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UF/IFAS PEER REVIEWED

FSHN20-2

How to Start a Food Business: Basic Food Technology—Food Acidity[1]

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This fact sheet is one in a "Food Entrepreneurship in Florida" series that assists beginning and established food entrepreneurs by providing them with information on topics highly relevant to starting and running a food business, including regulations, safety, labeling, processing, and marketing. This series serves as a useful guide to help run a successful food-related business.

Food acidity is a critical parameter in food product development. Most people know that food acidity influences flavor, but more importantly, food acidity can affect the ability of microorganisms to grow in food. Food acidity, or the amount of acid that is present in the food, is used to classify a food product, and that classification determines the regulatory requirements for the specific food product. Therefore, food entrepreneurs must understand how to measure food acidity and how food is classified based on its acidity. This article is written for starting and early-stage food entrepreneurs to introduce the concept of food acidity and why it is important in food processing. This article especially focuses on canned food processing, because regulatory requirements for canned foods depend on their acidity.

What is pH?

The measure of a sample's degree of acidity is called pH. The pH scale ranges from 0 to 14, with pH 7 being considered neutral. Pure water has a pH value of 7. Any substance with a pH value less than 7 is considered acidic, while those with a pH value greater than 7 are considered basic or alkaline. Most foods are naturally acidic. Table 1 shows pH values of some food items. Technically, pH is a measure of hydrogen ion (H^+) concentration in a sample. To be more precise, pH is defined as the negative log of the hydrogen ion (H^+) concentration. Therefore, if a food has a pH value of 4, then the concentration of hydrogen ions present in that food is equal to 10^{-4} (0.0001) moles/liter. Aqueous (water-based) solutions have both hydrogen ions (H^+) and hydroxyl ions (OH^-). Acid solutions have an excess of H^+, and the greater the H^+ concentration, the more acidic the product gets. Because pH is the negative log of the hydrogen ion (H^+) concentration, the lower the pH value of a food product is, the more acidic the food product is.

What is equilibrium pH?

In a food product, equilibrium pH is the pH value after the added acid has spread throughout the entire food. Equilibrium pH is important because food is differently regulated based on its equilibrium pH. Therefore, when you monitor the acidity of food as a part of process monitoring, you should always measure the equilibrium pH. For an accurate equilibrium pH reading, you have to wait at least 24 hours after processing. Do not use the pH of a product measured

1. This document is FSHN20-2, one of a series of the Department of Food Science and Human Nutrition, UF/IFAS Extension. Original publication date March 2020. Revised August 2024. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication. This article was funded by the United States Department of Agriculture–National Institute of Food Agriculture (USDA-NIFA) Grant #2016-70020-25784.

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immediately after the processing, because this does not accurately represent the equilibrium pH.

How is pH measured?

The pH of a food can be measured by multiple methods. Currently, the most common and reliable method to measure the pH of a food is using a pH meter. A pH meter has a probe containing a glass electrode and reference electrode. This probe is placed into a solution (test sample), and the voltage between the two electrodes is electronically measured. For an accurate reading, the test sample's temperature should be between 20°C and 30°C. If the product is composed of distinct solid and liquid parts, they must be blended together (in the same proportion used in the product) to a consistent paste before testing because each part often differs in acidity. For accurate measurement, a pH meter should be calibrated, which is usually done with 2 standard buffers (pH 4 and pH 7). The probe should be rinsed with distilled water between readings and then stored in distilled water or buffer according to the manufacturer's instruction. A pH meter can be purchased from a scientific equipment supplier. Its cost ranges from less than $100 to over $1,000, depending on its type and features.

Another way to measure a pH value is using pH test paper strips. These paper strips estimate pH value based on color change in the paper. Paper strips are inexpensive compared to a pH meter and simple to use; however, because pH value is only "estimated" using color, they are difficult to read and therefore often lead to inaccurate reading. For this reason, regulations allow the use of paper strips (or other colorimetric monitoring) only for foods with pH levels below 4.0.

Why is acidity important in food processing?

Food acidity is an important parameter in food product development. Food acidity not only influences flavor but also affects the ability of microorganisms to grow in food. Food acidity (presented as pH) is used to classify a food product, and that classification determines the regulatory requirements for the specific food product. Therefore, it is important to understand how food is classified based on its acidity. If a food has a pH above 4.6, it is defined as a low-acid food. If the pH of a food is 4.6 or lower, the food is classified as an acid food (also called a high-acid food).

