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Food Acidity and Safety

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Food acidity is an important parameter in foods. Besides affecting flavor, food acidity affects the ability of microorganisms to grow in a food. Microorganisms prefer minimal acidity and are prevented from growing when the acid level gets high enough.

Acidity Is Measured Using the pH Scale

Aqueous solutions (water-based liquids) have both hydrogen ions (H^+) and hydroxyl ions (OH^-). The

ratio of these ions is measured to arrive at pH. Acid solutions have an excess of (H^+) and basic solutions have an excess of (OH^-). Pure water is where the ions are balanced. The pH scale ranges from 0-14, with water being neutral at pH 7. A pH of 6 is 10-times more acid than pH 7. A pH of 5 is 100-times more acid than pH 7.

Figure 1. Jar of peppers from 1977 botulism death



Table 1. Some food pH levels

<i>Note that most foods are below neutral pH (< 7.0).</i>	Lemon juice pH ~2-2.5
	Vinegar ~2.5 – 3
	Most Fruits ~3-4
	Tomatoes ~4-5
	Meat and Fish ~6-7
	Pure water 7
	Soda Crackers ~8

Acidity and Canned or Jarred Foods

Clostridium botulinum produces a deadly toxin that has caused illness and deaths from consuming improperly canned foods. *C. botulinum* produces spores resistant to boiling water temperatures. Higher temperatures (~250°F) are required to kill botulism spores when canning foods. This is accomplished by using pressure. Canning low acid food requires special equipment and special knowledge that places this process out of reach for most small and very small food processors.

Food acidity can also prevent botulism from growing. This fact is used in canning acid foods. Because the acid prevents *C. botulinum* growth, the heat required to destroy pathogens is closer to that of boiling water. This allows commercial processors to use a hot fill process or boiling water canning process.

Table 2. Acidity and Canning Requirements

Acid (pH)	Type	Bot.*	Canning Method
pH ≤ 4.6	Acid Food	NO	Hot fill** (~190°F) or Boiling Water Canner (~212°F)
pH > 4.6	Low Acid Food	YES	Pressure required (~250 °F)

*Bot. = Botulism potential

**Note: hot fill processing is only recommended for licensed food processors. Home canners should use the boiling water canning process.

Table 3. U.S. FDA Classification of Acid Foods

Acid food	An acid food is a food product that is naturally acidic. Examples are tomatoes and most fruits with a natural pH at or below 4.6.
Formulated acid food	A formulated acid food is a majority acid food that has very small quantities of low acid foods. An example is barbecue sauce (tomato paste and bits of garlic and onion).
Acidified food	An acidified food is a non-acid food that is acidified with something like vinegar or lemon juice. Examples are pickled cucumbers and pickled peppers. The U.S. FDA requires that anyone supervising the commercial production of acidified foods be certified in Better Process Control School ¹ .
Exempt food	An exempt food is either (a) kept refrigerated or (b) has a water activity ² or 0.85 or less. An example of a low water activity food is chocolate sauce. The large proportion of sugar prevents bacteria from growing, including botulism.

¹Better Process Control Schools (BPCS) certify supervisors of thermal processing systems, acidification, and container closure evaluation programs for low-acid and acidified canned foods. Each processor of low-acid or acidified foods must operate with a certified supervisor on hand at all times during processing. Details on Better Process Control School can be found here: <http://www.fpa-food.org/content/BPCS.asp> (Accessed 25 Jul 2006).

²Water activity is a measurement of “free” water available for microorganisms to grow. The measurement range is 0-1.0. Drying foods; or adding salt or sugar, can reduce the water activity.

Classifying Acid Foods

The U.S. FDA classifies foods with a pH at or below pH 4.6 into four categories: acid, formulated acid, acidified, and exempt.

So, how does one classify an acid food? This is most often done by a “Process Authority” (someone knowledgeable in this area). Dr. Nummer (the author) is a process authority and helps food processors in the state of Utah. Contact your state’s land-grant university to find a process authority outside of Utah.

