MICROBES AND FOOD

MICROBES AS FOOD

- **Edible Fungi** as edible mushrooms – are cultivated world-wide.
- **Edible Algae** – thickening agents and in ice cream also are nutritionally important in vegetarian diets
- **Yeast** – common flavoring agent of food and for food production
- **Bacteria** – used to produce dairy products as cheese and yogurt

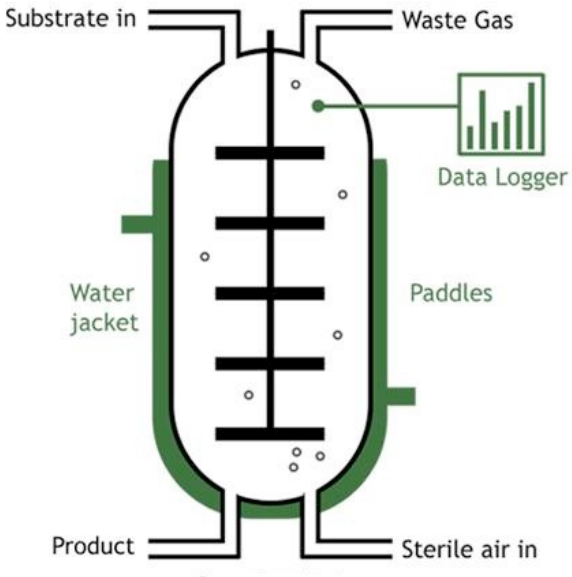
FOOD PRODUCTION USING MICROBES

Fermentation Process

Fermentation is any process where microbes use an external food source for energy. This process is done in a fermenter, conditions are controlled by mixing, water jacket.

Fermenter

Below is a diagram of a simple fermenter. In industry, these would be very large and would have lots of different pipes and tubes coming out of it for various functions.



Paddles	Inside the fermenter, they are rotated to evenly distribute the mixture.
Water Jacket	Cold water is pumped through this to reduce and maintain the temperature. Respiration by microorganisms heats it up.
Data logger	Measures a range of conditions (temperature, pH, oxygen concentration); measurements can be used to adjust the conditions in the fermenter.
Products	Products are removed, all at once in batch culture or bit by bit in continuous.
Air supply	Provides oxygen for respiration. Must be sterilized so no extra microorganisms contaminate the fermenter.

In the wine making process, yeast cells are kept short of oxygen, causing sugars in grape juice to ferment, forming alcohol and carbon dioxide. In the making of cheese and yoghurt, bacteria perform a similar job, turning lactose into lactic acid. Rennet is then added to separate the curds and whey

Yogurt Production

A fermentation process is used to make yogurt. Milk contains the sugar lactose; and some bacteria will ferment lactose to produce lactic acid.

Yogurt is produced by batch culture, where pasteurized milk has the bacteria *Lactobacillus bulgaricus* and *Streptococcus thermophilus* added. The mixture is maintained at a temperature of around 40°C. The bacteria will produce lactic acid by respiration, and this lowers the pH. When it reaches a target the product is harvested.

Dairy products - fermentation of milk generates lactic acid, which precipitates milk proteins and prevents other microbial growth

- **buttermilk** (from skim milk)
- **yogurt**
- **sour cream** (from cream)
- **acidophilus milk** - *Lactobacillus acidophilus*
- **cheeses**– Cheeses are characterized by the water content
  - **soft** - cottage , cream, mozzarella
  - **semi-soft** - monterey jack Muenster bleu,
  - **hard** - cheddar , swiss
  - **very hard** - parmesan romano

  Cheese facts:
  - There are 2000 varieties
  - Some cheeses like cottage and cream cheese are not ripened and are called fresh cheese
  - The holes in swiss cheese are made by bacteria
  - Blue cheese has mold

baked goods - Baker's yeast (*Saccharomyces cerevisiae*) aerobically generates carbon dioxide for breads and pastries to make the dough rise

- **"regular" bread** - *S. cerevisiae* provides flavor and carbon dioxide for "holes" to give light texture
- **sourdough bread** - *S. exiguus* provides flavor and carbon dioxide and *Lactobacillus* provides flavor

miscellaneous foods

- **coffee** (coffee beans)
- **Kimchee** (napa = Chinese cabbage)
- **olives** (green olives)

- **pickles** (cucumbers)
- **sauerkraut** (cabbage)
- **soy sauce** (soybeans)
- **tempeh** (tofu = soybean curd)
- **vinegar** (apple juice, wine)
- **chocolate** (cocoa)
- **vanilla**

Alcoholic beverages

- **brews** (beer, ale)
  - germinate grains (barley, wheat, rice) to allow amylase activity to release fermentable sugars (malting)
  - dry and crush malted grains, then rehydrate and allow further enzymatic activity (mashing)
    fermenting tanks with yeast
  - add hops heat in brew kettle
  - remove hops, add *Saccharomyces carlsbergensis* for beer or *S. cerevisiae* for ale (pitching), then ferment 7-12 days (---> 2-5% ethanol)
  - "age" (lagering)
  - pasteurize or filter, then package
- **wines, champagnes**
  - press grapes (must)
  - add *Saccharomyces ellipsoideus*, then ferment 3-5 days (---> 8-14% ethanol)
  - settle
  - "age"
  - bottle (champagne has "extra" sugar and is fermented after bottling to generate carbon dioxide for bubbles)
  - "age" some more...how long depends on the wine
- **distilled alcoholic beverages** (whiskey, brandy, rum, etc.)
  - generate brew (*Saccharomyces spp.*)
  - distill to increase alcohol content to 25-100% ethanol

