BACTERIOLOGY OF FOOD & AIR

ABSTRACT

The role of bacteriology in food and air impacts our health is understandable and the detail information about food borne and airborne pathogenic bacteria helps in improving public health services. As we generally known, microorganisms are present everywhere on the earth, and bacteria are regularly found in food, both in raw and in prepared forms. Even though certain bacteria, such as those found in fermented foods and probiotics, are helpful, others are infectious pathogens that can lead to a variety of health issues, including typhoid, diarrhea, and food poisoning. Human activities that are transfer bacteria into the air include sneezing, coughing, and even breathing. Certain bio aerosols lead to infections, which in turn produce a host of health problems, including physiological alterations, particularly in lung infections. Nearly all bacterial diseases, including respiratory infections, are brought on by airborne germs, and the circumstances become much more serious when a healthy person is exposed to a hospital setting where the load of harmful bacteria is higher.

Keywords: Probiotics, Foodborne, Airborne, Aerosols.

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I. INTRODUCTION

The importance of clean food and pure air in our lives affects us in many ways. If we do not have pure food, we can suffer from many diseases, and along with this, food imbalances can result in deficiencies, obesity and related metabolic problems, a higher risk of cancer and cardiovascular illnesses, and obesity. These days, improving the nutritional quality of foods that are widely available and consumed can be accomplished through plant metabolic engineering. Food bacteriology is an important field of study that examines the existence, impacts, and management of bacteria in food. Microorganisms are ubiquitous in all over the world, and among these bacteria are commonly present in food, even in raw as well as in prepared food. Some bacteria are used as a beneficial source like fermented food and probiotics, and some of them are infectious pathogen that causes many health-related problems like food poisoning, diarrhoea, typhoid, etc.

II. ROLE OF FOOD-ASSOCIATED BACTERIA IN HUMAN HEALTH

Fermented Food Products

Almost all fermented foods together with yoghurt, cheese, sauerkraut, pickles, and fermented soy products like tempeh and miso are made feasible by bacteria. Lactic acid bacteria, along with some *Streptococcus* species, are essential to these activities. These contribute to food preservation by boosting nutritional value and flavor. Fermented drinks like kombucha and some varieties of beer and wine are also made by bacteria. Bacteria are responsible for converting alcohol into acetic acid and vinegar. Similarly, cultivated dairy products, also known as fermented milk products are dairy products that have undergone fermentation caused by a group of lactic acid bacteria that cause milk to soure or curdle. [1]

In addition to offering a viable and nutritious substitute for meats, the fermentation of protein-rich foods like legumes with lactic acid bacteria strains raises the concentration of bioactive compounds and may improve the amino acid profiles, aiding in the fight against under nourishment and hunger in developing nations. [2,3]

Probiotics

Probiotics are beneficial non-pathogenic microbes that are administered with diet to improve health & microbial balance particularly in digestive tract.

Probiotics exert their health effects through synthesizing micronutrients (e.g. vitamin B12), supporting immune system function, aid in digestion, decreasing colonization and invasion by pathogenic organisms. The genera *Lactobacillus* and *Bifidobacterium* provide widely utilised probiotics. Additional bacteria that bear comparison are *Streptococcus thermophilus*, non-pathogenic *E. coli* strains, *Enterococcus*, *Bacillus*, and yeasts such *Saccharomyces boulardii*. [4].

According to studies, Lactic acid bacteria and probiotics are found to fortify and enhance the human immune system, making it more resistant to a wide range of illnesses. Probiotic cultures and lactic acid bacteria are potentially used in a variety of industrial applications, such as fermented food items, which can impact product features and serve as human health-promoting meals. Probiotics also have the important advantage of lowering cholesterol levels by reducing the absorption of cholesterol by precipitating cholesterol with free bile salts into bile acids. [5]. Furthermore, probiotics improve the body's ability to absorb minerals like calcium, which helps ward off disorders associated with a lack of certain minerals like osteoporosis. By creating different enzymes that aid in food digestion and synthesizing cofactors and vitamins (K and B), they also improve nutritional value.[6]

Additionally, probiotics have been shown to inhibit the growth of pathogenic bacteria by binding to intestinal epithelial cells, facilitating the production of mucins and reducing cell permeability. For instance, lactic acid bacteria inhibit pathogen growth by producing organic acids, which creates an acidic environment. Probiotics also stimulate the production of serum immunoglobin A (IgA) and plays a critical role in intestinal humoral immunity. [7]

