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**Microorganisms**

**Abstract**

The discovery of microorganisms revolutionized science and medicine and opened the doors to a world the human eye could not see before. This breakthrough began in the late 17th century with the pioneering work of Antonie van Leeuwenhoek. Leeuwenhoek used a single-lens microscope to observe and document tiny living organisms called "animalcules" in water samples, dental plaque, and other substances. His meticulous observations and detailed drawings laid the foundations for microbiology. Following Leeuwenhoek's discoveries, further advances were made in the understanding and identification of microorganisms. In the 19th century, Louis Pasteur and Robert Koch made essential contributions to establishing microbiology as a scientific discipline. Pasteur's experiments refuted the theory of spontaneous generation and showed that microorganisms were responsible for fermentation and disease. His development of pasteurization, a process for killing harmful bacteria in food and beverages, profoundly impacted public health. Known as the father of bacteriology, Robert Koch developed methods for isolating and growing bacteria in pure cultures, which allowed the identification of specific pathogens responsible for diseases such as tuberculosis, cholera (Vibrio cholerae), and anthrax. Koch's postulates, a criterion for proving a causal relationship between a microbe and a disease, remain fundamental in microbiological research today.

**Keywords:** Leeuwenhoek, Pasteur, Specific pathogens, Spontaneous, Vibrio cholerae.

**Mikroorganizmalar**

**Özet**

Mikroorganizmaların keşfi bilim ve tıpta devrim yarattı ve daha önce insan gözünün göremediği bir dünyanın kapılarını açtı. Bu atılım 17. yüzyılın sonlarında Antonie van Leeuwenhoek'in öncü çalışmasıyla başladı. Leeuwenhoek, geliştirdiği tek lensli mikroskobu kullanarak su örneklerinde, diş plaklarında ve diğer maddelerde "hayvancıklar" adı verilen küçük canlı organizmaları gözlemledi ve belgeledi. Titiz gözlemleri ve ayrıntılı çizimleri mikrobiyolojinin temelini attı. Leeuwenhoek'un keşiflerinin ardından mikroorganizmaların anlaşılması ve tanımlanmasında daha fazla ilerleme kaydedildi. 19. yüzyılda Louis Pasteur ve Robert Koch, mikrobiyolojinin bilimsel bir disiplin olarak yerleşmesine önemli katkılarda bulundular. Pasteur'ün deneyleri kendiliğinden oluşma teorisini çürüttü ve fermantasyon ve hastalıktan mikroorganizmaların sorumlu olduğunu gösterdi. Yiyecek ve içeceklerdeki zararlı bakterileri öldürmeye yönelik bir süreç olan pastörizasyonu geliştirmesi, halk sağlığını derinden etkiledi. Bakteriyolojinin babası olarak bilinen Robert Koch, tüberküloz, kolera (*Vibrio cholerae*) ve şarbon gibi hastalıklardan sorumlu spesifik patojenlerin tanımlanmasına olanak tanıyan, saf kültürlerde bakterileri izole etmek ve büyütmek için yöntemler geliştirdi. Bir mikrop ile bir hastalık arasındaki nedensel ilişkiyi kanıtlamaya yönelik bir kriter olan Koch'un varsayımları, bugün mikrobiyolojik araştırmalarda temel olmaya devam etmektedir.

**Anahtar kelimeler:** Leeuwenhoek, Pasteur, Spesifik patojenler, Sponten, *Vibrio cholerae*.

**1. INTRODUCTION**

A minimal number of foods (for example, all foods except foods heat-treated at high temperatures) contain one or more groups of microorganisms. Some of these play the desired role in foods (for example, in producing naturally fermented foods), while others cause spoilage in foods or the emergence of foodborne diseases. To investigate the role of microorganisms in foods and, if necessary, to control them, they need to be isolated in pure form, and their morphology, physiology, biochemical, and genetic characteristics need to be determined. Some simple methods used in such studies today have been realized in the last 300 years [1] This study aims to investigate and interpret the history of probiotic microorganisms and their benefits to human health in line with recent developments.

