Principles of Acidified Foods
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Outline

• History
• Definitions, regulations, exemptions
• pH and acidity
• Acidification procedures
• Thermal processing
• Processing considerations
• Summary
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• Resources
History of Food Production

- **1910's** Women spent ~44 hours a week preparing meals. 40% of the population lives on farms. Diet consists of meat & potatoes.

- **1920's** 11% of married women join the workforce. The 1st refrigerator is sold.

- **1940's** Women make up 35% of the labor force.

- **1950's** Women spend less time on meal preparation, approximately 20 hours per week.

- **1980's** More than ½ of women over 16 are in the workforce. Families are increasingly on the go and eating out.

- **2000's** Food spending on meals consumed outside of the home increases to 48.5%. Full service restaurants are expanding their business with take-out offerings.
1795 -- Who offers 12,000 francs for devising a way to preserve food for his army? 

Napoleon

Nicolas Appert
1858 – What American invents a practical glass jar for home canning? 

What year were the first U.S. regulations specific to Acidified Foods adopted?

1945 1959 1968 1979

John L. Mason
What microorganism is of the most concern for LACF and Acidified Foods?

- Salmonella
- E. coli
- Clostridium botulinum
- Staphylococcus aureus
Question

What are some common foods you may be making that qualify as acidified?
Question:

Pickles
Salsas
Sauces
Dressings
## Pickle History Timeline

<table>
<thead>
<tr>
<th>People/Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancient Mesopotamians</td>
<td>2400 BC</td>
</tr>
<tr>
<td>Aristotle</td>
<td>850 BC</td>
</tr>
<tr>
<td>Julius Caesar/Cleopatra</td>
<td>60 BC</td>
</tr>
<tr>
<td>Dill introduced to Europe from Sumatra</td>
<td>900 AD</td>
</tr>
<tr>
<td>Shakespeare mentions them in his works</td>
<td>15th century</td>
</tr>
<tr>
<td>Amerigo Vespucci, explored the new world</td>
<td>15th century</td>
</tr>
<tr>
<td>Dutch immigrants make NY the largest concentration of picklers</td>
<td>16th century</td>
</tr>
<tr>
<td>John Mason invents the Mason jar</td>
<td>1858</td>
</tr>
<tr>
<td><strong>Vlasic Pickles, the polish-style pickle company, was born in Detroit.</strong></td>
<td>1942</td>
</tr>
<tr>
<td>Steven Trotter became the youngest man to conquer the crest of Niagara Falls in a pickle barrel</td>
<td>1985</td>
</tr>
<tr>
<td><strong>It is estimated that Americans eat 9 lb pickles/person annually</strong></td>
<td>Present</td>
</tr>
</tbody>
</table>

http://www.nyfoodmuseum.org/_ptime.htm
Pickle Martini

[Image of a cocktail glass with a pickle garnish next to a jar of pickles]

http://thesweetspotblog.com/pickle-martini/
<table>
<thead>
<tr>
<th>People/Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aztecs combined chilies with tomatoes</td>
<td>3,000 BC</td>
</tr>
<tr>
<td>Chilies are brought to Spain by Dr. Diego Álvarez Chanca, the doctor who</td>
<td>1494</td>
</tr>
<tr>
<td>accompanied Columbus on his second voyage.</td>
<td></td>
</tr>
<tr>
<td>The Spanish were first exposed to tomatoes and this dish after they</td>
<td>1591</td>
</tr>
<tr>
<td>conquered the Aztecs</td>
<td></td>
</tr>
<tr>
<td>Hot sauce is bottled and sold in Massachusetts. It is made with cayenne</td>
<td>1807</td>
</tr>
<tr>
<td>chilies</td>
<td></td>
</tr>
<tr>
<td>The first &quot;salsa&quot; is manufactured by Charles E. Erath of New Orleans.</td>
<td>1916</td>
</tr>
<tr>
<td>It is technically not salsa, but a pepper sauce</td>
<td></td>
</tr>
<tr>
<td>Salsa Brava was manufactured by La Victoria Foods in Los Angeles.</td>
<td>1917</td>
</tr>
<tr>
<td>Margaret and David Pace found Pace Foods to manufacture their Picante</td>
<td>1947</td>
</tr>
<tr>
<td>Sauce</td>
<td></td>
</tr>
<tr>
<td>Salsa overtakes ketchup America’s No. 1 condiment</td>
<td>2013</td>
</tr>
</tbody>
</table>
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Definition