FOOD SPOILAGE AND FOOD CONTAMINATION

- Microbes play a key role – bacteria and fungi – in food spoilage and decomposition
- Many types can live at low temperatures as mold on food in the refrigerator
- Food preservation techniques as salt and high acid affect microbes

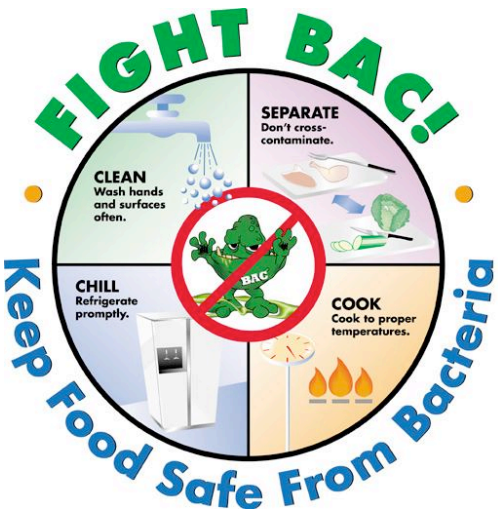
Contamination of Fresh Foods – Food is considered contaminated when unwanted microorganisms are present. Most of the time the contamination is natural, but sometimes it is artificial.

Natural contamination occurs when microorganisms attach themselves to foods while the foods are in their growing stages. For instance, fruits are often contaminated with yeasts because yeasts ferment the carbohydrates in fruits.

Artificial contamination occurs when food is handled or processed, such as when fecal bacteria enter food through improper handling procedures.

Food Spoilage – Microbes can cause food to deteriorate and develop unpleasant odors, tastes, and textures.

- They can cause fruits and vegetables to get mushy or slimy, or meat to develop a bad odor.
- Food that is left too long at unsafe temperatures could be dangerous to eat, even though the smell and look just fine.
- Bacteria will grow anywhere they have access to nutrients and water.
- Under the correct conditions, spoilage bacteria reproduce rapidly and the populations can grow very large.
- In some cases, they can double their numbers in as little as 20 minutes.
- The large number of microorganisms and their waste products cause the objectionable changes in odor, taste, and texture.
- Foods consumed by man and animals may be classified into eight main divisions.



These are cereal and cereal products, vegetables, fruits, milk and dairy products, meat and poultry, eggs, sea food, and sugar and sugar products

Foods may also be classified on the basis of stability:

- Perishable foods such as meat and fish.
- Semiperishable foods such as potatoes.
- Stable foods such as cereals, flour and sugar.

CONDITIONS SUITABLE FOR MICROBIAL GROWTH AND ENZYME ACTION

- organic food (proteins, carbohydrates, fats)
- suitable temperature
- moisture (water)
- aerobic environment though some are anaerobic
- suitable pH – close to neutral (pH ~ 7) for bacteria

pH of Foods

- Most vegetables and pasta have a very *high* pH when uncooked, but turn neutral and more hazardous when cooked.
- Highly acidic foods such as citrus, tomatoes, apples, vinegar, and berries are relatively unattractive to bacteria. They will grow, it just takes a lot longer.
- Mold prefers a more acid environment pH ~ 5, so they will grow on fresh fruit as citrus and berries

FOOD PRESERVATION

Methods of Food Preservations

Heat (Pasteurization, Sterilization)

Low temperature (Chilling, Freezing)

Chilling

- -1 to 8°C
- Reduce Enzyme and microbial activities
- Proper temperatures
  -1 to +1°C (fresh meat,fish)
  0 to +5°C (milk, cream, yogurt, baked goods, pizzas, sandwiches)
  0 to +8°C (fully cooked meat, margarine, fruits, cheese)
- Not all foods can be chilled
- Some fruits suffer from chilling injury at 3-10 °C
- Changes in atmospheric composition can increase the

Freezing

- Temperature below freezing point
- Berries, peas, green beans, beef, lamp, poultry, pies, pizzas, ice cream
- Blanching before freezing helps to reduce microorganisms and inactivate enzymes
- Water becomes ice crystals and stops metabolic activity of microbes

Dehydration

- The oldest method of preservation
- Microorganisms need free water to grow and multiply

Fermentation - Controlled action of selected microorganisms

- Alter the texture of foods and preserve foods by production of acids or alcohol.
- Additional flavors and aromas

Salting/Sugaring

Salting is to selectively allow some microorganisms that are tolerant to salt to grow and ferment

Sweetened milk, sweetened fruits

Irradiation – ionizing radiation by using ionizing (gamma rays) and nonionizing (UV) radiation

Chemical additive

Acids - combined treatment with other methods

- Yeast/Mould can grow better at low pH
- Acetic acid (as vinegar) in Pickle and sauerkraut (+salt), ketchup (+heat)
- Propionic acids: mold and bacteria inhibitor. Up to 0.32% in flour
- Caprylic acid -mold inhibitor in cheese

Esters

Other Organic Chemicals