**2. HISTORICAL DEVELOPMENT OF FOOD MICROBIOLOGY**

**2.1. Discovery of Microorganisms**

The discovery of microorganisms paralleled the invention and development of the microscope. Around 1658, Athanasius Kircher said he had seen tiny creatures called maggots in spoiled milk and meat, albeit briefly, using a microscope. This researcher could not see bacteria because the magnification of his microscope was insufficient. In 1664, Robert Hooke defined the structure of molds. However, the first person to see different types of microorganisms (mainly bacteria) was probably Antony Leeuwenhoek, who examined them under a microscope, the magnification of which was not more than 300 times. Leeuwenhoek examined bacteria in saliva, rainwater, vinegar and other materials. As a result, he divided the creatures he saw into 3 morphological (outward appearance) groups outline, round or cocci-shaped, cylindrical root or rod and spiral-shaped, and defined them as living beings that could move. This researcher accepted these creatures he observed among animals (1676 -1683). Since better microscopes were not available then, only Leeuwenhoek's observation was valid in scientific studies conducted by other people working in this field and for the next 100 years. As a result of the industrial revolution in the 19th century, it became possible to examine and identify many living things due to the production and easier use of more advanced microscopes. In 1830, Ehrenberg proposed at least 16 species in 4 genera using the term bacteria, and in 1875, Ferdinand Cohn first developed the preliminary classification system of bacteria and discovered spore-producing bacteria. With the discovery of the electron microscope in the mid-19th century (1940), even viruses, which are very similar to bacteria, could be visualized [2].

**2.2. Where Did Microorganisms Come From?**

Following Leeuwenhoek's discovery, although there was no intensification in observation activities, according to some scientific views, enthusiasts observed that animalcules spread in many different objects. During this period, society was at the beginning of the Renaissance period, and the idea was known as experimental philosophy. Many educated and elite people supported this theory of 'spontaneous generation' (observing living objects in inanimate objects). The maggot emergence event in the time of the Greeks was a spontaneous generation seen in dead bodies and deteriorated bodies. However, in a study conducted around 1665 to refute this theory, if insects were allowed to contaminate spoiled food, maggots, which were defined as unknown creatures, were seen in the meat and fish used in the experiment. Supporters of the spontaneous generation theory argued that maggots could not revive on their own (biogenesis). However, maggots were found in different generations during abiogenesis (spontaneous generation). In 1749, Turbevill Needham showed that after storing boiled meat or meat broth in a covered container, creatures called maggots appeared in a short time. In his study, Lazarro Spollani (1765) quickly closed the mouth of the container he used for storage after boiling the boiled meat broth to prevent contamination by these microscopic organisms. This study showed that Needham's theory was wrong. During this time, Antoine Lavoisier and his colleagues determined that some living things needed oxygen. If we recall Spallanzoni's theory, it was said there was no need for oxygen for microbial organisms that did not form spontaneously. However, in this case, it was shown that spontaneously formed organisms needed oxygen [2]. Then Schulze analyzed it in 1830 by passing air through the acid, Theodore Schwan tried it in 1838 by passing air through a very hot tube, and Schröeder used this air in boiled meat broth by passing air through a filter made of cotton in his experiment in 1854 and observed that bacteria did not grow. Finally, Louis Pasteur showed in 1861 that organisms could grow if bacteria in the dust in the air contaminated the boiled meat broth. With all these studies, bacteria could be produced in a controlled and perfect way and the spontaneous generation theory was refuted. John Tyndall showed in his experiment in 1870 that microorganisms did not grow by storing boiled meat broth in a box containing air without dust [1].

