CC – 9, UNIT 1. INTRODUCTION TO FOOD MICROBIOLOGY

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Dear viewers in this chapter let us try to understand the importance of microbiology in food.

This chapter includes:

1. History and Development of Food Microbiology

2. Definition and Scope of Food Microbiology

3. Inter-relationship of microbiology with other sciences

4. History and Development of Food Microbiology

All foods harbor one or more types of microorganisms, except for a few sterile foods. Microbes have a desirable role in food production, especially as fermented foods. Microbes can also cause food spoilage and foodborne diseases. To control such spoilage, understanding their role in food is necessary. To understand the role of microbes, they are isolated them as pure culture and characterized. Some of the simplest techniques for these studies were developed over the last 300 years. This episode deals with

It is hard to pinpoint the precise beginning of human awareness of the presence and role of microorganism in food. The era before the establishment of bacteriology as a science may be designated as a prescientific era. The prescientific era is divided into the food-gathering period and the food producing period.

Spoilage of prepared foods apparently dates from around 6000 BC. Western Europe started making pottery by about 5000 BC. The art of cereal cooking, brewing, and food storage were either started at about this time or stimulated by this new development.

- Babylonian civilization (7000 BC) were the first evidence of beer manufacture
- Sumerians of about 3000 BC are believed to have been the first great livestock breeders and dairymen. They were first to make butter, salted meats, fish, fat, hide, wheat, and barley.
- Egyptians (3000 BC) civilization shows the use of Milk, butter, and cheese.
- The Jews were the first to use salt from the Dead Sea in the preservation of various foods, between 3000 BC and 1200 BC
- The Chinese and Greeks used salted fish in their diet, and the Greeks are credited with passing this practice to the Romans. Their diet included pickled meats. Mummification and preservation of foods were related technologies which have influenced both Chinese and Greek development.
- Fermented sausages were prepared and consumed by the ancient Babylonians and the people of ancient China way back 1500 BC.

The spontaneous generation of life debate: The belief in the spontaneous generation of life from nonliving matter was introduced by Aristotle, who lived around 350 BC. He concluded that aphid arises from the rainfall which falls on plants and mice originates from dirty food storage structures.

Fig.1. Aristotle 384-322 BC

Between the birth of Christ, AD 1100 few advances were made towards understanding the nature of food poisoning and food spoilage. *Ergot* poisoning (caused by *Claviceps purpurea*, a fungus that grows on rye and other grains) caused many deaths during the Middle Ages.

- During AD 943- over 40,000 deaths occurred due to ergot poisoning in France, but it was not known that the toxin of this disease was produced by a fungus.
- During AD 1156 - meat butchers came into existence
- During1248- Swiss were concerned with marketable and nonmarketable meats.
- In 1276, a compulsory slaughter and inspection order was issued for public abattoirs in

Augsburg.

Until the 13th century, the knowledge of the relationship between quality and microorganism was not known. Kircher, a monk, in 1658 examined decaying bodies, meat, milk, and other substances. He named the spoilage organism as ″worms″ invisible to the naked eye. Kircher′s descriptions lacked precision, thus, did not get wide acceptance.

Anton van Leeuwenhoek, a tailor, used lenses to examine cloth. He discovered: micro" organisms – organisms so tiny that they were invisible to the naked eye. He called these tiny living organism "animalcules" he first described bacteria and the protozoans.

Fig.2. Anton van Leeuwenhoek (1632-1723) and his microscope

In 1765, Spallanzani showed that boiled beef broth when sealed remained sterile and did not spoil (Fig). Spallanzani performed this experiment to disprove the doctrine of the spontaneous generation of life. However, his work was criticized because they believed Oxygen (O2) was excluded and O2, which they thought was vital to spontaneous generation.

During the same period in 1795, a French confectioner named Nicholas Appert was granted a patent for meat preservation, when it was placed in glass bottles and boiled (Fig). This was the beginning of food preservation by canning. Today, this process is known as pasteurization.

Fig.3. Nicolas Appert developed first food preservation by canning

In 1837, Schwann showed that heated infusions remained sterile in the presence of air, which was supplied by passing it through heated coils (Critics concluded that heating changed the effect of air, as it was needed for spontaneous generation).