Food Spoilage

Food deterioration is able to bring on by certain microorganisms that break down food ingredients, producing heat labile or stable toxins, strange smells due to adulteration and flavours. *Bacillus, streptococcus, Clostridium*, and *Pseudomonas* are commonfood spoilage microorganisms. Foodborne illness risk can rise when spoilage promotes the growth of microorganisms. Most of the food spoilage done by spore forming bacteria such as *Bacillus spp.* that tolerate high temperature. These Gram-Positive bacteria can grow in facultative temperature in the food items. Lactic acid bacteria group including *lactobacillus* and*Padiococcus*are useful in fermented foods. [9].In addition, street food which is usually consumed as ready to eat may play critical role in various health related issues.Foodborne illnesses are one of the primary issues connected to eating street food; they constitute a significant preventable public health issue

that has a significant impact on both health and the economy.[10]On other hand, food additives and ultra-processed food (UPFs) also play a critical role for causing serious intestinal infections including bowel disease and certain cancers. [11]

Antimicrobial Substances in Food

Numerous food contains natural antimicrobial substances such as enzymes, inhibitors etc. Coumarin, a colorless crystalline solid found in fruits & vegetableshave antimicrobial activity. The common coumarin analogues as antimicrobial agents include miconazole analogue, beta lactum derivatives, coumarin – sulphonamide derivatives etc. Cow milk & eggs are also rich in antimicrobial substances. Eggs are rich in an enzyme called lysozyme. Lysozyme is a bacterial cell wall-degrading enzyme. Herbs and spices are rich in varieties of antimicrobial compounds, which are given in tabulated form.[12]

Table 1: Herbs & their Antimicrobial Agents

Herbs/spices	Antimicrobial agent
Garlic	Allicin
Cloves	Eugenol
Basil	Rosmarinic acid

Table 2: Microbes in Food

Sl. No.	Bacteria	Common source	Disease	Reference
1.	***Aeromonas sp***	Contaminated water and seafood.	Gastroenteritis and diarrhea	[18]
2.	***Bacillus cereus***	Rice, pasta, and other starchy foods that have been improperly stored or reheated.	Food poisoning	[19]
3.	***Brucella spp.***	Unpasteurized dairy products and undercooked meat from infected animals.	Brucellosis	[20]
4.	***Campylobacter spp.***	Raw or undercooked poultry, unpasteurized milk, and contaminated water.	Campylobacteriosis	[21]
5.	***Clostridium perfringens***	Improperly canned or preserved foods, particularly home-canned products.	Clostridial food poisoning	[22]
6.	***Clostridium botulinum***	Improperly canned or preserved foods, particularly home-canned products.	Botulism	[23]

7.	***Cronobacters akazakii***	Powdered infant formula, milk, and tea.	Neonatal infections and severe foodborne illness	[24]
8.	***Escherichia coli (E. coli) O157***	Undercooked ground beef, contaminated raw vegetables, and unpasteurized juices.	Hemorrhagic colitis and Hemolytic Uremic Syndrome (HUS)	[24]
9.	***Enterococcus spp.***	Contaminated food, particularly undercooked meat and dairy products.	Gastrointestinal infections and other opportunistic infections	[25]
10.	***Listeria monocytogenes***	Ready-to-eat deli meats, unpasteurized dairy products, and soft cheeses.	Listeriosis	[26]
11.	***Mycobacterium bovis***	Unpasteurized milk and dairy products from infected cattle.	Tuberculosis (Bovine TB)	[27]
12.	***Pseudomonas spp.***	Contaminated water, fresh produce, and processed foods.	Spoilage of food and opportunistic infections	[28]
13.	***Salmonella spp.***	Raw meat, poultry, eggs, unpasteurized milk, and other contaminated foods.	Salmonellosis	[29]
14.	***Shigella spp.***	Contaminated food, water, and surfaces, especially in conditions with poor hygiene.	Shigellosis	[30]
15.	***Staphylococcus aureus***	Improperly stored or handled foods, such as meats, dairy, and bakery products.	Food poisoning	[31]
16.	***Streptococcus spp.***	Contaminated milk, dairy products, and food handlers.	Streptococcal infections, including tonsillitis, scarlet fever, and foodborne illness	[32]
17.	***Vibrio cholerae***	Contaminated water and undercooked seafood.	Cholera	[33]
18.	***Vibrio parahaemolyticus***	Raw or undercooked seafood, particularly shellfish.	Vibrio infections	[19]
19.	***Vibrio***	Raw or undercooked seafood,	Vibrio	[19]

	vulnificus	especially oysters.	infections, including wound infections and septicemia	
20.	***Yersinia enterocolitica***	Pork, unpasteurized milk, and contaminated water.	Yersiniosis	[34]

List of Pathogenic Bacteria in Food Items in Tabulated Form

Milk Bacteriology

Milk is a balance, historically recognized high nutritional value food for mammals. Because of its nutritional richness, it is first food that provides necessary nutrients to ensure proper growth of infants, children & individual of all age groups. [13] Milk is good medium for microbial growth even pathogenic or non-pathogenic. Following table depict microbes in milk.

