Introduction to Acid, Acidified and Fermented Foods

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Lesson Objectives

At end of this module, you will be able to:

- **Identify factors that affect the presence and growth of microorganisms**
- **Identify an Acidified Food**
- **Identify the characteristics of *Clostridium botulinum* and the public health concern of *C. botulinum* and other pathogens in Acid, Acidified and Fermented foods**
- **Identify causes for spoilage in Acid, Acidified and Fermented foods**

Characteristics and Behavior of Microorganisms

- **All raw foods normally contain microorganisms that will eventually cause spoilage unless they are controlled or destroyed**
- **Food preservation is a competition between the human species and microorganisms**
  - **We attempt to preserve the food that microorganisms attempt to utilize**

Characteristics and Behavior of Microorganisms

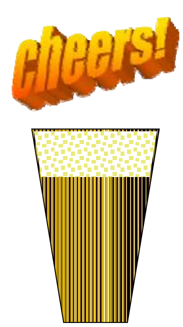
- **Food preservation requires that microorganisms be controlled or destroyed**
- **Need to know what they are and how they behave**

Characteristics and Behavior of Microorganisms

- **The microorganisms of primary concern to the food processor are molds, yeasts, and bacteria**
- **They can grow in food or the processing environment under suitable conditions**

General Microbiology

- **Helpful bacteria include:**
  - **Lactic acid bacteria that ferment:**
    - **Pickles and sauerkraut**
    - **Cheese and yogurt**
- **Helpful yeasts and molds include:**
  - **Beer and wine yeasts**
  - **Molds in blue cheese**



Types of Microorganisms Associated With Food

- Those which can reproduce in the Food
  - Bacteria
  - Fungi (Yeast & Mold)

- Those which cannot reproduce in food
  - Viruses
  - Prions
  - Protozoa

What are top AF concerns?

- To destroy all microorganisms of public health significance
- To destroy all microorganisms of non-health significance that could spoil the product under normal conditions of storage and distribution

Why does the FDA care if the product is spoiled?

Spoilage vs. Illness

- Spoilage causes changes in a food which make it:
  - Unwholesome
  - Unattractive
  - Unsalable
  - May affect quality (BUT NOT NECESSARILY SAFETY)
- Illness is caused by pathogenic microorganisms and/or their toxic by products

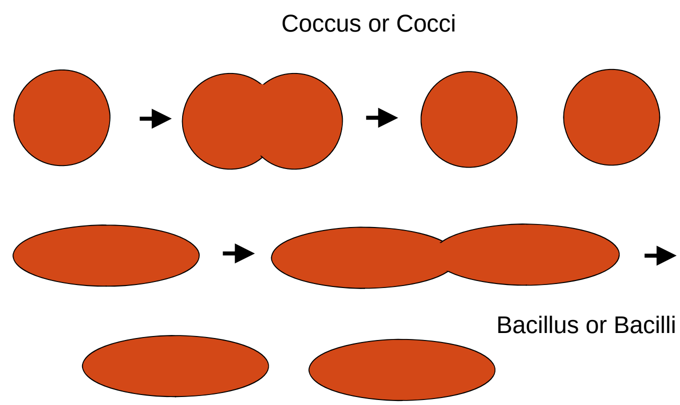
Where Do Microbes Come From?

- Ubiquitous in nature (most spoilage, some pathogens)
- Sources of fecal contamination (mostly pathogen
- Humans (poor hygiene practices)

Where Do Microbes Come From?

- **Waterborne contamination (transport or rinse water)**
- **Airborne contamination (dust, moisture)**
- **Cross-contamination**
  - **Contaminated raw product**
  - **Processing equipment and utensils**

Most bacteria are harmless and many are helpful to humans



Introduction to bacteria

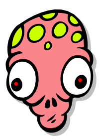
- **Microbes were mostly unknown until the late 1800s, because they are so small**
- **Most bacteria DO NOT cause food-borne infections!**

Some Microorganisms Cause Disease

- **The majority of laboratory-diagnosed cases of bacterial foodborne illnesses are caused by just a few microorganisms**
  - ***Salmonella* spp.**
  - ***Campylobacter***
  - ***Shigella* spp.**
  - ***Clostridium perfringens***
  - ***Staphylococcus aureus***

Food Poisonings & Infections

- Food poisoning (intoxication) results from eating a toxin
  - some bacteria produce toxins or poisons when they grow in foods
  - the poison, not the bacteria, causes disease



- Food infection results from eating live bacteria
  - some bacteria only make you sick when you eat the live cells

Clostridium botulinum

- Gram + sporeforming anaerobe found environmentally
- How did it get there in the first place?
- Classified by the type of toxin produced (A, B, C, D, E, F, G)
- A, B, E are the proteolytic Group I – "terrestrial"
- B, E, F are the non-proteolytic Group II – "marine"

Clostridium botulinum cont

- Group I
  - pH 4.6
  - aW 0.93
  - min. growth temp. 10C (50F)
  - D-value 0.2 min
- Group II
  - pH 5.0
  - aW 0.97
  - min growth temp 3.3C (38F)

Clostridium botulinum cont

- 3 types of illness
  - Infant
  - Wound
  - Foodborne

1. How does it affect humans?

2. What types of products are commonly associated?

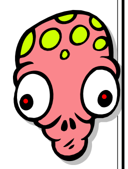
3. Recent examples?

