

Chapter 32

Food Microbiology

Grains

- Rye, wheat, and oats
 - Molds
 - *Claviceps purpurea* (ergot)
 - Hallucinogenic - deadly
 - *Aspergillus flavis*
 - Aflatoxins - mutagens - carcinogens
 - *Rhizopus nigricans*
 - *Penicillium*, *Aspergillus*, *Chrysonilia sitophila* (formerly *Monila* - pink bread mold)

Fruits and vegetables

- Pseudomonds
- *Salmonella*, *Shigella*, *Entamoeba histolytica*, *Ascaris*
- Viruses
- Skin of fruits and vegetables
 - Waxes with antimicrobial substances
- Leafy vegetables
 - *Erwinia carotovora*
 - Soft rot on leaves and potatoes
 - *Phytophthora infestans* (water mold)
 - Irish potato blight (famine 1846)
 - Fruits - *Fusarium*, *Rhizopus*, *Penicillin*, *Leuconostoc*, *Lactobacillus*

Meats and poultry

- Molds - *Rhizopus*, *Mucor* (white fluffy growth)
- Bacteria -
 - *Pseudomonas mephitica* - green color with stink (H₂S)
 - *Clostridium* spp. - bone stink
- Ground meats
 - Lactobacilli - helps retard growth of pathogens
 - Molds - *Rhizopus*, *Mucor*
- Pork
 - *Trichinella spiralis* (helminth) Trichinosis

Meats and poultry

- Poultry
 - More than 20 pathogens
 - 50% *Salmonella*, 25% *Clostridium perfringens*, 25% *Staphylococcus aureus*
 - Pseudomonds (slime)
 - Eggs
 - *Salmonella*
 - Fungi

Meats and poultry

- Fish and shellfish
 - *Salmonella typhimurium*, *Vibrio cholera*
 - Filter feeders - filter sewage
- Crabs and shrimp
 - *Clostridium botulinum*, *Cryptococcus*, and *Candida*
 - Growth before processing

Milk

- Fresh milk
 - *Staphylococcus epidermidis*, *Micrococcus*, *Pseudomonas*, *Flavobacterium*, *Erwinia*, *Escherichia coli*, *Acinetobacter johnsoni*,
 - Spoilage organisms
 - *Mycobacterium bovis* (TB)
 - *Brucella* spp. (brucellosis or undulant fever)
 - Testing and vaccination have eliminated these pathogens
 - *Staphylococcus aureus*, *Salmonella*
- Sour milk
 - *Streptococcus lactis*, *Lactobacillus* spp.

Honey

- *Clostridium botulinum* and other toxins

Bacteria in spices

TYPE OF SPICE	TOTAL AEROBES	COLI-FORMS	YEASTS & MOLDS	AEROBIC SPORES	ANAEROBIC SPORES
Bay leaves	520,000	0	3,300	9,200	<2
Cloves	3,000	0	5	<2	<2
Curry	>7,500,000	0	70	>240,000	>240,000
Marjoram	370,000	0	18,000	54,000	>24,000
Paprika	>5,500,000	600	2,300	>240,000	620
Pepper	>2,000,000	0	15	>240,000	>24,000
Sage	6,800	0	10	7	1,700
Thyme	1,900,000	0	11,000	160,000	>24,000
Turmeric	1,300,000	50	70	>110,000	430

Pathogens in food and milk

ORGANISM	DISEASE
<i>Staphylococcus aureus</i>	Food poisoning
<i>Clostridium perfringens</i>	Food poisoning
<i>Bacillus cereus</i>	Food poisoning
<i>Clostridium botulinum</i>	Botulism
<i>Salmonella</i> species	Salmonellosis
<i>Shigella</i> species	Shigellosis
Enteropathogenic <i>Escherichia coli</i>	"Montezuma's revenge" and other diseases
<i>Campylobacter</i>	Gastroenteritis
<i>Vibrio cholerae</i>	Cholera
<i>Vibrio parahaemolyticus</i>	Asian food poisoning