Table 3: Microbes in Milk

Properties	**Microbes**
Acid forming bacteria	*Lactobacilli, streptococcus lactis, streptococcus fecalis*
Gas forming bacteria	*Clostridium* species, coliform bacteria
Proteolytic bacteria	*Bacillus cereus, Staphylococcal* species
Inert bacteria (Produce no change in milk)	Achrobacters

Source of Bacteria in Milk

- Use of unsterilized milk equipment
- Unclean Milker's hand
- Milk ducts of udder
- Milk from unhealthy animal e.g. Tuberculosis
- Adulteration with contaminated water [14]

Pasteurisation

It is described as heating milk to a temperatures and durations necessary to eradicate any potential pathogens that may produce least alteration to its

composition, flavor, and nutritional value. The following three techniques can be used to produce pasteurization:

- **Holder Method:** During this procedure, milk is rapidly cooled to 5 °C after being maintained at 63–66 °C for at least 30 minutes.
- **HTST Method (High Temperature, Short Time):** This involves quickly cooling milk to 4 °C after heating it to 72 °C for roughly 15 seconds. This approach is currently the most widely used one and suitable for large quantity of milk.
- **Ultra High Temperature (UHT) Method:** Rapid heating in two stages at 125^0C & 145^0C for few seconds.

Pasteurisation destroys 90% of microbes in milk, including tubercle bacilli. It does not have microbial spores. [15]

III. BACTERIOLOGY OF AIR

In the natural environment, air is present everywhere, and it is the basic need for life on earth. However, microorganisms are also ubiquitous in nature, these mixed with the air and known as bio aerosols particularly bacteria, viruses, fungi and their spores. Because they are the main living components in the air, atmospheric microorganisms (which include bacteria, fungus, viruses, and pollen) also need to be given more attention in atmospheric research because of their prevalence and the large variations in their abundances that occur under various climatic conditions. [16]

Bacteria are the commonest microorganisms, it can be released into the air from soil water bodies, plants and animals such as *Pseudomonas, Bacillus and Clostridium sp.* and so on. Furthermore, activities by human beings such as coughing, sneezing, talking and even breathing can release the bacteria into the air. Some bio aerosols cause infections and through these many healths related issues develop such as physiological changes especially in the lung infections like tuberculosis (*Mycobacterium tuberculosis*). Sometimes risk of respiratory diseases including coughing, sneezing, throat infection and allergic rhinitis. Meanwhile, many airborne bacteria are harmless to human beings but may still affect environmental conditions and contribute to bio aerosol formation. Biological aerosols were reported to make up approximate 10% of the total suspended particle mass and about 25% of atmospheric particles. In addition, the contribution of bio aerosols to indoor particulate matter air pollution was predicted to range from 5 to 30%. [17]

IV. HEALTH IMPLICATION OF AIR BACTERIA

Almost bacterial infections like respiratory infections are caused by bacteria present in air and the situation become more critical when a healthy individual may be influenced with hospital environment where pathogens load are higher. A high bacterial load was discovered when comparing the research region to other indoor air biological standards. Researchers investigated that *Staphylococcuc aureus* and coagulase-negative *Streptococcus* are predominated bacterial isolates. [17]. There are number of bacteria like *Streptococcus pneumoniae, Streptococcus pyogenes, Mycoplasma pneumoniae, Haemophilus influenzae, Klebsiellapneumoniae, Pseudomonas aeruginosa,* and *Mycobacterium tuberculosis* etc present in air and may cause infection in an immuno-compromised individual.[16]

According to studies, bacterial load isolated from household's kitchen may vary from pathogenic to nonpathogenic. Bacterial species such as *Micrococcusspp*., *Psudomonas spp. Paenibacillus spp., Salmonella spp*., and *Bacillus spp*. are found in air in which *Bacillus species* and *Salmonella spp*., are pathogenic to human being by causing food spoilage and typhoid fever. Some opportunistic pathogen may also cause harmful infection mostly in immunocompromised host. [18] Here are a list of pathogenic airborne pathogenic bacteria that are clinically important and causing variety of infections in humans.

