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Understanding GMPs for Sauces and Dressings

Food Processing for Entrepreneurs Series

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Many entrepreneurs enter the food industry by manufacturing sauces and dressings. It is important to understand the basic scientific principles necessary to provide consumers with **safe and superior** quality foods. These scientific principles along with **Good Manufacturing Practices** (GMPs) are your keys to safety and success.

Food preservation requires killing or limiting the ability of microorganisms of public health significance to grow along with packaging to limit recontamination. In order to grow and produce toxins, pathogens need nutrients, the proper temperature, an adequate water supply, an environment with the proper acidity (pH), an environment free of growth inhibitors and the proper atmosphere (either aerobic or anaerobic). The food manufacturer, handler and retailer can control pathogen growth by limiting one or more of the conditions needed for growth. The growth of pathogenic microorganisms in food products can be controlled by:

- Control of pH (acidity)
- Control of water activity (A_w)
- Chemical preservatives
- Control through packaging

These means often are used in conjunction with thermal processing(heat treatment) to providesafe,shelf-stable foods. Water activity and pH may be directly controlled in foods by adding salt, sugar or acids. Microbial growth may be stopped by adding growth inhibiting chemicals and/or substances such as salt. The food is then confined in containers that eliminate recontamination with microorganisms (hermetically sealed). From a food safety standpoint, packaging serves two functions: it prevents contamination of the food, and extends the effectiveness of food preservation methods. Very often processors use a combination of these controls, rather than relyingononlyone. This is becausea one-controlpreservation system can be harsh, thus reducing the consumer acceptance of the product. The use of multiple controls is called the **hurdle concept.** Microbiological controls using pH, water activity, inhibitors, packaging and atmosphere often are used in combination during the production of sauces, dressings and condiments.

Control of pH

Dressings,sauces,marinades,relishes,pickledvegetables and similar food products most often depend on their acidity to prevent spoilage. These foods may consist of naturally acid foods, such as fruits or tomatoes, or they may be formulated by combining food acids or acid foods with other foods to achieve the desired acidity. Some foods, such as vinegar and certain pickled vegetables, develop acidity from microbial fermentation.

Because foods without adequate acidity could allow the growth of microorganisms capable of causing illness, the federal government regulates the manufacture of these products. Title 21 of the Code of Federal Regulations, Parts 114 & 108 (21CFR114 & 21 CFR 108), regulate acidified foods. The process needs to be scientifically established to ensure that the final pH is always below 4.6. Processors must test each lot of finished product for equilibrium pH. That means a natural pH balance has been reached by all ingredients, which can take as long as 10 days in foods with very large particulates. Products that require several days to reach equilibrium pH may need to be refrigerated during this time to prevent growth of *Clostridium botulinum* or other pathogens.

Categories of Foods Preserved by Acids

Naturally acid foods and fermented foods along with jams, jellies, preserves, certain dressings, sauces with smooth consistencies and carbonated beverages are exempt from the provisions of 21 CFR Part 114. Generally, if a food is formulated predominantly from acid foods, it qualifies for exemption. If, however, the food contains a mixture of acid and low-acid foods, the regulation applies.

Acidity and pH

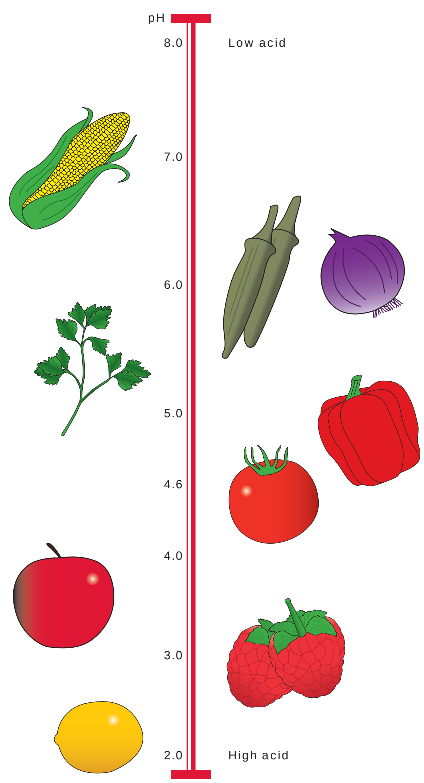
The acidity of a food is indicated by its pH value. The pH scale *(Figure 1)* ranges from 0 to 14, with pH 7.0 being neutral. Any pH below 7.0 falls in the acidic range while those above pH 7.0 are in the basic range. The lower the pH reading, the more acid is the food.