**2.3. Functions of Microorganisms**

The effect of invisible organisms in many diseases in humans was determined by Roger Bacon as early as the 13th century. In the 16th century, Girolamo Fracastaro Verona also suggested that small creatures transmitted many animal diseases from person to person. Kircher also stated this view in 1658. In 1762, von Plenci of Vienna said that invisible organisms were responsible for different diseases. Theodore Schwan (1837) and Hermann Helmholtz (1843) stated that putrefaction and fermentation occurred with organisms coming from the air. Finally, Pasteur showed in 1875 that microorganisms produced wine from grapes and the souring of wine. Pasteur also proved that spoilage in meat and milk was related to microorganisms. Later, Pasteur stated that microorganisms played a role in many diseases seen in humans and animals. He developed vaccines against many diseases seen in humans and animals under the conditions of that day. Robert Koch isolated the bacteria responsible for anthrax, cholera, and tuberculosis in Germany between 1880 and 1890 (as pure culture). He also developed Koch's famous Koch theory, showing the relationship between specific bacteria as effective substances for some diseases. He developed the agar counting method with his colleagues to isolate bacteria as a pure culture. They also created the petri dish (in his laboratory) and staining techniques for better observation of bacteria. He provided microbiological development in soil fertility, plant diseases, fermentation, food spoilage, food-borne diseases and other areas with unique methods. Over time, the importance of microorganisms in human and animal diseases was realized. Microbiology developed as a separate discipline. Later, it developed in different disciplines, such as medical microbiology, soil microbiology, plant pathology, and food microbiology.

**2.4 Early Developments in Food Microbiology**

When considered as a logical concept, it is accepted that our ancestors who were engaged in hunting and agriculture were aware of foodborne diseases and food spoilage. In the past, food was made safe by using ice or fire. Around 8000 BC, agriculture and animal husbandry were adopted and the period of domestication began. The preservation of food became important in the production of everyday foods. Between 8000-1000 BC, many food preservation methods: drying, cooking, baking, smoking, salting, sanding (using honey), low-temperature storage (in ice), airless environments (underground storage), fermentation (fruits, vegetables, grains and milk), pickling and seasoning methods were probably used to reduce food spoilage [1].

In the 1670s, it was thought that microorganisms discovered everywhere by Leeuwenhoek would cause food spoilage, food fermentation and foodborne diseases. Before the 19th century, in the 1870s, many scientists began to study food microorganisms, which Pasteur introduced. With this, the foundation stones of the studies to be carried out in microbiology for the 20th century were laid. Some of the most critical events in the history of food preservation, food spoilage and food poisoning in the 19th century are listed below.

**2.5. Food Microbiology: Current Status**

In the early 20th century, studies continued to understand the importance and cohabitation of microorganisms, especially pathogenic bacteria, in foods. Unique methods were developed for the isolation and identification of microorganisms. The importance of sanitation in food storage increased to reduce the contamination of microorganisms. Special techniques were also studied to kill and prevent spoilage and pathogenic bacteria from multiplying. There was also intense interest in isolating beneficial bacterial sources in food fermentations, especially milk fermentation. After 1950, food microbiology entered a new field. Information on the biological characteristics, physiology, biochemistry and microbial physiology, biochemistry, genetics and immunology of various microbial interactions in foods and their environment helped open new files in food microbiology. In recent years, food fermentation and probiotics, food spoilage, foodborne diseases and other topics have been covered [2].

**2.5.1. Food fermentation and probiotics**

Fermentation is an essential biochemical process that provides ATP production through glycolysis under anaerobic conditions, i.e. when oxidative phosphorylation cannot occur. Studies on fermentation and probiotics are as follows [1]:

* Development of species with desired metabolic activity by genetic transfer between species.
* Development of lactic acid bacteria resistant to bacteriophages.
* Development of methods for using lactic acid bacteria to carry immunity proteins.
* Sequencing genomes of crucial lactic acid bacteria and bacteriophages to better understand their characteristics.
* Biological protection of foods using desired bacteria and their antimicrobial metabolites.
* Understanding important characteristics of probiotic bacteria and development of desired species.
* Determination of effective methods for starter culture production for direct use in food processes.