4. Other uses?

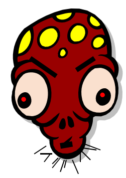
5. Why do we have a 12D process?

Other food pathogens

- *Staphylococcus aureus*
  - **Makes a heat resistant toxin**
  - **But, unlike C-BOT, Staph does not make spores**



- *Salmonella*
  - **Causes food-borne infections**
  - **Does not make toxins or spores**
- ***Escherichia coli* O157:H7**
  - **Acid resistant**
  - **Serious food infections**



Logarithmic Review

$10^0 = 1$

$10^1 = 10 = 1$ log

$10^2 = 100 = 2$ log

$10^3 = 1{,}000 = 3$ log

$10^4 = 10{,}000 = 4$ log

$10^5 = 100{,}000 = 5$ log

$10^6 = 1{,}000{,}000 = 6$ log

Remember you can't subtract exponents

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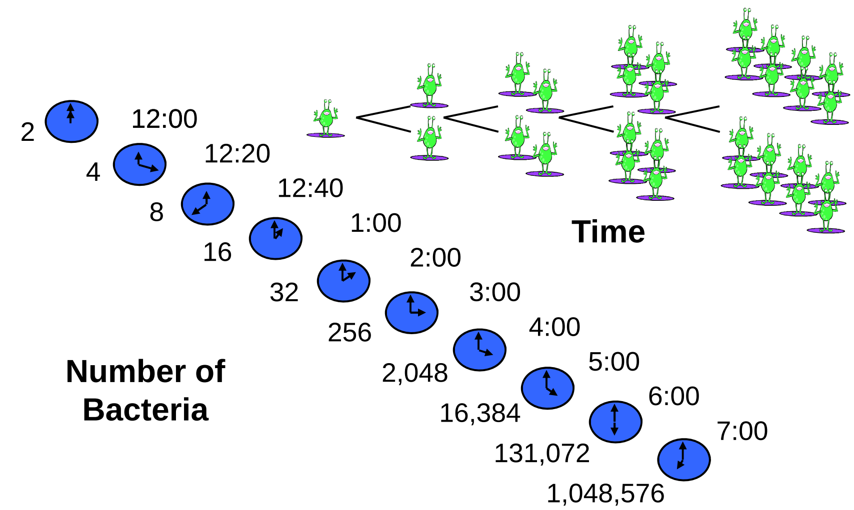
Exponential (log) growth of bacteria



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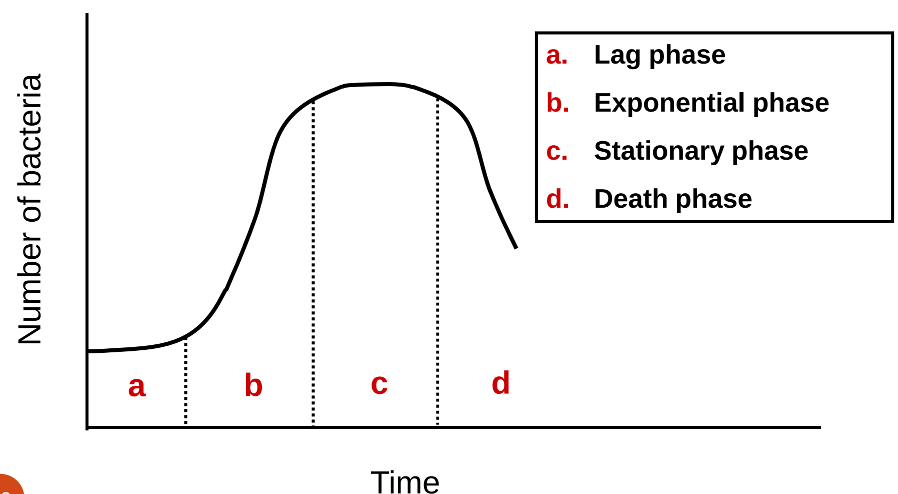
Bacterial Growth Curve



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Vegetative cells, Sporeformers, & Toxins

- **Vegetative cells are metabolically active cells and spores exist in dormant state**
- **Vegetative cells of yeasts, molds, bacteria, viruses, parasites and heat-labile toxins are easily inactivated by heat**
- **Spores and some heat stable toxins can be very heat resistant**
- **Examples: Bacillus spores and toxin, Clostridial spores, and Staphylococcal toxin, thermophilic spores**

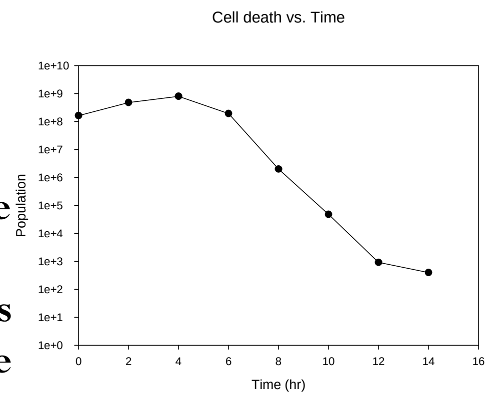
Heating or cooking foods

- **C-BOT toxin is destroyed**
- **Vegetative cells are destroyed**
- **However:**
  - **Staph toxin is heat resistant**
  - **Spores are heat resistant**

NOTE: Eating C-BOT spores will not hurt you, but if the spores germinate in foods… ***TROUBLE!***

Microbial Death Curve

- Microbial death is often a logarithmic function. This means that the number (but not the proportion) of organisms that die is dependent upon the initial number of organisms present.