pH Value	*Concentration of Hydrogen Ions*	
0	10,000,000	
1	1,000,000	
2	100,000	
3	10,000	
4	1,000	Acidity
5	100	
6	10	
7	0	Neutral
	Concentration of Hydroxyl Ions	
8	10	
9	100	
10	1,000	
11	10,000	Alkalinity
12	100,000	
13	1,000,000	
14	10,000,000	

Figure 1. The pH scale

The regulation requires that foods preserved by acidity have a pH of 4.6 or less. At these levels, production of deadly botulism toxin by the organism *Clostridium botulinum* is inhibited. Foods that have a pH greater than 4.6 are low-acid foods, and require a much more severe heat treatment to produce a safe, shelf-stable food. Most fruits and fruit products are acid foods, and most vegetables and meats are low-acid foods. Remember, low-acid foods have high pH readings. *Table I* lists the pH values of some common foods.

Table I. pH values of common foods.



Acidified foods

Acid foods depend on one or more food acids, such as citric, lactic, malic or acetic acid, to achieve stability. Most acidified foods, including dressings and sauces, use vinegar (acetic acid) to attain the desired acidity. Vinegar is a familiar and effective source of food acid. Lemon juice is a common source of citric acid, while malic acid is the predominant acid in apples. Lactic acid is found in fermented dairy products and some fermented vegetable and meat products. Each of these acids provides a different flavor profile when used in foods.

When low-acid foods are used in formulations, it is important that the low-acid component be properly acidified before spoilage or toxin-producing microorganisms can grow. The pH must reach its equilibrium value before spoilage begins. The rate of acid uptake by low-acid foods can be influenced by factors such as particle size or the presence of a waxy peel. These factors often can be overcome simply by cutting the low acid food into smaller pieces. When oil is used in the formulation, the low-acid components should reach an equilibrium pH of 4.6 or less before the oil is added.

Most foods possess a chemical property called buffering capacity that allows them to resist changes in pH. At certain pH levels, greater amounts of acid must be added to the food to continue to reduce the pH. Buffering can be a useful property because it prevents changes of pH with minor variations in the amount of acid added.

Measuring pH

The pH of a food usually is determined using a pH meter. Electrodes from the meter are inserted into solution to measure the pH electronically. A variety of pH meters are available from scientific equipment suppliers. Prices range from less than $100 to over $1,000, depending on the type of meter and its features.

Figure 2. Portable pH meters

The pH can also be estimated colorimetrically using pH test papers, which change their color according to the acidity of the solution in which they are placed. These papers are available at a minimum cost from scientific supply houses. FDA regulations allow colorimetric monitoring for foods with pH levels below 4.0. Test papers cannot be used to determine the pH of foods with an equilibrium pH of 4.0 or above. Colorimetric methods are not allowed for USDA regulated foods. To provide a safety factor, acid and acidified foods normally are formulated to a pH well below 4.6. Most acidified foods have a pH of 4.2 or less. When balanced with the proper amount of sweetener the optimum flavor often is achieved at a pH of 4.2 or below.

Before the pH of a food is measured, the food should be in liquid form or prepared as a puree in a blender. Distilled water may be added to aid in mixing the components thoroughly. Be sure to test a sample representative of the whole. If an oil layer is present, it should be decanted so that the non-oil phase can be measured. To measure the equilibrium pH of a low-acid food, first separate low-acid food particles or chunks from the acidifying portion. Then prepare and measure the low-acid portion. This is done by screening out chunks, rinsing the particles with distilled water then blending them into a puree before measuring the pH. The acidifying medium and the particulate matter must be measured separately.

When measuring the pH of a prepared sample, carefully follow the instructions provided with the pH meter and follow these guidelines:

- Calibrate the pH meter using two buffer solutions, usually one with a pH of 4.0 and one with a pH of 7.0.
- Make sure the temperature compensation is set properly.
- Rinse the electrodes with distilled water between readings. Pat them dry with tissue.
  Caution: Do not rub the electrodes with the tissue as rubbing produces a static charge that can produce erroneous readings.
- Stir the samples while measuring them. Record the pH only after the reading stabilizes.
- Products that have high oil contents may clog the electrodes. Clean the electrodes in alcohol or as recommended by the manufacturer.
- Store the electrodes with their tips submerged in distilled water or in a buffer solution as directed by the manufacturer.

