in the USDA canning regulations. The FDA requires that each company processing acidified foods shall file a process including: heat processing conditions, control of pH, salt, sugar and preservative levels for each product and each container size of that product. Each batch of product must be produced in compliance with this scheduled process. The FDA further requires that the company report any spoilage process deviation or contamination of public health significance if any part of the defective lot has reached interstate commerce (has been shipped).

Proper acidification is necessary to prevent the growth of *C. botulinum*. The equilibrium pH of an acidified food must be 4.6 or lower. Steps also must be taken to insure proper sanitation and eliminate the possibility of spoilage before attaining the equilibrium pH of the food.

Meaning and Determination of pH

The term pH is used to describe the degree of acidity or alkalinity of an aqueous solution. The pH value is a measure of the negative logarithm of the hydrogen ion (H+) concentration in solution. All solutions contain both hydrogen ions and hydroxyl ions (OH-). The pH of a solution is directly related to the ratio of hydrogen (H+) and hydroxyl (OH-) present in solution. The more hydrogen ions that are present the more acidic the solution. If the two ions are present in the same concentration the solution is neutral (pH 7.0).

Pure water is neutral and has a pH of 7.0. This indicates that the hydrogen ion concentration is 0.0000001 grams per liter. To use such numbers is difficult so a scale using the reciprocal of the hydrogen ion concentration was adopted. This pH scale ranges from 0 to 14, with the pH of pure water equaling 7.0. Numbers smaller than 7.0 indicate an increase in the hydrogen ion concentration (more acid), while numbers larger than 7.0 signify a decrease in hydrogen ion concentration and an increase in hydroxyl ion concentration (more basic). The numbers are on a logarithmic scale thus a pH of 6.0 indicates a solution has 10 times more hydrogen ions than are present at pH 7.0, while a pH of 5.0 represents 10 times more hydrogen ions than a pH 6.0 and 100 times more hydrogen ions than are present at pH 7.0.

As acid is added to a food the pH decreases (becomes more acid). The speed and amount of pH change depends upon the acid added and the buffering capacity of the food. Most food acids such as citric acid or acetic acid are relatively weak acids. The buffering capacity of a food is its ability to resist changes in pH. Therefore, the amount of acid that must be added to a food to lower the pH is dependent upon the buffering capacity of the food. Foods high in protein such as meats have greater buffering capacity than vegetables. Meat will thus require greater amounts of acid to lower the pH to the same degree. Maturity and varietal differences affect the buffering capacity of vegetables.

The pH of a food may be measured by three methods: colorimetric methods, electromagnetic methods or titratable acidity.

1. Colorimetric methods use pH sensitive dyes that change colors over a limited range of pH. The dyes selected must have the greatest color at the pH of the solution being tested. This method gives only approximate pH values, and thus the FDA allows this method to be used only for products of pH 4.0 or less. It is difficult to measure highly colored or thick foods by colorimetric methods
2. Electrometric methods utilize pH meters which measure the electric potential developed between electrodes submerged in solution. A wide range of pH meters are available with costs that range from less than $100 to several hundred dollars. Some must be confined to laboratory benches while others are portable and can be adapted to production settings.
3. Titratable acidity is the least common method and requires the operator to perform tests to determine a correlation between pH and titratable acidity. Titratable acidity measures total available hydrogen ions in solution. This measurement includes both the free hydrogen ions and the undissociated hydrogen ions from acids that can be neutralized by sodium hydroxide.

pH meter Standardization

Regardless of the type of pH meter it must be standardized before any measurements are made. Standardization is a procedure by which a given meter is set to accurately read solutions of known pH (standards). The pH meter must accurately read within a range between at least two standard solutions i.e. pH 4.0 and pH 7.0. The meter must be standardized before any measurements are made and at least once an hour thereafter. More frequent standardization may be necessary if one is testing oil or fat containing products.

Acidification Procedures

Acidified, low acid foods must be acidified to a pH of 4.6 or less. Preferably the pH should be less than 4.6 to allow a safety margin. Optimal flavor profiles for most products are reached at approximately pH 4.2. If the flavor is slightly acidic the flavor profile may be balanced with the addition of a small quantity of sugar. Perishable ingredients should be carefully monitored and protected from microbial spoilage before acidification and until equilibrium of 4.6 or less is reached.

Low acid foods may be acidified by

1. Blanching low acid food ingredients in an acidified aqueous solution. The blanch time, temperature and acid concentration must be carefully controlled to properly acidify particulate foods.
2. The blanched low acid food may be immersed in an acidified aqueous solution. The food product is blanched in a steam or water blancher then dipped in an acid solution before placing it in containers. The product must be properly blanched and the acid concentration and acid contact time must be carefully controlled.

3. Direct batch acidification is normally the best way to acidify fluid material. Ingredients are mixed in a kettle and acid is directly added to the batch. High temperatures improve the rate of penetration into solid particles. Batch pH must be checked before filling the product into containers.
4. A predetermined amount of acid may be directly added to individual containers. This method is not recommended because it is the least dependable and most inaccurate method of acidification. The potential problems include overlooking individual containers, inadequate mixing and solid materials not penetrated with acid.
5. Acid foods may be directly added to low acid foods in controlled portions. The acid food is mixed with the low-acid food to provide an acidified food product. Tomato sauce or other fruits could be used for acidifying agents.

Critical Control Points

To insure proper production of acidified food products several critical control points must be checked to ensure that the acidification process is properly controlled.

1. Each container of food must be acidified in the same proportions. Solid to liquid ratios must be the same for each container.
2. The buffering capacity of the food must be known and the processing operations must be monitored to ensure that they do not impact the pH of the product.
3. Monitor pH measurement before and after equilibrium. The pH of the finished product must be 4.6 or below (preferably 4.3 or below). The finished product is the product in the container after thermal processing. The pH must be recorded and reviewed at proper intervals.
4. The scheduled thermal process must be monitored. The object of the thermal process is to destroy vegetative microbial cells of public health significance, and those of non-health significance capable of reproducing in the food during normal conditions of storage and distribution. Products that are high acid or are acidified to a pH of 4.6 or less may be processed at the temperature of boiling water approximately 212°F (100°C) or lower. The thermal process pasteurizes the product by killing vegetative cells. The low pH (4.6 or less) prevents spores from germinating and growing.
5. Container handling must be controlled to insure that containers are not damaged and the product decontaminated.

Improper Acidification

If a product has not been properly acidified it shall be reprocessed to render it safe or it shall be destroyed. The product may be fully reprocessed using an established process to ensure that the product is safe. The product may be thermally processed as a low acid food (retorted or pressure processed). The product may be set aside for further evaluation as to its safety (evaluated by a process authority). The product may be destroyed. In no instance may an improperly acidified product be shipped or otherwise handled in a manner in which it could be consumed without proper evaluation or reprocessing.

Education and Outreach by the University of Nebraska–Lincoln Food Processing Center and the University of Nebraska–Lincoln Department of Food Science and Technology

An in-depth short-course offered for supervisors in the food industry entitled the Better Process Control School is available through the UNL Food Processing Center. The Food Processing Center also offers technical and business service assistance to the food industry. These services can be found at *www.fpc.unl.edu*.

Several academic courses are offered to our resident students that provide in-depth information about food microbiology, food chemistry and food processing. To receive information about the academic programs in the University of Nebraska–Lincoln Food Science and Technology Department contact the department at (402) 472-2831 or at *www.foodsci.unl.edu*.

UNL Extension publications are available online at *http://extension.unl.edu/publications*.

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