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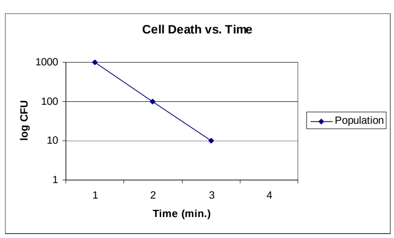
What do we mean by logarithmic cell death?



- There exists a 1 log difference in the population between points 1 and 2 min.
- By calculation:

  10^3-10^2=1000-100=900

  900/1000 = 90% Death
- Therefore it takes 1 minute to achieve a 1 log (90%) reduction in bacterial count

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Concept Expanded

Exp. count	Number	Log #	% red.	Tot. % red.	Log red.
10^0	1	0	90	99.9999	6
10^1	10	1	90	99.999	5
10^2	100	2	90	99.99	4
10^3	1,000	3	90	99.9	3
10^4	10,000	4	90	99	2
10^5	100,000	5	90	90	1
10^6	1,000,000	6	0	0	Initial load

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Common Examples

- **4 log (4D) reduction in *Salmonella* for raw almonds (99.99% reduction)**
- **5 log (5D) reduction in Juice pasteurization (99.999%)**
- **12 log (12D) reduction in *C. botulinum* in LACF (99.9999999999%)**
- **One more fun example - Lysol**

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Where do Spores Come From?

- Soil
- Ingredients that originated from or near the soil
- Fecal contamination
- Water
- Environment

AF: Microorganisms of Concern

- Pathogens
  - *Clostridium botulinum*
  - *E. coli* O157:H7
  - *Bacillus cereus*?
  - *Staphylococcus aureus*?
- Spoilage organisms
  - *B. stearothermophilus*
  - *B. coagulans and others*
  - *C. thermosaccharolyticum*
  - *C. butyricum*
  - *Desulfotomaculum nigrificans*
  - Yeasts, Molds and non-sporeforming bacteria

Why no others?

Factors that Affect Growth

- **Atmosphere (Aerobe vs. anaerobe)**
- **Temperature (mesophile vs. thermophile)**
- **Time**
- **pH (acid tolerant sporeforming spoilage organisms – not a LACF issue but may be a critical factor)**
- **aW (amount of available water, can be a critical factor but usually not an important factor in LACF spoilage and safety)**

Aerobe vs. Anaerobe

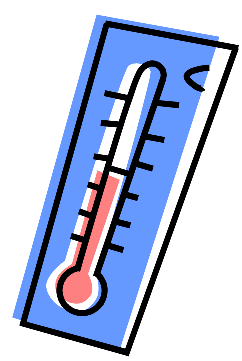
- **Aerobic growth nor microaerophilic growth are of concern in properly canned unopened products**
- **Anaerobic growth is a concern due to the preparation of the product – steam tunnels, blanching and cappers are designed to remove residual air for a proper vacuum seal**
- **Is a properly sealed can anaerobic?**
- **What does facultatively anaerobic mean?**

Mesophile vs. Thermophile

- Psychrotrophs (32 - 70°F)
  - Capable of growing at refrigeration temperatures
- Mesophiles (70 - 110°F)
  - Optimum growth at temperatures similar to human and animal body temperatures
  - Most pathogens are in this group
  - Some sporeforming spoilage bacteria
- Thermophiles (110 - 130°F)
  - Grow at higher temperatures
  - Problems usually arise in canned foods not cooled, stored or distributed properly

Temperature

- Under "normal" processing, storage and distribution conditions, if properly retorted, temperature is not a concern
- However, elevated storage and distribution temperatures may result in thermophilic spoilage



Time

- If delays occur after 1) sealing before processing or 2) in cooling after processing:
  - Growth of spoilage organisms or outgrowth of mesophilic or thermophilic sporeforming spoilage organisms may occur

Temperature and time abused LACF spoilage concerns

- If product is held too long before thermally processing, after sealing the container, growth of microorganisms may cause spoilage before the thermal process
- This type of spoilage is referred to as "incipient spoilage"

Temperature & time abused AF spoilage concerns

- **The aforementioned sporeforming thermophiles may grow in equipment that contacts food if the temperature is within their growth range**
- **Microorganisms that grow under these elevated temperatures create spores that are even more resistant to heat**

Temperature & time abused AF spoilage concerns cont.