Controlling Spoilage

Properly acidifying food to a pH of 4.6 or less will inhibit the growth of *Clostridium botulinum* and the formation of botulism toxin. Acidification cannot take the place of proper sanitation and care in manufacturing. The manufacturer must therefore adhere to the highest standards of cleanliness and product protection. These standards are covered under the regulation: 21 CFR Part 110, often referred to as “Good Manufacturing Practices.”

Even if manufactured with proper acidification and sanitation, a food product can be spoiled by bacteria, yeasts and molds. To prevent this spoilage, processors usually heat acid and acidified foods to 180°F or higher and package them hot. This process kills yeast and most mold spores on the products and in the container and cap. Usually containers are inverted for a brief time immediately after filling and capping to allow the hot product to kill any yeast or mold spores that may be on the inner surface of the cap. Before the product is placed in cardboard cases it should be cooled to prevent “stack bum.”

Some products (mayonnaise, some salad dressings and other emulsified sauces) cannot tolerate heating. These products require the addition of more acid (lower pH) and chemical preservatives. Sodium benzoate and potassium sorbate are the preservatives commonly used. They are often used together to take advantage of their combined effects. Sodium benzoate is most commonly used in acid foods. Sanitation is especially important if such foods are to be successfully marketed. All equipment should be sanitized after each batch, and the cleanliness should be confirmed by appropriate testing. Sauces or dressings of this type usually are vacuum packaged or closed while back flushing with nitrogen to protect the product from discoloration and rancidity.

Water Activity (A_w)

Every microorganism has a minimum, optimum, and maximum water activity for growth. Water activity is a measure of the water available for microbial growth. The water activity is measured instrumentally using either an electric hygrometer or a dew point instrument. Yeasts and molds can grow at low water activity. However 0.85 is considered the safe cutoff level for pathogen growth because it is the point where *Staphylococcus aureus* can no longer grow and produce toxin. A water activity of 0.93 is the point below which *Clostridium botulinum* can no longer grow.

Water Activity	*Classification*	*Requirements for Control*
Above 0.85	Moist Foods	Requires refrigeration or another barrier to control growth of pathogens
0.60 to 0.85	Intermediate Moisture Foods	Does not require refrigeration to control pathogens Limited shelf life because of spoilage, primarily by yeasts and molds
Below 0.60	Low Moisture Foods	Extended shelf life with out refrigeration

Foods with water activities above 0.85 require refrigeration or another barrier to control the growth of pathogens. Foods with water activities between 0.60 and 0.85 are classified as intermediate moisture foods. These do not require refrigeration to control pathogens, but have a limited shelf life because of spoilage, primarily by yeast and mold. Foods with a water activity below 0.60 have an extended shelf life, even without refrigeration. These foods are called low moisture foods.

Some examples of moist foods (those with water activities above 0.85) are:

Moist Foods	*Water Activity*
Fresh meat	0.99
Apples	0.99
Milk	0.98
Cured meats	0.87

Most fresh meats, fruits and vegetables fall into this category.

Some examples of intermediate moisture foods (water activity between 0.60 and 0.85) are:

Intermediate Moisture Foods	*Water Activity*
Molasses	0.76
Heavily salted fish i.e. cod	0 .70
Some soft pet foods	0.70
Jams	0.80
Dried fruit	0.70
Soy sauce	0.80

Some unique products like soy sauce appear to be a high moisture product, but because salt, sugars or other ingredients bind the moisture, their water activities are quite low. Soysauce has a water activity of around 0.80. Because jams and jellies have a water activity that will support the growth of yeast and mold, they are mildly heat-treated immediately before packaging to prevent spoilage. Some sauces and dressings have high oil, salt and sugar contents and are intermediate moisture foods.

Control of water activity

Some of these products require careful control of water activity, while others do not. For example, the jam would not be jam (it would not gel), and could not be marketed unless the sugar needed to reduce the water activity was present. These types of products do not require control of water activity in order to be safe. However, you could market a moister dried fruit, such as figs, or a less salty fish, which might be unsafe from a water activity standpoint. For that reason, control of water activity is important in these products.

