Food Microbiology

- Microorganisms in Food
- Food Preservation
- Food-borne Illness
- Fermented Foods

Microorganisms in Food

- Factors affecting microbial growth in food
  - composition
  - pH
  - presence and availability of water
  - oxidation-reduction potential
    - altered by cooking
  - physical structure
  - presence of antimicrobial substances

Microorganisms in Food

- Factors affecting microbial growth in food
  - temperature
    - lower temperatures retard microbial growth
  - relative humidity
    - higher levels promote microbial growth
  - atmosphere
    - oxygen promotes growth
  - modified atmosphere packaging (MAP)
    - use of shrink wrap and vacuum technologies to package food in controlled atmospheres

Microorganisms in Food

- Composition and pH
  - Putrefaction
    - proteolysis and anaerobic breakdown of proteins, yielding foul-smelling amine compounds
  - pH impacts make up of microbial community and therefore types of chemical reactions that occur when microbes grow in food

Microorganisms in Food

- Water availability
  - in general, lower water activity inhibits microbial growth
  - water activity lowered by:
    - drying
    - addition of salt or sugar
  - osmophilic microorganisms
    - prefer high osmotic pressure
  - xerophilic microorganisms
    - prefer low water activity

Microorganisms in Food

- Physical structure
  - grinding and mixing increase surface area and distribute microbes
    - promotes microbial growth
  - outer skin of vegetables and fruits slows microbial growth

Microorganisms in Food

- Antimicrobial substances
  - coumarins – fruits and vegetables
  - lysozyme – cow's milk and eggs
  - aldehydic and phenolic compounds – herbs and spices
  - allicin – garlic
  - polyphenols – green and black teas

Microorganisms in Food

- Food spoilage
  - results from growth of microbes in food
    - alters food visibly and in other ways, rendering it unsuitable for consumption
  - involves predictable succession of microbes
  - different foods undergo different types of spoilage processes
  - toxins are sometimes produced
    - algal toxins may contaminate shellfish and finfish

Microorganisms in Food

- Toxins
  - ergotism
    - toxic condition caused by growth of a fungus in grains
  - aflatoxins
    - carcinogens produced in fungus-infected grains and nut products
  - fumonisins
    - carcinogens produced in fungus-infected corn

Food Preservation

- Removal of Microorganisms
  - usually achieved by filtration
  - commonly used for water, beer, wine, juices, soft drinks, and other liquids

Food Preservation

- Low Temperature
  - refrigeration at 5°C retards but does not stop microbial growth
  - microorganisms can still cause spoilage with extended spoilage
  - growth at temperatures below -10°C has been observed

Food Preservation

- Canning
  - food heated in special containers (retorts) to 115° C for 25 to 100 minutes
  - kills spoilage microbes, but not necessarily all microbes in food
  - Spoilage of canned goods
    - spoilage prior to canning
    - underprocessing
    - leakage of contaminated water into cans during cooling process

Food Preservation

- Pasteurization
  - kills pathogens and substantially reduces number of spoilage organisms
  - different pasteurization procedures heat for different lengths of time
  - shorter heating times result in improved flavor

Food Preservation

- Reduced water availability
  - Drying
  - Freeze-drying (lyophilization)
  - Addition of high concnetrations of solutes such as sugar or salt

Food Preservation

- Chemical-Based Preservation
  - GRAS
    - chemical agents “generally recognized as safe”
  - pH of food impacts effectiveness of chemical preservative

Food Preservation

- Radiation
  - ultraviolet (UV) radiation
    - used for surfaces of food-handling equipment
    - does not penetrate foods
  - radappertization
    - use of ionizing radiation (gamma radiation) to extend shelf life or sterilize meat, seafoods, fruits, and vegetables
    - kills microbes in moist foods by producing peroxides from water
    - peroxides oxidize cellular constituents

Food Preservation

- Microbial Product-Based Inhibition
  - Bacteriocins: bactericidal proteins active against related species
  - some dissipate proton motive force of susceptible bacteria
  - some form pores in plasma membranes
  - some inhibit protein or RNA synthesis
  - e.g., nisin: used in low-acid foods to inactivate *Clostridium botulinum* during canning process

Food-borne Illness

- Food-Borne Infection
  - ingestion of microbes, followed by growth, tissue invasion, and/or release of toxins
- Food-Borne Intoxications
  - ingestion of toxins in foods in which microbes have grown
  - include staphylococcal food poisoning, botulism, *Clostridium perfringens* food poisoning, and *Bacillus cereus* food poisoning

Food-borne Illness

- Detection of Food-Borne Pathogens
  - culture techniques
  - immunological techniques - very sensitive
  - molecular techniques
    - probes used to detect specific DNA or RNA
    - sensitive and specific

Food-borne Illness

- Detection of Food-Borne Pathogens
  - PulseNet
    - established by Centers for Disease Control
    - uses pulsed-field gel electrophoresis under carefully controlled and duplicated conditions to determine distinctive DNA pattern of each bacterial pathogen
    - enables public health officials to link pathogens associated with disease outbreaks in different parts of the world to a specific food source
  - FoodNet
    - active surveillance network used to follow nine major food-borne diseases
    - enables public health officials to rapidly trace the course and cause of infection in days rather than weeks

http://www.cdc.gov/foodnet/
http://www.cdc.gov/pulsenet/

Fermented Foods

- Alcoholic Beverages
  - Alcohol is produced from fermentation by the yeast *Saccharomyces cerevisiae*
- Bread
- Dairy Products
- Other Fermented Foods