- An *acidified food* is a low acid food to which acid(s) or acid food(s) is added to produce a product which has a finished equilibrium pH of **4.6 or less** and a water activity of **greater than 0.85**.
- **21 CFR 114** contains the acidified foods regulations.
Acid Foods - Exempt

- Carbonated drinks
- Foods with >90% acid foods
- Certain condiments and dressings, e.g. Mayo-std of identity

Acid formulation, pH < 4.6
Exempt products

Characteristics:
- Naturally acidic pH < 4.6
- Water activity < 0.85

Examples: Jams, Jellies, Syrups etc. that meet standard of identity
Other Exemptions

Refrigerated Foods

Naturally Fermented Foods
Low Acid Foods with Added Acid - Regulated

- Pickles
- Relish
- Salsa

Acidic pH < 4.6
Definition

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• *21 CFR 114* contains the acidified foods regulations
What is Water Activity?

Is a ratio of vapor pressures...

$$aw = \frac{p}{po} = \frac{ERH(\%)}{100}$$

Pure Water = 1.0

Microorganism Growth!
What is Water Activity?

Is measured by a specialized instrument

Water Activity (aw) of Some Common Foods

<table>
<thead>
<tr>
<th>Food</th>
<th>aw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liverwurst</td>
<td>0.96</td>
</tr>
<tr>
<td>Cheese Spread</td>
<td>0.95</td>
</tr>
<tr>
<td>Red Bean Paste</td>
<td>0.93</td>
</tr>
<tr>
<td>Caviar</td>
<td>0.92</td>
</tr>
<tr>
<td>Fudge Sauce</td>
<td>&lt;0.85</td>
</tr>
<tr>
<td>Soft Moist Pet Food</td>
<td>0.83</td>
</tr>
<tr>
<td>Salami</td>
<td>0.82</td>
</tr>
<tr>
<td>Soy Sauce</td>
<td>0.80</td>
</tr>
<tr>
<td>Peanut Butter (15% moisture)</td>
<td>0.70</td>
</tr>
<tr>
<td>Dry Milk (8% moisture)</td>
<td>0.70</td>
</tr>
</tbody>
</table>

https://www.fda.gov/ICECI/Inspections/InspectionGuides/InspectionTechnicalGuides/ucm072916.htm
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Meaning of pH

• pH is a symbol used to designate the degree of acidity or alkalinity.

• It is a measure of *free hydrogen ion concentration*; the pH of pure water is 7.

• The *lower* the pH the *higher* the acidity
### pH and Hydrogen Ion Concentration

#### Table 3-1—The pH scale as it correlates to hydrogen ion concentration.

<table>
<thead>
<tr>
<th>pH Scale</th>
<th>Hydrogen Ion Concentration (moles/liter)</th>
<th>Hydrogen Ion Concentration (as an exponent)</th>
<th>Examples of Foods</th>
<th>Degree of Acidity Compared with Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
<td>$10^0$</td>
<td></td>
<td>10,000,000</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>$10^{-1}$</td>
<td></td>
<td>1,000,000</td>
</tr>
<tr>
<td>2</td>
<td>0.01</td>
<td>$10^{-2}$</td>
<td></td>
<td>100,000</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>$10^{-3}$</td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>4</td>
<td>0.0001</td>
<td>$10^{-4}$</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>5</td>
<td>0.00001</td>
<td>$10^{-5}$</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>0.000001</td>
<td>$10^{-6}$</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>0.00000001</td>
<td>$10^{-7}$</td>
<td></td>
<td>NEUTRAL</td>
</tr>
<tr>
<td>8</td>
<td>0.000000001</td>
<td>$10^{-8}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.0000000001</td>
<td>$10^{-9}$</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>0.00000000001</td>
<td>$10^{-10}$</td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>11</td>
<td>0.000000000001</td>
<td>$10^{-11}$</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>12</td>
<td>0.0000000000001</td>
<td>$10^{-12}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0.00000000000001</td>
<td>$10^{-13}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.000000000000001</td>
<td>$10^{-14}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**pH** is determined by the logarithm of the reciprocal of the H$^+$ ion concentration:

\[ pH = -\log([H^+]) \]
pH Value of Various Canned Foods

<table>
<thead>
<tr>
<th>pH Value</th>
<th>Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>Plums, Gooseberries, Dill pickles, apricots, Apples, blackberries, Sour cherries, peaches, Kraut, raspberries, Blueberries, Sweet cherries, Pears, Tomatoes</td>
</tr>
<tr>
<td>4.0</td>
<td>Okra, Pumpkins, carrots, Turnips, Beets, string beans, Sweet potatoes, Spinach, asparagus, Baked beans, Red kidney beans, Lima beans, Succotash, Peas corn salmon, Shrimp, Hominy, ripe olives</td>
</tr>
<tr>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td></td>
</tr>
</tbody>
</table>
pH Scale

Because the numbers are on a logarithmic scale:

pH of 6.0 = 10X more hydrogen ions than 7.0
pH of 5.0 = 10X more hydrogen ions than 6.0
pH of 4.0 = 100X times more hydrogen ions than 6.0
Buffering Capacity

Is the ability of foods to resist a change in pH.

Foods high in protein, such as meat, have high buffering capacity than foods low in proteins, i.e. vegetables.

Foods with high buffering capacity require more acid to lower the pH.
Determination of pH

pH is measured by:
- Colorimetric Methods
- Electrometric Methods

With foods containing both solid and liquid components:
1) Separate
2) measure the pH of the liquid component
3) Rinse, blend and measure the pH of the solid component.

Only use for Products under pH < 4.0
Large Price Range

pH devices: $80-$1,000
pH Meter Standardization

**Before** any measurements are made

Calibrate at least *once an hour* after; more may be necessary

Store probe in *pH 4.0 buffer* when not in use

Be aware that *temperature* affects readings
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Acidification Procedures

1. Blanch food ingredients in acidified aqueous solution (large particles)

2. Immerse blanched food in an acidified aqueous solution (2-step)

3. Direct batch acidification (most common)

4. Direct addition of a pre determined amount of acid to individual containers during filling

5. Addition of acid foods to a low-acid foods in controlled potions
How is a product determined as exempt?

Small amount of low-acid food(s) = no more than 10% by weight (exclude oil and water) of low-acid food(s) in the finished product.

Resultant finished equilibrium pH that does not significantly differ from that of the predominant acid or acid food are excluded from the coverage of 21 CFR part 114.
Example 1: Applesauce Made from Fresh Delicious Apples and Fresh Figs

Description of product:
1. Fresh Delicious apples (natural pH of 3.9)
2. Fresh figs (natural pH of 5.7)
3. Finished equilibrium pH: 4.3

Questions:
1. The product contains an acid food (fresh apples)
2. The product contains a low-acid ingredient (fresh figs)
3. The finished equilibrium pH of the product is less than 4.6
Example 1: Applesauce Made from Fresh Delicious Apples and Fresh Figs

Calculations (small amount provision):
- The weight of all acid ingredients (fresh apples) is 450 pounds;
- The weight of all low-acid ingredients (figs) is 50 pounds;
- The total weight of all ingredients is 500 pounds;
- The percent of low-acid ingredients is 10% (50 pounds/500 pounds).

pH Shift Data:
- Predominant acid food is apples; pH of the fresh apples is 3.9, (<4.2)
- Finished equilibrium pH of the applesauce with added figs is 4.3, (<4.4)
- Shift in pH is 0.4 (4.3 – 3.9), which is >0.3. Consider that:
- Resultant finished equilibrium pH of your product differs significantly from that of predominant acid food; and
- The product is COVERED by 21 CFR part 114.
Example 2: Applesauce Made from Fresh McIntosh Apples and Fresh Dates

Description of product:
1. Fresh McIntosh apples (natural pH of 3.4)
2. Fresh dates (natural pH of 4.7)
3. Finished equilibrium pH: 3.5

Questions:
1. The product contains an acid food (fresh apples)
2. The product contains a low-acid ingredient (fresh dates)
3. The finished equilibrium pH of the product is below 4.6
Example 2: Applesauce Made from Fresh McIntosh Apples and Fresh Dates