- **Thermal processes are not designed to destroy an indefinite number of these spores, therefore….**
  - **Products and containers should always be held at 170°F or higher or at room temperature to prevent the growth of thermophiles**
  - **Containers should be rapidly cooled below 105°F after thermal processing as well as stored and distributed below 95°F**

Spoilage by Acid-Tolerant Sporeformers

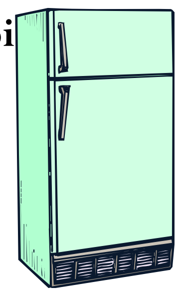
- **Some flat-sour facultative aerobes, such as *Bacillus stearothermophilus*, are thermophiles**
- **Proper cooling after thermal processing and avoiding high temperatures during storage are essential since the thermal process for acid food is not sufficient to destroy their spores**

Spoilage by Acid-Tolerant Sporeformers

- **Spoilage by the thermophilic anaerobe *Clostridium thermosaccharolyticum* has been seen in canned tomato products in the pH range 4.1 to 4.5**
- **The thermal process for acidified foods is not adequate to destroy the spores of the organism; however, the problem will not occur if the product is properly cooled and stored at temperatures below 95°F**

Temperature

- **Refrigeration slows down food spoilage, but does not stop it!**
- **Cold temperatures slow microbi growth, although…**
- **Some bacteria grow at refrigeration temperatures**
- ***Listeria monocytogenes***
  - **Grows at refrigeration temperatures**



pH and Acidity

- **Most food pathogens don't grow in acid or acidified foods**
- **At or below pH 4.6 *Clostridium botulinum,* (a.k.a. C bot) can NOT PRODUCE deadly botulism toxin.**
- **Maintaining proper pH is critically important for acidified foods!**

pH is important!

- An acidified food with improper pH control can:
  - Appear normal
  - Taste normal…

...and still contain deadly toxin

pH Requirements

- In general pH refers to the degree of acidity or alkalinity
- The pH of a food influences the types of microorganisms that will grow in it
- In general, yeast and mold grow at a lower pH compared with bacteria
- All bacteria have an optimum pH range for growth - generally around neutral pH

pH Requirements

- **All bacteria have a minimum below which they will not grow and a maximum above which they cannot grow**
- **The pH of foods can be adjusted to help control microbial growth**
- **The pH of a food is extremely important with respect to the control of *Clostridium botulinum***

Effect of pH on *C. botulinum* Growth

- **Spores of *C. botulinum* and other spoilage types can be found in both acid and low-acid foods**
- **In acid or acidified products, the pH is a critical factor for control, with a finished equilibrium pH of 4.6 or less, so that growth and toxin formation will not occur even if the spores of *C. botulinum* are present**

Effect of pH on Required Heat Treatment

- **The application of mild heat destroys all bacteria that are non-sporeformers or all vegetative cells in either low-acid or acid foods, including the vegetative cells of *C. botulinum***
- **In low-acid foods, high heat must be applied to kill the spores of *C. botulinum* or the spores of other food spoilage organisms**

Effect of pH on Required Heat Treatment

- **Thus, these foods must be heat processed under pressure**
- **In acid foods, there is no concern with the spores of *C. botulinum***
- **These spores are prevented from germinating and growing because the pH is 4.6 or below**

Effect of pH on Required Heat Treatment

- **Since only the vegetative cells must be destroyed in acid foods, boiling water cooks or hot-fill and hold procedures may be used**

Approximate pH Range for Selected Foods

Lemon Juice	2.0 - 2.6	Tuna	5.2 - 6.1
Apples	3.1 - 4.0	Sweet Potatoes	5.3 - 5.6
Blueberries	3.1 - 3.3	Onions	5.3 - 5.8
Sauerkraut	3.3 - 3.6	White Potatoes	5.4 - 5.9
Orange Juice	3.3 - 4.2	Spinach	5.5 - 6.8
Pineapple, canned	3.4 - 4.1	Beans	5.6 - 6.5
Apricots	3.3 - 4.0	Peas, canned	5.7 - 6.0
Tomatoes, canned	3.5 - 4.7	Corn, canned	5.9 - 6.5
Peaches, canned	3.7 - 4.2	Soy Beans	6.0 - 6.6
Pears, canned	4.0 - 4.1	Mushrooms	6.0 - 6.7
Bananas	4.5 - 5.2	Clams	6.0 - 7.1
Beets, canned	4.9 - 5.8	Salmon	6.1 - 6.3
Asparagus, canned	5.0 - 6.0	Coconut milk	6.1 - 7.0
Beef	5.1 - 7.0	Milk	6.4 - 6.8
Carrots	4.9 - 5.2	Garbanzo Beans	6.4 - 6.8
Peppers, green	5.2 - 5.9	Chicken	6.5 - 6.7
Papaya	5.2 - 6.0	Eggs, whole	7.1 - 7.9

Spoilage by Acid-Tolerant Sporeformers

- **Acidified foods do not require a severe thermal process to assure product safety**
- **Therefore, a variety of spoilage-causing, acid-tolerant sporeformers may survive the process**
- **A thermal process for acidified foods is designed to inactivate a certain level of these sporeformers**

Spoilage by Acid-Tolerant Sporeformers

- **Their survival is typically a result of excessive pre-processing contamination**
- **Sometimes underprocessing, either due to an inadequate process or to process deviations, may also result in the survival of these acid-tolerant sporeformers**
  - **Butyric acid producing anaerobes**
  - **Aciduric flat-sour sporeformers**