Louis Pasteur was the first person to prove the relationship between microorganisms in infusions and the chemical changes that took place in those infusions. Pasteur concluded that all fermentative processes were caused by microorganisms. Fermentation (e.g. alcoholic, lactic or butyric) were the result of specific types of microorganisms. He demonstrated the role of microorganisms in the spoilage of French wines, which resulted in the rediscovery of bacteria. In 1857, he showed that souring milk was caused by microbes and in 1860, he demonstrated that heat destroyed undesirable microbes in wine and beer. The latter process is now called as

pasteurization. Pasteur is known as the founder of food microbiology. He demonstrated that air needs heating to remain sterile. He finally disproved spontaneous generation. His experiment to disprove the old theory of spontaneous generation "micro-organisms are the result of decaying matter" led to the new germ theory. It says microorganisms cause decay of matter and the microorganisms can be killed by applying heat, today known as pasteurization.

Fig.4. Louis Pasteur and his drawings for disproved spontaneous generation

In the 19th century, Industrial Revolution, improved microscope. By 1838, Ehrenberg introduced the term bacteria and proposed at least 16 species in four genera. In1875 Cohn developed the preliminary classification system of bacteria. Cohn was the first to discover that some bacteria produced spores. Although like bacteria, the existence of submicroscopic viruses was recognized in the mid- 19th century, they were observed only after the invention of the electron microscope in the 1940s. The history of food microbiology is summarized in Table 1. & 2.

Table 1. Development of history of food microbiology

Year	Events
1782	-Canning of vinegar introduced by a Swedish chemist
1810	-Preservation of food by canning was patented by Appert in France -Peter Durand was issued a British patent to preserve food in "glass, pottery, tin or other metals or materials." The patent was later acquired by Hall, Gamble, and Donkin, possibly from Appert.
1813	-Donkin, Hall, and Gamble introduced the practice of post processing incubation of canned foods. -Use of SO_2 as a meat preservative is thought to have originated around this time.
1825	- Patent preserving food in tin cans (Kensett and Daggett)
1835	-Patent making condensed milk (Newton in England)
1840	-Fish and fruit were first canned.
1842	-Patent freezing foods by immersion in an ice and salt brine (Benjamin in England)
1843	-Sterilization by steam was first attempted by Winslow in Maine.
1853	- Patent for sterilization of food by autoclaving (Chevallier-Appert)
1854	-Pasteur began wine investigations. Heating to remove undesirable organisms was introduced commercially in 1867-1868
1855	- First to produce powdered milk (Wade in England)
1857	-Louis Pasture showed that souring milk was caused by microbes and in 1860 he

	demonstrated that heat destroyed undesirable microbes in wine and beer.
1865	-The artificial freezing of fish on a commercial scale was begun in the United States. Eggs followed in 1889.
1874	-The first extensive use of ice in transporting meat at sea. -Steam pressure cookers or retorts were introduced.
1878	-The first successful cargo of frozen meat went from Australia to England.
1880	-The pasteurization of milk begun in Germany.
1886	-Krukowitsch was the first to note the destructive effects of ozone on spoilage bacteria.
1890	-The commercial pasteurization of milk begins in the United States. -Mechanical refrigeration for fruit storage begins in Chicago
1907	-Metchnikoff and co-workers isolated, and named one of the yogurt bacteria, *Lactobacillus bulgaricus*. -The role of acetic acid bacteria in cider production was noted by Barker
1908	-Sodium benzoate was given official sanction by the United States as a preservative in certain foods.
1916	-The quick freezing of foods was achieved in Germany by Plank, Ehrenbaum, and Reuter
1917	-Birdseye in the United States began work on the freezing of foods for the retail trade. -Franks was issued a patent for preserving fruits and vegetables under CO_2
1920	-Bigelow and Esty published the first systematic study of spore heat resistance above 212°F. The "general method" for calculating thermal processes was published by Bigelow et al the method was simplified by Ball in 1923
1922	-Esty and Meyer established method for studying *Clostridium botulinum* spores in phosphate Buffer at18°F
1928	-The first commercial use of controlled atmosphere storage of apples was made in Europe (first used in New York in 1940).
1929	-A patent issued in France proposed the use of high-energy radiation for the processing of foods. - Frozen foods were placed in retail markets A method developed by Birdseye
1943	- Proctor in the United States was the first to employ the use of ionizing radiation to preserve hamburger meat
1950	-The D value concept came into general use.
1954	-The antibiotic nisin was patented in England for use in certain processed cheeses to control Clostridial defects
1955	-Sorbic acid was approved for use as a food preservative. -The antibiotic chlortetracycline was approved for use in fresh poultry (oxytetracycline followed a year later). Approval was reissued in 1966.
1967	-The first commercial facility designed to irradiate foods was planned and designed in the United States. The second became operational in 1992 in Florida.
1988	-Nisin accorded GRAS (generally regarded as safe) status in the United States
1990	-Irradiation of poultry approved in the United States