Table 4: List of Common Pathogenic Bacteria of Air in Tabulated Form

Sl. No.	Bacteria	Infection Cause	Reference
1.	***Acinetobacter baumannii***	Associated with Nosocomial infection	[35]
2.	***Neisseria meningitidis***	Meningococcal meningitis and septicemia	[36]
3.	***Klebsiella pneumoniae***	Causing pneumonia	[37]
4.	***Pseudomonas aeruginosa***	Respiratory infections, especially in immunocompromised individuals.	[38]
5.	***Staphylococcus aureus MRSA (Methicillin-resistant Staphylococcus aureus)***	Skin infections, pneumonia, and other serious conditions.	[39]
6.	***Corynebacterium***	Diphtheria	[40]

	diphtheriae		
7.	***Bacillus anthracis***	Anthrax	[41]
8.	***Streptococcus pneumoniae***	Pneumonia, meningitis	[42]
9.	***Mycobacterium tuberculosis***	Tuberculosis (TB)	[43]
10.	***Haemophilus influenzae***	Respiratory tract infections, including pneumonia, bronchitis and meningitis.	[44]
11.	***Bordetella pertussis***	Whooping cough	[45]
12.	***Mycoplasma pneumoniae***	Atypical pneumonia	[46]
13.	***Chlamydia pneumoniae***	Pneumonia and bronchitis	[47]
14.	***Clostridium difficile***	Diarrhea and colitis	[48]
15.	***Streptococcus pyogenes***	Throat infection, scarlet fever, and skin infections like impetigo	[49]
16.	***Moraxella catarrhalis***	Respiratory tract infections	[50]

Bacteriological Examination of Air

Human respire about 15 m^3 air in a day. The microbial content of air depends on population density of human and animal, vegetation & environmental conditions (temperature, rain, humidity, wind etc) in a particular area. Bacteriological examination is essential for surgical theaters, pharmaceutical and food industries, hospital wards, ICUs etc.

Methods of Bacteriological Examination of Air

- **Settle Plate Method:** This is more primitive method for sampling airborne microbes.
  The nutrient agar and blood agar plates are exposed for half to one hour. Heavy dust particles containing large bacteria settle over the surface of the medium. The incubation is done at 37 ° C for 24 hours. Colonies are counted. Blood agar plates are used for pathogenic staphylococci and streptococci. This method can be used for testing air in surgical operations theatres and other wards of hospitals.

- **Slit Sampler Method:** Slit sampler method determines the number of bacteria present in a measured volume of air. One cubic foot volume of air is allowed on to a plate packed with culture medium through a slit 0.25 mm wide. Plate is rotated mechanically to distribute the organisms evenly on the medium. Culture media are incubated and the colonies are counted. The number of colonies reflects the number of bacteria present in the air.

Bacterial count should not increase the limit of 50 per cubic foot in industries, homes & work place. The upper limit is 10 per cubic foot in general surgical theaters& 1 per cubic foot for neurological theaters. [53]

V. CONCLUSION

The bacteriology of food is the complex interaction between bacteria and food products, so the importance of understanding monitoring and controlling bacterial contamination is to ensure food safety and public health. The need for strict hygiene practices throughout the food production and supply chain is important to prevent bacterial contamination. Regularities standards of food safety and health authorities to minimize the risk of material infections can be done by advancement in microbiological techniques, such as rapid detection methods to improve food safety. Highlighting the significance of identifying the controlling common pathogens that can cause severe illnesses. Moreover, the importance of educating people about proper food handling, storage and preparation to diminish the risk of bacterial contagion at the domestic level is important.

For removing the pathogenic airborne bacteria, we should monitor them in hospitals and clinics to prevent the spread of infections. Air quality control system and regular testing helps to minimize the risk of airborne transmission. These airborne bacteria can be collected using air samples that capture particles on filters or in liquid media. The samples are then analyzed using culture-based methods, microscopy or molecular techniques like PCR. Further, high efficiency particulate air filters (HEPA) can remove bacteria from the air, improve the air quality in home, workplace and healthcare facilities. Moreover, proper ventilation produces the concentration of airborne bacteria and lowers the risk of transmission in crowded or enclosed spaces. Time to time regular cleaning with disinfections and proper waste disposal help to reduces the sources of airborne bacteria particularly with the high human activities.

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