**1) Food spoilage**

We can state the issues related to food spoilage as follows;

* Control and determination of new spoilage bacteria related to recent changes in food processing and preservation methods,
* Spoilage of foods with extended shelf life by cooling or freezing due to bacterial enzymes,
* Development of molecular methods for the determination of metabolites of spoilage bacteria in foods and
* Determination of the importance of environmental factors on the resistance of harmful bacteria to antimicrobial preservatives.

**a) Foodborne diseases**

We can state the issues related to foodborne diseases as follows;

* Development of methods for urgently diagnosing foodborne pathogenic bacteria from contaminated foods.
* Adoption of molecular biology techniques (nanotechnology) to rapidly diagnose pathogenic bacteria in food and its environment.
* Identification of effective diagnosis and control methods of foodborne pathogenic viruses.
* Determination of the potential for transmission of diseases from animals used as food to humans.

**b) Pathogens**

* Determination of the importance of environmental stress for detecting and killing pathogens.
* Determining the factors that cause the increase in antibiotic-resistant pathogens in foods.
* Determining food-borne pathogens that adhere to foods and equipment used in production.
* Determining the pathogenicity mechanism of food-borne pathogens.
* Using effective methods in the epidemiological study of food-borne diseases.
* Controlling pathogenic parasites in foods.

**2) Other studies**

Other studies carried out in this field are as follows;

* Application of hazard analysis at critical control points (HACCP) in the production, processing and preservation of foods,
* New food processing technologies,
* Microbiology of unprocessed food production and low-temperature processed ready-to-eat foods,
* Microbial control of foods from farm to table (total quality management) and
* Food safety regulations.

**3. FOOD MICROBIOLOGY AND FOOD MICROBIOLOGISTS**

As understood from the above, we should accept food microbiology as a branch of science. Before 1990, food microbiology was generally based on controlling food. In the following years, the production, processing, preservation and marketing of food with technology became effective in food consumption. These changes provided the solution of new problems in a short time. Thus, the issues that can be effective in modern food microbiology today have been largely solved with science. Since this branch of science does not cover the production and control of microorganisms in food spoilage and foodborne diseases, information on microbial ecology, physiology, metabolism and genetics in these living things is needed. This information has enabled the development of many methods in the development of these methods, such as examining the effect of DNA structures of spoiled and pathogenic bacteria, facilitating the production of fermented foods, using heat-sensitive enzymes in foods, and excluding pathogens [1].

To fully understand food microbiology, the following information must first be known:

* Determining the microbiological quality of foods and food additives using appropriate techniques.
* Determining the types and sources of microorganisms that are effective in spoilage and posing a health hazard.
* Properly designed procedures for the control of food spoilage and pathogenic microorganisms.
* Learning rapid methods for isolating and identifying pathogenic and harmful bacteria in foods and their environment.
* When separating how new technologies are adapted in food processing, specific microbiological problems may arise; methods for these problems can be established.
* Arrangements for effective sanitation procedures to control spoilage and pathogen problems in food processing environments.
* Effective use of desired microorganisms to produce fermented foods.
* Methods for producing better starter cultures used in fermented foods and probiotics.
* Information on food laws (national and international).
* Understanding microbiological problems in imported foods.

**4. CONCLUSIONS**

In conclusion, adaptation to living together with hunting and domesticated animals has taken place in the civilization of humans not only for production but also for preserving food. The fact that food spoilage was discovered shortly before the formation of microorganisms has made it clear that spoilage and its health hazards are essential. Once the importance and association of microorganisms in food are proven, the basic interaction principles between food and microorganisms will be understood with the effort put in. This knowledge has been used to control unwanted microbes and effectively control desired ones. Recent studies have led to the understanding of microorganisms at the molecular level. A food engineer should understand the characteristics of microorganisms important in food and the latest developments in food microbiology.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

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