Table 2. History of Food Spoilage

Year	Events
1780	-Scheele identified lactic acid as the principal acid in sour milk
1836	-Latour discovered the existence of yeasts
1857	-Pasteur showed that the souring of milk was caused by the growth of organisms in it.
1867	-Martin advanced the theory that cheese ripening was similar to alcoholic, lactic, moreover, butyric fermentations.
1873	-The first reported study on the microbial deterioration of eggs was carried out by Gayon. -Lister was first to isolate *Lactococcus lactis* in pure culture
1887	-Forster was the first to demonstrate the ability of pure cultures of bacteria to grow at 0 ℃
1888	-Miquel was the first to study thermophilic bacteria
1895	-The first records on the determination of numbers of bacteria in milk were those of Von Geuns in Amsterdam. -Prescott and Underwood traced the spoilage of canned corn to improper heat processing for the first time.
1902	-The term *psychrophile* was first used by Schmidt-Nielsen for microorganisms that grow at 0℃
1912	-The term *osmophilic* was coined by Richter to describe yeasts that grow well in an environment of high osmotic pressure.
1915	-*Bacillus coagulans* was first isolated from coagulated milk by Hammer
1917	-*Bacillus stearothermophilus* was first isolated from cream-style corn by Donk.
1933	-Oliver and Smith in England observed spoilage by *Byssochlamys fulva;* first described in the United States in 1964 by Maunder

2. **Definition and Scope of food microbiology**

Microbiology is a specialized area of biology that deals with the study of microbes ordinarily too small to be seen without magnification. Microorganisms are microscopic (in Greek *micros* means small and *scopein*- to see). They are independently living cells that live in communities. Microorganisms include large and diverse groups of microscopic organisms that exist as a single cell or cell clusters (e.g., bacteria, archaea, fungi, algae, protozoan, and helminths) and the viruses, which are microscopic.

Before the 1970s, food microbiology was regarded as an applied science mainly involved in the microbiological quality control of food. Since then, the technology used in food production, processing, distribution and retailing and food consumption patterns have changed

dramatically. These changes have introduced new problems that can no longer be solved by merely using applied knowledge. This discipline includes microbiological aspects of food spoilage and foodborne diseases and their effective control and bioprocessing of foods. It also includes basic information on microbial ecology, physiology, metabolism, and genetics. This information helped to develop methods for rapid and effective detection of spoilage and pathogenic bacteria. It also is used to develop desirable microbial strains by recombinant DNA technology, to produce fermented foods of better quality, to develop thermostable enzymes.

2.1 Scope of Food Microbiology This aspect is covered as

- Bacteriology
- Mycology
- Parasitology
- Algae (Phycology)
- Virology
- Parasitology
- Prions
- Epidemiology

Food microbiology in the changing World concerns

- International trade:
- Consumers trends and communication
- Development of new technology
- Production of Food Ingredients

3. Inter-relationship of microbiology with other sciences

In the early 20th century, studies continued to understand the association and importance of microorganisms, especially pathogenic bacteria in food. Specific methods were developed for their isolation and identification. The importance of sanitation in the handling of food to reduce

contamination by microorganisms was recognized. Specific methods were studied to prevent growth as well as to destroy the spoilage and pathogenic bacteria. There was also some interest to isolate beneficial bacteria associated with food fermentation, especially dairy fermentation. However, after the 1950s, food microbiology entered a new era. Availability of basic information on the physiological, biochemical, and biological characteristics of diverse types of food, microbial interactions in food environments and microbial physiology, biochemistry, genetics, and immunology has helped open new frontiers in food microbiology. Among these are:

