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Production of Fermented Foods



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History

- Fermentation is described as a process in which microorganisms change the sensory (flavour, odour) and functional properties of a food
- One of the earliest traditions developed by cultures to extend the storage time of foods
- Fermented fruits were probably among the first fermented foods eaten
- Developed over a period of time from the experiences of many generations



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Fermentation as a Preservation Method

- Is very inexpensive, very basic equipment, used for extending the shelf life of the product
- Remains an appropriate method for use in developing countries and rural communities
- Microbial spoilage of food is prevented by using four basic principles:
 - Minimize the level of microbial contamination
 - Inhibit the growth of contaminating microbiota
 - Kill the contaminating microorganisms
 - Remove the contaminating microorganisms



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Factors that contribute to Stability

- Low pH
- Organic acids – lactic, acetic, and formic acid
- Low redox potential
- Nutrient depletion
- Accumulation of toxins, bacteriocins, antibiotics, hydrogen peroxide
- Ethanol
- Diacetyl
- Carbon dioxide



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Microorganisms used for Fermentation

- Lactic Acid Bacteria – Lactic Acid
- Acetic Acid Bacteria – Acetic Acid
- Yeasts – Alcohol and CO₂
- Molds – Enzymes
- **Microbial metabolic end products used:**
 - Carbondioxide (leavening bread)
 - Ethanol (alcoholic beverage)
 - Acetic acid (vinegar)
 - Lactic acid (fermented vegetables)
 - Diacetyl (dairy products)



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Lactic Acid Bacteria (LAB)

- Health benefits of LAB
 - Production of vitamins and essential amino acids
 - Improved digestion of lactose
 - Lowers serum cholesterol, inhibits tumour growth
 - Control of intestinal infection
- Lactic acid fermentations include:
 - Sauerkraut, pickled cucumbers, radishes, olives, carrots
 - Fermented milks - Yogurt, cheese, kefir
 - Leavened bread such as sourdough breads
 - Fermented sausages



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Acetic Acid Bacteria

- Acid tolerant (growth below < 5.0), Gram-negative, motile rods, and are obligate aerobes
- Consists of two genera – *Acetobacter*, *Gluconobacter*
- *Acetobacter* can oxidize acetic acid to CO_2 and water using Krebs cycle enzymes
- Present in nature (plant nectars) where ethanol is produced by fermentation of carbohydrates by yeasts



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Yeasts and Molds

- **Yeasts**
 - Widely distributed in nature (500 species) that are nutritionally rich in carbohydrates (fruits and plant nectars)
 - Rarely toxic or pathogenic
 - Only a few species are used to make alcoholic beverages (used to produce ethanol, CO₂, flavor, aroma)
- **Molds**
 - Majority have filamentous hyphae
 - Aerobic and grouped into four main classes (physiology)
 - Used to produce specific enzymes such as amylases for use in bread making
 - Tolerant to extreme conditions



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Starter Cultures

- Fermented foods are produced by action of fermentative microorganisms
- Starter culture – preparation of living organisms that are used to assist the beginning of fermentation, producing specific changes in the chemical composition and sensorial properties of the food
- Mixed starter cultures improve the quality of foods when the organisms are mutually beneficial
- Food fermentation involves several microorganisms that act in dynamic environmental conditions



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Starter Cultures

- Fermentative microorganisms must be safe to eat even in high numbers and must produce substantial amounts of end product
- Organisms should be easy to handle and should grow well, enabling them to outcompete undesirable ones
- Traditional fermentations use natural microflora
- Starter cultures are increasingly used to increase reliability, reproducibility, and the rate at which fermentation is initiated



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Fermented Products

- Grouped based on the microorganisms, biochemistry, or on the product type given by Campbell=Platt
 - Beverages
 - Cereal products
 - Dairy products
 - Fish products
 - Fruit and vegetable products
 - Legumes
 - Meat products



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Fermented Products

- Based on type of fermentation given by Steinkraus:
 - Alcoholic beverages – fermentation of fruits or sugars by yeasts (beer and wine)
 - Distilled spirits – concentration in excess of 17% alcohol obtained by distillation (whisky, rum)
 - Dairy products – yogurt is a coagulated milk product obtained by LAB fermentation (*Lactobacillus delbrueckii* subsp. *bulgaricus*, *Streptococcus thermophilus*) and cheese is a concentrated milk product obtained after coagulation and whey separation of milk



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Fermented Products

- Fermented vegetables – cucumbers, olives, cabbage
- Animal products –to extend shelf life and Gram-positive micrococci are important (sausage, fish sauce)
- Combined Fermentations – release of CO₂ by microorganisms has two major roles in food:
 - Act as leavening agent
 - Used for carbonation of beverages



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Fermented Products

- Bread – yeasts contribute to flavor and aroma and when the loaves are baked proteins are denatured, and the low levels of ethanol produced evaporate
- Sourdough products have extended shelf life, and fermentation combines metabolic activity of LAB for souring and yeasts for leavening. The sourness depends on fermentation temperature and time, type of grain, and the strains of yeast and LAB



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Fermented Products

- **Vinegar** – classified as a condiment that contains at least 4% (w/v) acetic acid and pH between 2 and 3.5
- Higher strength vinegars are used for pickling, spirit vinegar is made from alcoholic solution that is distilled
- Used for extending shelf life of pickled vegetables
- **Kefir** – produced by acid/alcohol fermentation of pasteurized milk with a mixture of LAB, Yeasts, and other bacteria
- Final product is acidic, slightly alcoholic, liquid to semi-liquid, effervescent, and consumed as beverage



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Fermented Products

- **Kefir Contd.....**
 - Kefir grains (proteins, polysaccharides, mixture of microorganisms) are used to inoculate the milk
 - Microorganisms – lactose fermenting yeasts (*Candida kefir*, *Saccharomyces kefir*), LAB (*Lactobacillus kefir*, *Leuconostoc sp*, *L. lactis*), aroma bacteria
- **Oriental Fermented Products:**
 - Soy sauce – fermentation of soy beans, wheat in a salt brine involving koji fermentation
 - Comprises of soybeans or grains on which molds grow to produce enzymes such as proteases, lipases, and amylases