Food preservation

- Canning
 - Moist heat under pressure (autoclaving)
 - Kills most endospores
 - *Bacillus stearothermophilus*
 - Bulging cans, gas production, seals broken
 - Thermophilic anaerobic spoilage
 - Gas and Acid - bulging and blackened can
 - Flat Sour spoilage
 - Acid - blackened can
 - Mesophilic spoilage
 - Improper canning and a broken seal

Food preservation

- Jams and jellies
 - Osmotic pressure
 - Sugar
 - Artificial sweeteners???
- Refrigeration and freezing
 - 4°C and -10°C
 - Does not destroy most microbes
 - Freeze-thawing promotes the growth of organisms

Food preservation

- Drying and lyophilization
 - Oldest method
 - 90% water removed
 - Stops the growth - does not kill
 - Addition of salt, sugar or chemical preservatives alters osmotic pressure

Food preservation

- Irradiation
 - UV - nonionizable
 - Surface - poor penetration
 - Microwave - nonionizable
 - Cooking and food prep., but not preservation
 - gamma rays - ionizable radiation
 - Penetrates well
 - Vitamins destroyed
 - Formaldehyde -benzene are formed

Food preservation

- Chemical additives
 - Organic acids
 - Benzoic, sorbic, propionic
 - Alkylating agents
 - Ethylene oxide, propylene oxide
 - Nuts and spices
 - Sulfur dioxide
 - Dried fruits
 - Ozone -
 - Beverages and shellfish
 - NaCl - osmotic pressure
 - Nitrates
 - Nitrates and nitrites → Nitrosamines (carcinogenic)
 - Keep meat red

Food preservation

- Antibiotics
 - Nisin
 - *Streptococcus lactis*
 - Antibiotics are not used very much
 - Good sanitation
 - Resistance development
 - Allergic reactions
 - Desired fermentation

Pasteurization of milk

- HTST - High temperature-short time (flash)
 - 71.6° for 15 sec
- LTLT - Low temperature-long time (holding)
 - 62.9°C for 30 min
- UHT - Ultra high temperature (sterilized milk)
 - 90°C (87.8) for 3 sec
 - Alters flavor

TABLE 32.1 Foods Produced Using Lactic Acid Bacteria

Food	Characteristics
Milk products	
Cheese (semipend)	Employs a starter culture usually containing <i>Lactococcus cremoris</i> and <i>L. lactis</i> .
Cheese (riped)	Employs rennin and a starter culture containing <i>Lactococcus cremoris</i> and <i>L. lactis</i> ; ripened for weeks to years; other bacteria and/or fungi may be added to enhance flavor development.
Yogurt	Employs a starter culture containing <i>Streptococcus thermophilus</i> and <i>Lactobacillus bulgaricus</i> .
Sweet acidophilus milk	<i>Lactobacillus acidophilus</i> added for purported health benefits.
Vegetables	
Sauerkraut	Cabbage; succession of naturally occurring bacteria including <i>Leuconostoc mesenteroides</i> , <i>Lactobacillus brevis</i> , and <i>Lactobacillus plantarum</i> .
Pickles	Cucumbers; naturally occurring bacteria.
Poi	Taro root; naturally occurring bacteria; Hawaii.
Olives	Green olives.
Kimchee	Cabbage and other vegetables; Korea.
Meats	
Dry and semidry sausages	Employs a starter culture containing species of <i>Lactobacillus</i> and <i>Pedococcus</i> ; meat is stuffed into casings, incubated, heated, and then dried.