Spoilage by Acid-Tolerant Sporeformers

- **The butyric acid producing anaerobes, such as *Clostridium butyricum* and *Clostridium pasteurianum*, are mesophilic sporeformers**
- **The spores are capable of germination and growth at pH values as low as 4.2-4.4 and consequently are of spoilage significance in acidified foods, particularly if the pH is above 4.2**

Spoilage by Acid-Tolerant Sporeformers

- **Spoilage by butyric acid anaerobes may be controlled either by lowering the pH of the product to below 4.2 or by increasing the thermal process**
- **Growth of these organisms in foods is characterized by a butyric odor and the production of large quantities of carbon dioxide and hydrogen gas**

Spoilage by Acid-Tolerant Sporeformers

- **Aciduric flat-sours bacteria are facultative anaerobic sporeformers that seldom produce gas in spoiled products**
- **The ends of spoiled cans remain flat; hence the term "flat sour"**
- **Spoiled products have an off-flavor that has been described as "medicinal" or "phenolic"**

Spoilage by Acid-Tolerant Sporeformers

- **These organisms (*Bacillus coagulans*) have caused spoilage in acid foods such as tomato products**
- **It is necessary to ensure that the thermal process is adequate to inactivate an expected number of spores**
- **The load of flat-sour spores is determined through bacteriological surveys**

Spoilage by Acid-Tolerant Sporeformers

- **Pinpointing the ingredient that is contributing the most to the total spore load may prove beneficial in process control**
- **For example, proper handling of fruits and vegetables prior to use, such as washing and culling, may also help to reduce spore loads**

Spoilage by Acid-Tolerant Sporeformers

- ***Alicyclobacillus* spp., such as *A. acidoterrestris* and *A. acidocaldarius,* are flat-sour sporeformers that can grow at a pH as low as 3 in shelf stable juice and other beverage products**
- **Spoilage caused by *Alicyclobacillus* spores has been reported in a variety of juices and beverages (in particular apple juice products), especially when the product packaging allows oxygen transmission**

Spoilage by Acid-Tolerant Sporeformers

- **The spoilage can be minimized by multiple approaches**
  - **Treating a selected ingredient with an intensified thermal process (at temperatures above 212°F)**
  - **Product formulation**
  - **Limiting oxygen availability**
  - **Rapid cooling of finished products**

Control of Bacteria by Water Activity

- **For thousands of years people have dried fruits, meats and vegetables as a method of food preservation**
- **It was also discovered that the addition of sugar would allow preservation of foods such as candies and jellies**
- **Salt preservation of meat and fish has been practiced over the ages**

Control of Bacteria by Water Activity

- **The measure of the availability of water in a food is made by determining the water activity**
- **Water activity is usually designated with the symbol "a_w."**

Control of Bacteria by Water Activity

- **When substances are dissolved, there is substantial reaction between the substance and the water**
- **A number of the molecules of the water are bound by the molecules of the substances dissolved**
- **All of the substances dissolved in the water reduce the number of unattached water molecules**

Control of Bacteria by Water Activity

- **Thus, if some ingredient – such as sugar, salt, raisins, dried fruits, etc. – is added to food, it competes with the microorganism for available water**
- **The water-binding capacity of a particular ingredient influences the amount of water left for the growth of microorganism**

Minimum a_w Requirements for Microorganism Growth

Most molds (e.g., *Aspergillus*)	**0.75**[1]
Most yeasts	**0.88**[2]
C. botulinum	**0.93**
Staphylococcus aureus[3]	**0.85**
Salmonella[3]	**0.93**

[1] some strains – 0.61
[2] some strains – 0.62
[3] Non-sporeforming food-poisoning bacteria readily destroyed by heat.

Control of Bacteria by Water Activity

- **Examples of foods preserved with this method are**
  - **Some cheese spreads**
  - **Peanut butter**
  - **Honey**
  - **Syrups**
  - **Jams and jellies**
  - **Canned breads**
  - **Confectionery preparations - toppings**

Water activity of some common foods

Liverwurst	0.96
Cheese Spread	0.95
Caviar	0.92
Fudge Sauce	0.83
Semi-moist Pet Food	0.83
Salami	0.82
Soy Sauce	0.80
Peanut Butter – 15% total moisture	0.70
Dry Milk – 8% total moisture	0.70

Control of Bacteria by Water Activity

- **As far as *C. botulinum* is concerned, a water activity of 0.85 provides a large margin of safety**
- **Studies with this organism show that an accurate water activity of 0.93 plus a mild heat treatment will give commercial sterility**

Regulatory Requirements Related to Water Activity

- **Under the FDA regulation 21 *CFR* Part 113, a canned food with a water activity greater than 0.85 and a pH greater than 4.6 is considered a low-acid food, and its minimum heat process will have to be filed by the individual packer**
- **If reduced water activity is used as an adjunct to the process, the maximum water activity must also be specified**