Calculations:
- The weight of all acid ingredients (fresh apples) is 490 pounds
- The weight of all low-acid ingredients (fresh dates) is 10 pounds
- The total weight of all ingredients is 500 pounds
- The percent of low-acid ingredients is \(2\%\) \((10 \text{ lbs}/500 \text{ lbs})\) – \(<10\%\)

pH Shift Data
- Predominant acid food is apples; the pH of the fresh apples is 3.4, \(<4.2\)
- Finished equilibrium pH of the applesauce with added fresh dates is 3.5, \(<4.4\)
- Shift in pH is 0.1 \((3.5 – 3.4)\), which is \(<0.4\). Consider that:
- Resultant finished equilibrium pH does not differ significantly from that of the predominant acid food
- Product is EXCLUDED from the coverage of 21 CFR part 114.
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Influence of pH on Thermal Processing

Spores are inhibited by acid and will not germinate. Vegetative cells are destroyed with mild heat treatment.

Figure 3-4—Influence of product pH on thermal processing.
Influence of pH on Thermal Processing

Figure 7—Influence of product pH on degree of thermal processing.

Mild heat required, since spores are inhibited by acid.

High heat required in order to destroy spores.

Mild Heat

Acid

Mild Heat

High Heat

High Acid Foods:
fruits

Low Acid Foods:
Vegetables, meats

Fruits: Apples, Oranges, Berries

Vegetables: Spinach, Beans

Meats

pH 4.6

pH 3.0

pH 7.0
## Simple Example of the Relationship of pH and Thermal Process

<table>
<thead>
<tr>
<th>Finished Equilibrium pH</th>
<th>Thermal Process Lethality</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 – 3.2</td>
<td>195 F = 0.1 minutes</td>
</tr>
<tr>
<td>4.0 – 4.2</td>
<td>200 F = 5.0 minutes</td>
</tr>
<tr>
<td>4.5 – 4.6</td>
<td>212 F = 10 minutes</td>
</tr>
</tbody>
</table>
## Thermal Process

\[ Z = 19.5, \text{ Ref } T = 160\textdegree F \]

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Target F Value (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>1.2</td>
</tr>
<tr>
<td>166</td>
<td>0.6</td>
</tr>
<tr>
<td>170</td>
<td>0.4</td>
</tr>
<tr>
<td>178</td>
<td>0.1</td>
</tr>
<tr>
<td>180</td>
<td>0.1 (6 sec)</td>
</tr>
</tbody>
</table>

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Processing Considerations

• **Hot-fill-hold**: hot product is filled and sealed into a container & held for a given time period at a given temperature prior to cooling.

• **Pasteurization Process**: product (hot or cold) is filled into the container and the container is sealed. It is then sent through a pasteurizer that heats the product and container together.
NOTE:
It is generally accepted that products using acetic acid as the primary acid and have a pH below 3.3 do NOT require a heat process, but DO require a temperature dependent holding time.
Processing Method: Pasteurization

1. The product may be filled into containers and sealed.
2. The thermal processing to achieve thermal process lethality at a pre-determined temperature/time takes place in the filled and sealed containers.
Improper Acidification

• Unless a product can be proven safe, it shall be reprocessed to render it safe or destroyed
• Fully reprocess using established process to ensure safe product
• Thermally process as a low acid food
• Set aside for further evaluation
• Destroy
FDA Regulations

- Each processor shall file a process including heat processing conditions, control of pH, salt, sugar, and preservative levels FOR EACH container size.

Known as “Filing a Scheduled Process”
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Acidified Foods
Food Processing for Entrepreneurs Series

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.

Durward A. Smith, Extension Food Processing Specialist and Jayne E. Stratton, Manager, Laboratory Testing Operations

http://www.ianrpubs.unl.edu/

Selecting a pH Meter
Food Processing for Entrepreneurs Series

This publication provides information about selection of equipment to measure the acidity (pH) of foods. Entrepreneurs who wish to market foods with a significant amount of non-acid food ingredient must acidify that food to a pH of 4.6 or lower, and maintain records of the finished pH of each batch of acidified low-acid food manufactured. A pH meter is necessary to measure the pH of the food.

Durward Smith, Extension Food Processing Specialist