The pH value of 4.6 is critical because it is the limiting factor for the growth of *Clostridium botulinum*. *C. botulinum* form spores when the environment becomes hostile for their growth and survival. Spores are extremely hard to eliminate, can survive for long periods of time, and can grow into a vegetative cell under the right conditions (a process called germination). *C. botulinum* is of special interest in food processing because it is responsible for a life-threatening disease called botulism. Botulism is caused by ingesting a potent neurotoxin produced by *C. botulinum*. This neurotoxin is one of the most toxic substances known. Spores of *C. botulinum* cannot germinate if the pH of a food is 4.6 or lower (acid food), so acid food can be safely processed with a water-bath canner. However, low-acid food with pH higher than 4.6 must be processed at higher temperatures for longer time to destroy spores (e.g., pressure-cooking).

What is acidified food and how is it different from acid food?

Acidified foods are low-acid foods to which acid or acid ingredients are added to produce a final equilibrium pH of 4.6 or lower *and* water activity greater than 0.85. Compared to acidified foods, acid foods have a *natural* pH of 4.6 or below. For example, lemons, which have a natural pH of 2, would be classified as an acid food, while pickles, which have vinegar added to achieve low pH, would be an acidified food. Examples of acidified food include pickled vegetables, sauces, salsa, and marinades.

A properly acidified food may be safely stored at room temperature. However, any deviation in their processing can reduce the ratio of acid to low-acid ingredients, resulting in a product that is not sufficiently acidified, and potentially supporting the growth of *C. botulinum*. Therefore, acidified foods are more strictly regulated than naturally acidic foods.

What are the regulatory requirements regarding food acidity?

Commercial processors of shelf-stable acidified foods and low-acid canned foods (LACF) must comply with Food and Drug Administration (FDA) regulations (21 CFR part 113 and part 114). Other than acidified and low-acid food-specific regulations, all food manufacturers are also required to follow Good Manufacturing Practices (21 CFR part 117, subpart B). Processors of shelf-stable acidified foods and LACF must register the processing facility with the FDA by filing the FDA form 2541 (FDA 2016), and also file the processing procedures called "scheduled process" by using an appropriate form (for example, FDA form

2541d for low-acid canned foods and 2541e for acidified foods). A scheduled process is a specific manufacturing process for certain products that can assure the safety of the final product. A scheduled process must be developed and reviewed by a qualified person or a process authority, who has expertise and appropriate training and experience in the thermal-processing requirements for low-acid canned foods and/or the acidification and processing of acidified foods. Processors also need to keep production records on hand, including formulation records, processing times and temperatures, pH test results, and container-closure evaluation records.

In addition, at least one person who is directly responsible for acidified food and/or LACF production must complete a training program called "Better Process Control School (BPCS)" before starting their commercial production. Currently, UF/IFAS does not offer this program; however, many other universities offer the training and some of them virtually offer training. The Consumer Brands Association provides a list of BPCS program at https://consumerbrandsassociation.org/wp-content/uploads/2020/01/2023-Partner-School-Brochure-1.pdf. You can also do a web search for "Better Process Control School" for options.

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Table 1. pH values of common foods*.

Food	pH Value Range
Dairy Products	
Butter	6.1 to 6.4
Milk	6.3 to 6.8
Cream	6.4 to 6.8
Yogurt	3.8 to 4.2
Meat, Poultry, Fish, and Seafood	
Beef (ground)	5.1 to 6.2
Chicken	6.2 to 6.4
Fish (most species)	6.6 to 6.8
Clams	6.5
Crabs	7.0
Oysters	4.8 to 6.3
Shrimp	6.8 to 7.0
Fruits and Vegetables	
Apples	3.3 to 3.9
Bananas	4.5 to 5.2
Blueberries	3.1 to 3.3
Grapes	2.8 to 3.8
Grapefruit (juice)	2.9 to 3.3
Honeydew melons	6.0 to 6.7
Limes	2.0 to 2.8
Oranges (juice)	3.3 to 4.2
Watermelons	5.2 to 5.6
Artichokes	5.5 to 6.0
Asparagus (buds and stalks)	6.0 to 6.7
Beans (string and lima)	5.6 to 6.5
Beets	5.3 to 6.6
Broccoli	6.3 to 6.5
Cabbage (green)	5.4 to 6.8
Carrots	5.9 to 6.4
Celery	5.7 to 6.0
Corn (sweet)	5.9 to 7.3
Cucumbers	5.1 to 5.8
Cucumbers, pickled	4.2 to 4.6
Lettuce	5.8 to 6.2
Olives (green)	3.6 to 4.6
Onions (red)	5.3 to 5.8
Potatoes (tuber and sweet)	5.3 to 5.7
Pumpkin	4.9 to 5.5
Spinach	5.5 to 6.8
Tomatoes (whole)	4.3 to 4.9
Eggs	
Egg yolks	6.0 to 6.3
Egg whites	7.6 to 9.5

*This table was created based on pH information from the IFT's report for the FDA (IFT 2003) and FDA Center for Food Safety and Applied Nutrition (FDA 2007). For a more comprehensive list, visit https://www.webpal.org/SAFE/aaarecovery/2_food_storage/Processing/lacf-phs.htm.