Regulatory Requirements Related to Water Activity

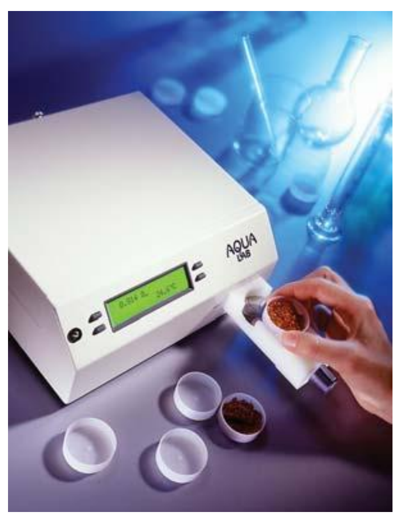
- **If the pH of the product has been adjusted to 4.6 or less and the water activity is greater than 0.85, the product is covered by the acidified food regulation (21 *CFR* Part 114) and requires only enough heat to destroy vegetative bacterial cells**

Regulatory Requirements Related to Water Activity

- **Any non-meat containing food, regardless of the pH, with an water activity of 0.85 or less is not covered by the regulations for either the low-acid food (21 *CFR* Part 113) or the acidified food (21 *CFR* Part 114)**
- **However, these products are covered by FDA's Current Good Manufacturing Practices (CGMPs) regulation (21 *CFR* Part 110**

Methods for Determining a_w

- One commonly used method is an electric hygrometer with a sensor to measure equilibrium relative humidity (ERH)
- The instrument was actually devised by weathermen, and the sensors are the same as those used to measure relative humidity in air



Methods for Determining a_w

- **A single measurement of water activity on a food provides information as to which types of microorganisms are most likely to cause spoilage and how close the water activity is to the safety limits**

Molds

- **Molds are widely distributed in nature, both in the soil and in the dust carried by air**
- **Under suitable conditions of moisture, air and temperature, molds will grow on almost any food**
- **The black or green discoloration that appears on moldy bread is a common example of mold growth**

Molds

- Molds are also able to survive on a wide variety of substances not normally thought suitable for supporting life
  - These include concentrated solutions of some acids
  - Water containing minute quantities of certain salts
  - Certain pastes used in labeling

Molds

- Mold spoilage of food in closed, processed containers is rare but not impossible
- Most molds have little heat resistance and cannot survive the thermal processes for low-acid canned foods
- Therefore, if present, it is the result of serious underprocessing or post-processing contamination
- Since molds need oxygen to grow, only slight growth can occur unless the food container has an opening to the outside environment

Danger!

Improperly Sealed jar lid

Air leaks in

Aerobic mold grows and raises the pH

Anaerobic conditions in the bottom of the Jar

C-BOT grows and toxin formed

Yeasts

- Another microorganism of importance to food preservation is yeast
- Yeasts are single cell microscopic living bodies, usually egg-shaped
- They are smaller than molds but larger than bacteria

Yeasts

- **Yeasts are widely found in nature and are particularly associated with liquid foods containing sugars and acids**
- **They are quite adaptive to adverse conditions such as acidity and dehydration**
- **Like molds, yeasts are more tolerant of cold than of heat**

Yeasts

- **Most yeast forms are destroyed on heating to 170°F**
- **Spoilage may result from the presence of yeast in canned food, but if this happens, severe underprocessing or leakage must be suspected**
- **Usually the growth of yeasts results in the production of alcohol and large amounts of carbon dioxide gas**
- **The gas will swell the container**

Introduction to Acidified Foods

- The preservation of foods using acid is older than recorded history (ex. yogurt and sauerkraut)
- The naturally formed acid serves as a preservative for the food and extends its shelf-life, but the nutritional quality of the food is relatively unchanged

Introduction to Acidified Foods

- It is not necessary to allow foods to ferment in order to preserve them
- The same preservative effect can be achieved by adding acids, such as vinegar, to low-acid ingredients, such as vegetables
- These products are called acidified or acidified low-acid foods

Definition of Acidified Foods

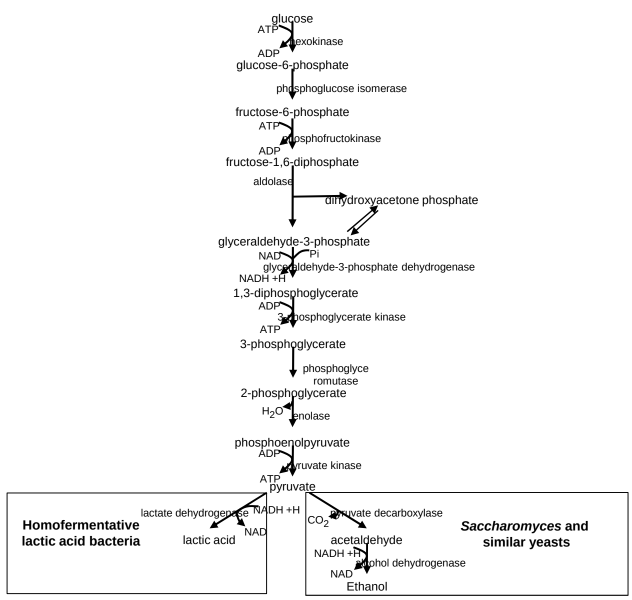
- **An "acidified food" is defined by FDA in 21 *CFR* 114.3 (b)**
  - **A low-acid food to which acid(s) or acid food(s) are added to produce a product that has a finished equilibrium pH of 4.6 or below and a water activity greater than 0.85**
- **Examples of acidified foods include:**
  - **Acidified artichoke hearts, bean salads, peppers or pimentos;**
  - **Marinated beets or mushrooms;**
  - **Fresh-pack pickles**