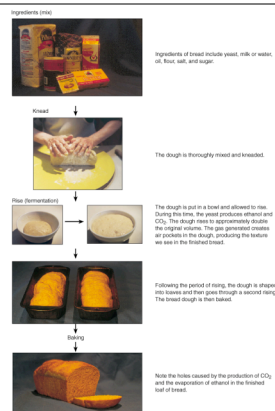
Food production

- Yeast - proteins & vitamins
 - Grown on waste materials - sewage
- Algae
 - *Scenedesmus* and *Chlorella*
 - Shortens the food chain
 - Treated sewage

Food production

- Bread
 - Yeast
 - *Saccharomyces cerevisiae*
 - Sour dough bread
 - Propionic bacteria

Bread Production



Food production

- Dairy products
 - Yogurt
 - *Streptococcus thermophilus*
 - *Lactobacillus bulgaricus*
 - *Lactobacillus acidophilus*
- Cheeses
 - Lactic acid bacteria
 - Enzyme from calf stomachs
 - Rennin
 - Enzyme from calf stomachs
 - Curd & whey

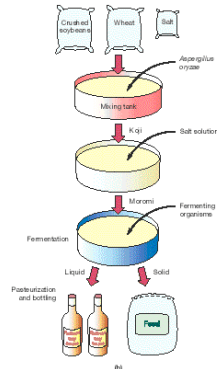
Ripened cheeses

CONSISTENCY AND RIPENING PERIOD	EXAMPLES	ORGANISMS ASSOCIATED WITH RIPENING
Soft (1-2 months)	Limburger	<i>Streptococcus lactis</i> , <i>S. cremoris</i> , <i>Brevibacterium linens</i>
Soft (2-5 months)	Brie and Camembert	<i>S. lactis</i> , <i>S. cremoris</i> , <i>Penicillium camemberti</i> , and <i>P. candidum</i>
Semihard (1-8 months)	Meunster and Brick	<i>S. lactis</i> , <i>S. cremoris</i> , <i>Brevibacterium linens</i>
Semihard (2-12 months)	Roquefort and Blue	<i>S. lactis</i> , <i>S. cremoris</i> , and <i>P. roqueforti</i> or <i>P. glaucum</i>
Hard (3-12 months)	Cheddar and Colby	<i>S. lactis</i> , <i>S. cremoris</i> , <i>S. durans</i> , and <i>Lactobacillus casei</i>
	Edam and Gouda Gruyere and Swiss	<i>S. lactis</i> and <i>S. cremoris</i> <i>S. lactis</i> , <i>S. thermophilus</i> , <i>S. helveticus</i> , <i>Propionibacterium shermani</i> , or <i>L. bulgaricus</i> and <i>P. freudenreichii</i>
Hard (12-16 months)	Parmesan	<i>S. lactis</i> , <i>S. cremoris</i> , <i>S. thermophilus</i> , and <i>L. bulgaricus</i>

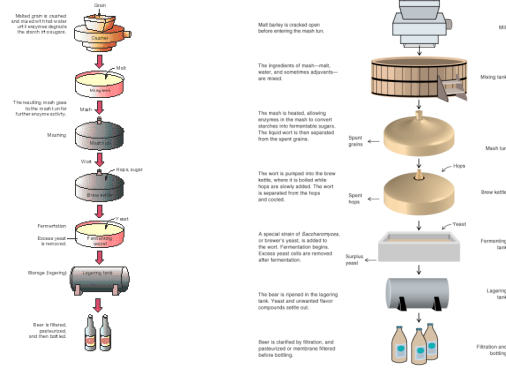
Cheese production



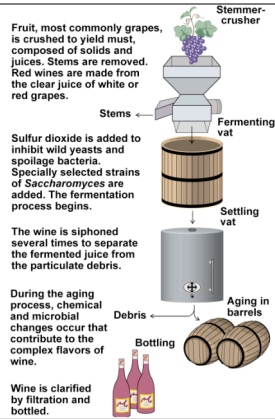
Making soy sauce



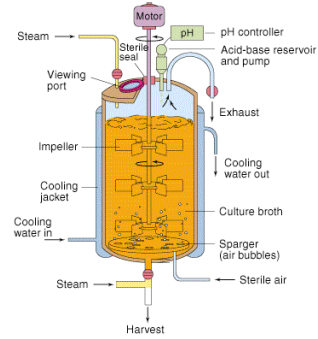
Beer fermentation process



Wine production



Continuous reactor



Yeast production