Acidity and refrigerated foods

For many years we wrongly believed that food illness causing bacteria could not grow in the refrigerator. Today, we are aware of three: *C. botulinum* type E (associated with seafood), *Listeria monocytogenes*, and *Yersinia enterocolytica*. Each can slowly grow at refrigeration temperatures. Fortunately, food acidity (pH 4.2 or below) can inhibit growth of these organisms if they are present. The latter two organisms are also easily killed by heating the food to pasteurization temperatures. But, this is not always beneficial to food quality.

pH Meters

Since the pH is often the determining factor whether or not the product will be safe to consume, it is very important that testing be done correctly and accurately. The pH of a food is usually determined using a pH meter. A variety of pH meters are available from scientific equipment suppliers. Prices range from less than \$100 to over \$1,000. A simple portable meter is recommended for small food processors (Figure 2. ~\$100). A meter electrode is inserted into a solution to measure acidity as free hydrogen ions (H⁺). The meter then calculates the acidity and expresses it in pH units of 1-14. 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 for a few dollars.

Regulations allow calorimetric monitoring for foods with pH levels below 4.0. With the low cost of pH

meters today, we recommend using a meter instead of test papers.

Figure 2. A typical portable pH meter.



Choosing a pH Meter

Accuracy should be the first consideration. The most expensive meters have an accuracy of ± 0.002 pH units. These instruments are meant for research and are overkill in the food industry. Most food processors should look for a unit with an accuracy of ± 0.01 - 0.02 pH units. The model in Figure 2. has an accuracy of 0.01 pH units.

Temperature compensation should be automatic. The pH measurement is standardized at a temperature of 25°C (77°F). Rather than having to make every sample be 25°C most meters will measure temperature and correct the pH internally. (Note the 27.0 reading in Figure 2. This is the sample temperature). Helpful features can include being waterproof, ease of calibration, lifetime of the electrode, and ease of replacing electrodes. (The pH meter in Figure 2. is waterproof, has one button calibration, has an electrode life of 1 year, and has an electrode that can be easily replaced for \sim \$50).

Calibration

Few instruments can measure anything accurately without calibration. A pH meter requires frequent calibration—often on a daily basis. Calibration of a pH meter to test food products is done using purchased USA or NIST standard buffers at pH 4.01, and 7.0. These standard buffers in bottles or other packaging can be purchased from the same location that sells pH meters.

Figure 3. pH Standard



Calibration is often specific to each meter. Typically, the electrode is placed into pH 4.01 and the reading is taken. A manual of automatic system is used to adjust the reading to pH 4.01. This is followed rinsing the electrode and placing the electrode into pH 7.0 buffer and adjusting the reading to 7.0.

Rinsing or Activating an Electrode

Distilled water is used to rinse the electrode between uses and activate a dry electrode. Distilled water can be purchased at most grocery stores. For ease of use, fill a clean sports bottle with the distilled water and attach a quick release tip.

Most electrodes require storage in distilled water or in a buffer. Some are allowed to dry between uses. In that case they must be activated by soaking in distilled water. The pH meter in Figure 1. requires a 30 minute soaking before using a dry electrode.

Measuring food pH

Moisture is required to measure pH. 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. Distilled water contains no free hydrogen ions (H^+) and its addition will not alter the pH. Several important pH measurements can be taken.

Brine pH	This is a measurement of a food product brine, such as pickle juice.
Solids pH	This measurement is obtained by straining out solids and then blending the solids before taking the pH measurement.
Blended pH	This measurement is taken after blending all ingredients to thoroughly mix them.

Finding pH meters to purchase

Search for any of these brands or meters on the Internet. Use caution (buyer beware) when using unknown vendors. *USU does not endorse one model over another, and models not pictured may be equally useful.*

Table 5. pH Meter Comparison

Oakton pHtestr 30	Hanna pHep® 5	Extech PH110
		
price: ~\$100	~\$100	~\$100
Accuracy in pH units: 0.01	0.05	0.01
water proof : <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
replaceable electrode: <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
auto temp. compensation: <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Be sure and test a sample representative of the whole. When taking the pH of a sample mix it well.

Allow the reading to stabilize and then record the results. Often, several samples are needed to ensure uniformity.

Oil

Oil does not have a true pH. Oil can coat an electrode and reduce its lifespan or require an intense cleaning. Avoid measuring oil in foods like vinaigrettes. Instead, measure the water phase only.

Cleaning and Maintenance

Consult the instruction manual for information on how to clean an electrode. Use caution cleaning and handling, since electrodes are delicate. Most of the models listed in this publication have an electrode life of 1 year, regardless of use. After that a replacement is needed.

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