Definition of Acidified Foods

- **Certain foods have been excluded**
  - **Carbonated beverages;**
  - **Jams, jellies and preserves;**
  - **Acid foods such as dressings and condiment sauces containing small amounts of low-acid food(s) that have a resultant finished product equilibrium pH that does not significantly differ from that of the predominant acid or acid food (sometimes called "formulated acid foods")**
  - **Fermented foods**

Fermentation

- **Anaerobic catabolism in which an organic compound serves as an electron donor and another serves as an electron acceptor with ATP being produced by substrate level phosphorylation**



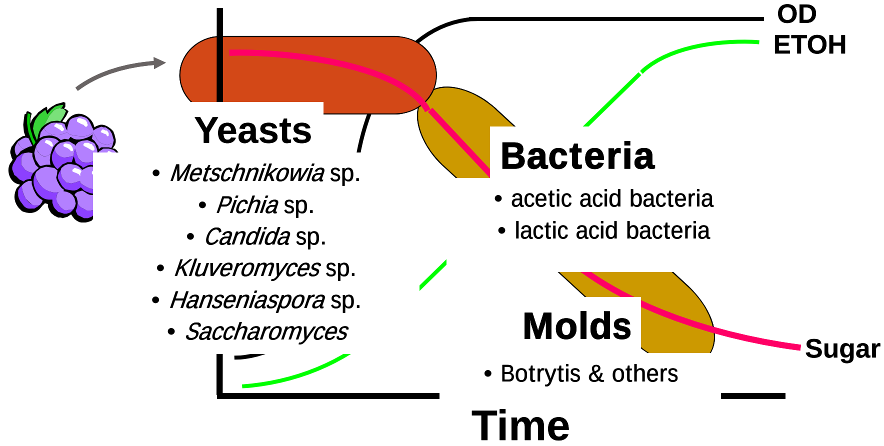
Summary

- Two primary types of fermentation organisms
  - Bacteria: Lactic acid bacteria-produce acids
  - Yeasts-produce ethanol
- Foods are fermented to
  - Preserve
  - Nutrition
  - Uniqueness
  - Sensory properties
  - Economics

Three ways to start a fermentation

- Natural
- Backslopping
- Starter culture

Natural fermentation



Natural Fermentation

- Vegetable fermentations
- Some wines
- Some cheeses

Natural Fermentation

- Positives
  - Distinct flavors
  - Less expensive in the short term
- Problems
  - Inconsistent end product
  - Limited control of fermentation
  - Scale issues in some industries

Backslopping

- Using a previously successful fermentation to start the next
- Still used in brewing industry and in sourdough bread making and small operations
- Similar positives and negatives to natural fermentation

Starter cultures

- Advantages
  - Consistent product
  - Consistent production
  - Increased scale
- Disadvantage
  - Loss of some exceptional product
  - costs

Sauerkraut

Cabbage

↓

Remove outer leaves and core

↓

Wash

↓

Shred and salt

↓

Convey to tanks and mix

↓

Fermentation

↓

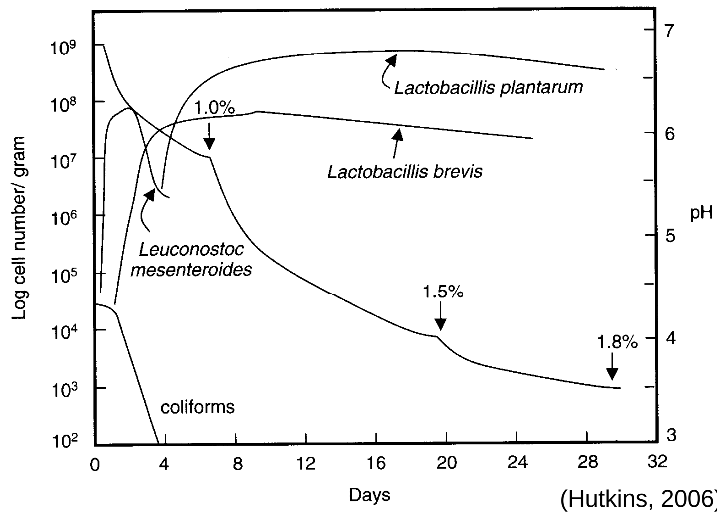
Package

↙ ↘

Pasteurize   Refrigerate

(Hutkins, 2006)

Sauerkraut



(Hutkins, 2006)

Lactic acid bacteria (LAB)

- **Gram (+), non-spore forming, anaerobic, cocci or rods**
- **Ubiquitous: plants, animal products, GI tract of man or animals**
- **Major role in food fermentation – preservation & organoleptic**

Sugars → Lactic acid + other products

- **Exhaust carbon source → exhaust nutrients**
- **Lower pH → out-compete**
- **Other products (EtOH, bacteriocins, H_2O_2) ↔ anti-microbial**
- **Un-stable raw material → Stable product**