There are two primary ways of reducing water activity in foods, drying and adding salt or sugar to bind the water molecules.

Drying is one of the oldest methods of food preservation. In addition to preservation, drying creates its own organoleptic characteristics in foods, much as fermentation does. While open air-drying is still practiced in many parts of the world, there are four primary methods of drying in this country:

- Hot air drying — used for solid foods like vegetables, fruit and fish
- Spray drying — used for liquids and semi-liquids like milk
- Vacuum drying — used for liquids or flowable slurries
- Freeze-drying — used for a variety of products.

The other method of reducing water activity in foods is by **adding salt or sugar**. This requires no special equipment, but the process must be carefully controlled. For liquid or semiliquid products, like soy sauce or jam, the process involves formulation control. For solid foods like fish or cured ham, salt can be applied dry, in a brine solution by injecting brine.

One must have a scientifically established process for drying, salting or a formulation that ensures a water activity of 0.85 or below. The finished product must be tested for water activity.

Chemical Inhibitors

Sometimes the chosen food preservation method does not provide protection against the growth of all microorganisms. In these cases, additional protection may be provided by adding chemical inhibitors. **Chemical inhibitors** include benzoates, sorbates, sulfites, nitrites and antibiotics. Many products use this method of control including:

- salad dressings that use sodium benzoate to inhibit yeast and mold
- bread that uses calcium propionate to inhibit mold
- smoked fish that uses sodium nitrite and some ingredients in the wood smoke to inhibit *Clostridium botulinum.*

Chemical preservatives work through one or more of four actions on microorganisms. They can denature protein, inhibit enzymes, and alter or destroy microbial cell walls or cell membranes.

Some more commonly used chemical preservatives are listed below.

- Benzoates, which include benzoic acid, sodium and potassium benzoate, and parabens. Benzoates are used primarily to inhibit yeast or mold.
- Sorbates: including sorbic acid, and sodium and potassium sorbate. Sorbates are used to inhibit mold.
- Propionic acid is used in breads, cakes and cheese to inhibit mold.
- Sulfites including sulfur dioxide are used in a variety of products including lemon juice, seafood, vegetables, molasses, wines, dried fruit and fruit juices. Sulfites are used primarily as antioxidants, but also have antimicrobial properties. The use of sulfite is restricted in many foods because it can cause severe asthma in susceptible individuals.
- Nitrites are used in cured meats and smoked fish, usually in combination with salt or sugar. Nitrites inhibit the growth of *Clostridium botulinum*.
- Salt also is used to prevent the growth of pathogens, especially *Clostridium botulinum*. Salt not only reduces the water activity in products like salted fish, but also has a direct anti-microbial effect in products like smoked fish.
- Nisin and natamycin are two antibiotics approved for use directly in food. They are used as anti-microbials in cheese.

These and other chemical preservatives, including the approved uses and use levels, can be found in the FDA's Food Additive Status List.

Registration Requirements

If acidified foods are improperly formulated resulting in a pH that will allow the growth of botulism-producing microorganisms — the public health hazard could be catastrophic. To reduce the likelihood of food-borne illness, the acidified foods regulation requires each plant to register with the FDA, and that the scheduled process for acidification and thermal processing for each product in each container size be filed with the FDA. The information filed must come from a recognized process authority qualified by training and experience to determine that the scheduled process will provide a safe, shelf-stable food. In addition, supervisors of acidified foods must attend an approved Better Process Control School and earn a certification as a supervisor for acidified foods. The regulation also addresses other important aspects of manufacturing, such as monitoring critical control points and record keeping.

Labeling the Product

Regulations dealing with food labeling are extensive and complicated. Before purchasing labels, seek the advice of an expert and request information from regulatory authorities.

Where to Get Help

A local University of Nebraska–Lincoln extension educator can help provide directions to food safety and food regulatory experts. The University of Nebraska Food Processing Center provides entrepreneurs with comprehensive help. The federal Food and Drug Administration Center for Food Safety and Applied Nutrition Web site (*www.cfsan.fda.gov/list.html*) is an excellent source of information concerning food safety, nutrition, regulations and has downloadable versions of the forms that must be filed by anyone wishing to process and market acidified, low-acid foods.

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

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