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 provide safe, 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 relying on only one. This is because a one-control preservation 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, pickled vegetables 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 (21 CFR 114 & 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.
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 1 lists the pH values of some common foods.

<table>
<thead>
<tr>
<th>pH Value</th>
<th>Concentration of Hydrogen Ions</th>
<th>Acidity</th>
<th>Concentration of Hydroxyl Ions</th>
<th>Alkalinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10,000,000</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>1</td>
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<td>100,000</td>
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<td></td>
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</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. The pH scale

Table 1. 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.

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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 read-
ings. 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 elec-
  trodes. 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 manufac-
  turer.

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 sani-
tation, 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
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 clean-
liness 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 mea-
sure 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 pro-
duce toxin. A water activity of 0.93 is the point below which
Clostridium botulinum can no longer grow.

Water Activity Classification Requirements for Control

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

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 activi-
ties 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](http://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.

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