Two Types of LAB

- **Homofermentative**
- **> 85% of products is lactic acid**

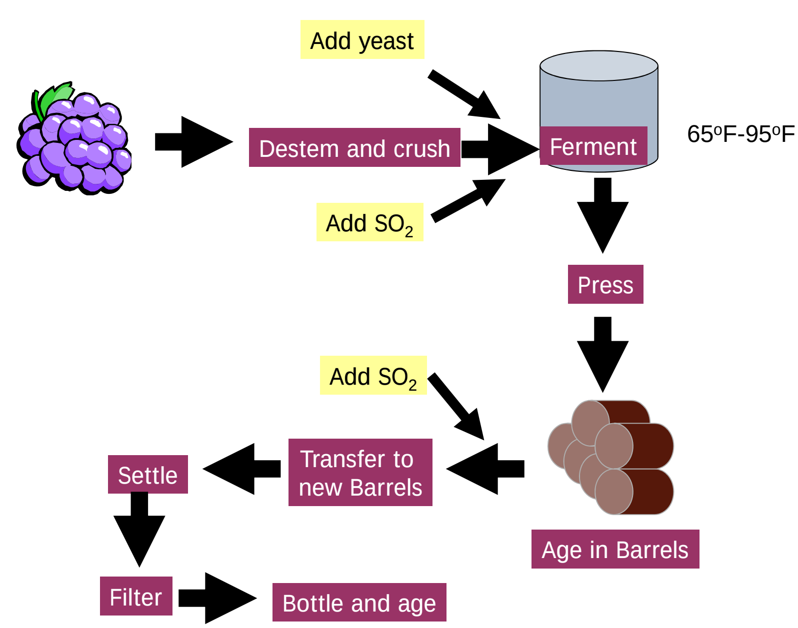
- **Heterofermentative**
- **50% prod. = lactic acid;**
- **50% others = ethanol, acetic acid, CO_2, …**

The magic of organic acids

- **Dependant on the pH and the pKa**
- **pH lower than pKa – most of the acid undissociated [HA]**
- **Neutral molecules diffuse into the cell**
- **Once inside pH is higher than pKa and acid dissociates**
- **In an attempt to maintain homeostasis cell exhausts itself and dies**

Spoilage issues

- Temperature too high or too much salt
  - Inhibits growth of *L. mesenteroides*
  - May lead to growth of *Rhodotorula*
    - Causes pinking
- Temperature too low or salt to low
  - Allow *Flavobacterium* or *Pseudomonas* to grow
  - These produce pectinolynic enzymes causing soft kraut
- *L. mesenteroides* producing dextrans



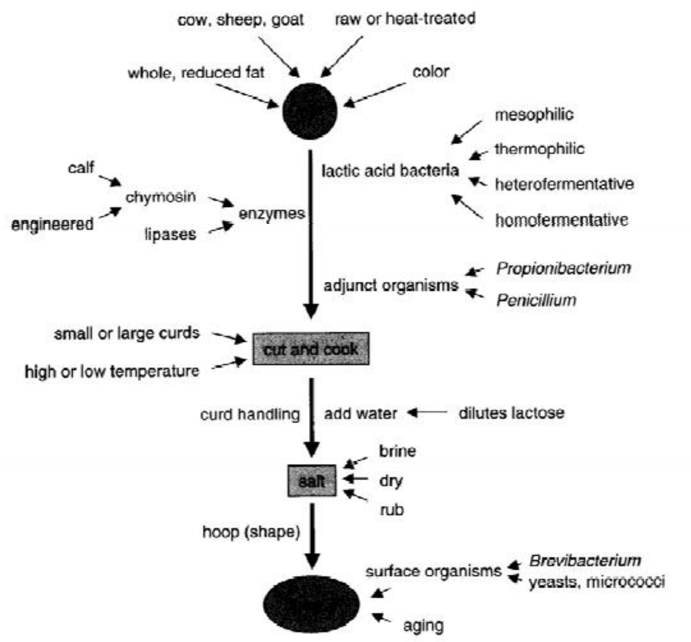


Figure 5-5. General steps for manufacture of hard cheeses.

(Hutkins, 2006)

Other fermentations

- **Over 3,500 types consumed**
- **Provide 20-40 % of the worlds food supply**
- **Responsible for production of 20-30 billion dollars worth of food products**

General Guidelines

- **Known organism (preferably LAB)**
- **Rapid and continuous pH reduction**
  - below 4.6 in less than 24h

Firm should be:

(1) evaluating the hazards that could affect food safety – based on science not faith
(2) specifying what preventive steps, or controls, will be put in place to significantly minimize or prevent the hazards
(3) specifying how the facility will monitor these controls to ensure they are working
(4) maintaining routine records of the monitoring
(5) specifying what actions the facility will take to correct problems that arise.

Miso

"Although it's technically done after two months, my ferment takes six months to hit its prime. The longer miso ferments the better it tastes, and as far as I know miso has an indefinite shelf life. I have no knowledge as to when my miso hits a 4.6 pH….. I really know nothing about the pH of miso."

QUESTIONS???