Fermented Foods

- Beer
  - "Beer is dear"
  - Produced by the fermentation of malted grain
    - Malted grain: Grain that has been allowed to germinate, then dried in a kiln & perhaps roasted
    - Germinating the grain causes the production of a number of enzymes, most notably α- and β-amylase
    - Malted grains that may be used are barley, rye, or wheat
    - Unmalted grains, such as rice or corn, may also be used

Fermented Foods

- Beer
  - The grain is ground into a grist and mixed with heated water in a process called “mashing”
  - A series of temperature changes (“mash rests”) activates different enzymes that, in turn, change the mash to produce desirable characteristics as well as fermentable sugars

Fermented Foods

- Beer
  - Mash Rests:
    - 49 - 55°C (120 - 130°F) activates various proteinases. Too much protein can make the beer hazy, but some protein has to remain to produce a head on the beer.
    - 60°C or 140°F activates β-gluconase, which breaks down gummy β-glucans and allows sugar to flow more freely from the grain. Fungal β-gluconase may be added as a supplement
    - 65 - 71°C (149 - 160°F) activates amylases that convert starch into fermentable sugars, such as maltose

Fermented Foods

- Beer
  - After mashing, the spent grain is separated from the liquid
  - The grain is usually sold for livestock feed
  - The liquid, at this point called “wort” is transferred to a large kettle where it is boiled with hops and perhaps other herbs or flavors
  - After boiling, the wort is clarified by spinning it in a “whirlpool” (like a continuous flow centrifuge) and transferred to fermentation tanks

Fermented Foods

- Beer
  - In the fermentation tank, yeast is added ("pitched")
    - Top-fermenting yeasts produce ales
    - Bottom-fermenting yeasts produce lagers
  - After fermentation for 1 - 3 weeks, the "green beer" is transferred to conditioning tanks where the yeast & other particulates are allowed to settle, and the beer is carbonated

Fermented Foods

- Beer
  - Most beers are filtered to remove yeast before packaging. This filtration may be accomplished by a bed of diatomaceous earth
  - The beer may be disinfected either by cold filtration through a 0.45 μm filter or by pasteurization
  - Some beers may undergo a secondary fermentation, either in tanks or in the bottles

http://en.wikipedia.org/wiki/Brewing

Fermented Foods

- Wine
  - "Wine is Fine"
  - Produced from the fermentation of fruit juice, usually from grapes
  - The grapes are crushed to form a "must"
    - For white wines, white grapes are usually used, and the skins are removed from the must ("pressing") before fermentation
    - For red wines, red or black grapes are used, and the skin is allowed to remain during fermentation
    - For rosé wines, red grapes are used and the juice is allowed to remain in contact with the skins just long enough for a rose or pink color to develop

Fermented Foods

- Wine
  - The must undergoes primary fermentation
    - Natural yeasts on the skins of the grapes may be used, but in commercial production cultured yeast is often used to give more predictable results
    - The amount of sugar in the must during fermentation is measured with a saccharometer (a calibrated hydrometer)
    - Malolactic fermentation by bacteria in the must converts malic acid into lactic acid
    - After primary fermentation, the must is pressed (red wines) and transferred to different containers for secondary fermentation

Fermented Foods

- Wine
  - Secondary fermentation and aging
    - Takes 3 – 6 months
    - Done in either stainless steel vessels or in oaken barrels
    - The vessel is kept airtight to prevent oxidation
    - Proteins are broken down, & particles settle
  - Blending and bottling

http://en.wikipedia.org/wiki/Winemaking

Fermented Foods

- Distilled spirits
  - “Likker is quicker”
  - Produced by the fermentation of grain mash (similar to beer), followed by distillation to increase the alcohol content
  - Different types of grain are used to produce different types of whisky

http://en.wikipedia.org/wiki/Whiskey
http://www.thewhiskyguide.com/

Fermented Foods

- Bread
  - involves growth of *Saccharomyces cerevisiae* (baker's yeast) under aerobic conditions
  - maximizes CO_2 production, which leavens bread
  - other microbes used to make special breads (e.g., sourdough bread)
  - can be spoiled by *Bacillus* species that produce ropiness

Fermented Foods

- Yogurt
  - Milk is feremented by a mixture of *Streptococcus salivarius* ssp *thermophilus* and *Lactobacillus bulgaricus* (official name *Lactobacillus delbrueckii* ssp. *bulgaricus*). Often these two are co-cultured with other lactic acid bacteria for taste or health effects (probiotics). These include *L. acidophilus*, *L. casei* and *Bifidobacterium* species.
  - Acid produced from the fermentation causes the protein in the milk (casein) to coagulate into a semisolid curd
  - If you want strawberries or peaches, you must add them after the yogurt is made

http://en.wikipedia.org/wiki/Yogurt

Fermented Foods

- Cheese
  - Milk is treated with lactic acid bacteria and an enzyme called rennin that partially hydrolyses the protein and causes it to coagulate into "curds." The liquid portion of the milk at this time is called "whey."
  - The whey is separated from the curds, and the curds are aged ("ripened")
  - Different microbes in the early and late stages of processing give rise to cheeses with different characteristics

http://www.realcaliforniacheese.com/

Fermented Foods

- Other fermented foods
  - sausages
  - hams
  - bologna
  - salami
  - izushi – fish, rice, and vegetables
  - katsuobushi – tuna
  - sauerkraut