A. Food Fermentation/Probiotics

- Development of strains with desirable metabolic activities by genetic transfer among strains
- Development of bacteriophage-resistant lactic acid bacteria
- Metabolic engineering of strains for overproduction of desirable metabolites
- Development of methods to use lactic acid bacteria to deliver immunity proteins
- Sequencing genomes of important lactic acid bacteria and bacteriophages for better understanding of their characteristics
- Food bio-preservation with desirable bacteria and their antimicrobial metabolites
- Understanding of important characteristics of probiotic bacteria and development of desirable strains
- Effective methods to produce starter cultures for direct use in food processing

B. Food Spoilage

- Identification and control of new spoilage bacteria associated with the current changes in food processing and preservation methods
- Spoilage due to bacterial enzymes of frozen and refrigerated foods with extended shelf life
- Development of molecular methods (nanotechnology) to identify metabolites of spoilage

bacteria and predict potential shelf life of foods

- Importance of environmental stress on the resistance of spoilage bacteria to antimicrobial preservatives

C. Foodborne Diseases

- Methods to detect emerging foodborne pathogenic bacteria from contaminated foods
- Application of molecular biology techniques and nanotechnology for rapid detection of pathogenic bacteria in food and environment
- Effective detection and control methods of foodborne pathogenic viruses
- Transmission potentials of prions from food animals to humans
- Importance of environmental stress on the detection and destruction of pathogens
- Factors associated with the increase in antibiotic-resistant pathogens in food
- Adherence of foodborne pathogens on food and equipment surfaces
- Mechanisms of pathogenicity of foodborne pathogens
- Effective methods for epidemiology study of foodborne diseases
- Control of pathogenic parasites in food

D. Miscellaneous

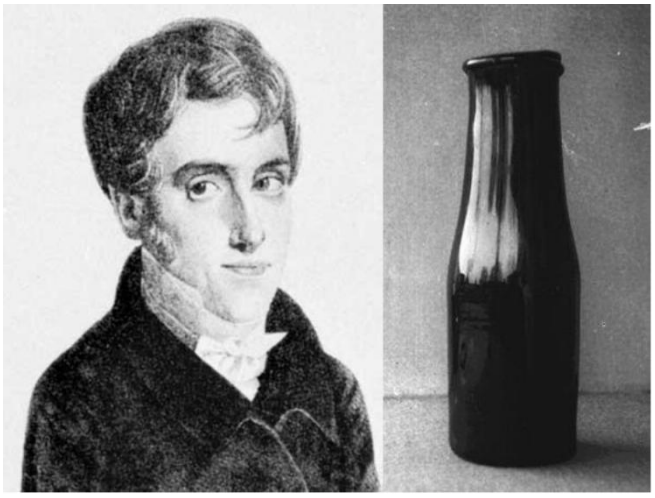
- Application of hazard analysis of critical control points (HACCP) in food production, processing, and preservation
- Novel food-processing technologies
- Microbiology of unprocessed and low-heat-processed ready-to-eat foods
- Microbial control of foods from farm to table (total quality management)
- Food safety legislation

Conclusion:

The human civilization began when hunters and gatherers adopted not only the production but also preservation of foods. Although the existence of microorganisms was recognized long back, its discovery was only in the 16th century. Our early ancestors conceived Their importances on food spoilage and health hazard. Every since the association and importance in food were proven, efforts were made to understand the basic principles associated with food and microbial interactions. This knowledge was used to control undesirable microbes and effectively use the desirable types. Current investigations are directed toward understanding microbes at the molecular level. A food microbiologist should have a good understanding of the current developments in food microbiology as well as the characteristics of microorganisms important in food.

Fig 1

Fig 2.



Nicolas Appert
(1749-1841)

First food preservation by canning

Fig 3.

Louis Pasteur

Pasteur drawings from the laboratory of Louis Pasteur France, 1860's

Fig 4.