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5. Food Microbiology

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5.1 General Principles of Food Microbiology:

- Microorganisms are present everywhere on earth, which includes humans, animals, plants and other living creatures, soil,water and atmosphere.

Microbes are also an important and essential component of an ecosystem. Molds and bacteria play key roles in the cycling of important nutrients in plant nutrition particularly those of carbon, nitrogen and Sulphur.

- Food microbiology is the study of microorganisms, which have both beneficial and deleterious effects on the quality, and safety of raw and processed meat, poultry, and egg products.

Microbiology is important to food safety, production, processing, preservation, and storage. Microbes such as bacteria, molds, and yeasts are employed for the foods production and food ingredients such as production of wine, beer, bakery, and dairy products. Specifically, areas of interest which concern food microbiology are food poisoning, food spoilage, food preservation, and food legislation. Studies in animal models that determine the responses of probiotic microorganisms in the gastrointestinal tract.

- Fundamental physiology and gene expression studies of food/ beverage microorganisms, unless they directly relate to the food/ beverage ecosystem; The isolation and characterization of antimicrobial substances such as essential oils, bacteriocins etc., unless their efficacy is tested and validated in the food/beverage ecosystem; Development of new methods for the analysis of microorganisms, unless the method is tested and validated in the food/beverage ecosystem.

5.2 Overview of Beneficial Microorganisms and Their Role In Food Processing And Human Nutrition:

- Beneficial microorganisms are those used in food fermentation to produce products such as cheese, fermented meat (pepperoni), fermented vegetables (pickles), fermented dairy products (yoghurt), and ethnic fermented products such as sauerkraut, idli and kimchi. In fermented products (produced by natural or controlled fermentation), microorganisms metabolize complex substrates to produce enzymes, flavor compounds, acids, and antimicrobial agents to improve product shelf-life and to prevent growth of pathogens and to provide product attributes. Microorganisms employed by the food industry include bacteria, yeasts, and molds. Differ morphologically and physiologically according to which the media, fermentation methods and the downstream processes vary. Advantages of microbial fermented food products: Extended shelf-life, nutritional benefit, Enhancement of sensory characteristics.

- Microorganisms with their enzymes, also breakdown indigestible compounds to make the product more palatable and easy to digest. Examples of beneficial microorganisms are *Lactobacillus acidophilus, Lactobacillus arabinosus, Lactobacillus lactis, and Pediococcus cerevisiae.*

Food spoilage microorganisms are those which upon growth in a food, produce undesirable flavour (odour), texture and appearance, and make food unsuitable for human consumption. Sometimes uncontrolled growth of many of the beneficial microorganisms can also cause spoilage.

Table 5.1: Fermented Dairy Products

Name	**Micro flora**
Srikhand (chakka)	*L. delbrueckii subsp. bulgaricus.*
Lassi	*S. salivarius subsp. thermophilus,*
Yoghurt	*S, salivarius subsp.thermophilus, L. delbrueckii subsp.*
butter milk	*lactic subsp. diacetylactis,*

Table 5.2: Commercially Produced Secondary Metabolites

Secondary Metabolite	**Microorganism**
Penicillin	*Penicillium chrysogenum*
Streptomycin	*Streptomyces griseus*
Cyclosporin A	*Tolypocladium inflatum*

Table 5.3: Commercially Produced Enzymes

Microorganism	**Enzyme**
Saccharomyces cerevisiae	Invertase
Mucor pusillus	Microbial rennet
Trichoderma reesii	Cellulase
Saccharomycopsis lipolytica	Lipase
Aspergillus niger	Glucoamylase

5.3 Over View of Sources Of Microorganisms In Food Chain (Water And Air):

- Water can support the growth of many types of microorganisms. This can be advantageous. For example, the chemical activities of certain strains of yeasts provide us with beer and bread. As well, the growth of some bacteria in contaminated water can help digest the poisons from the water. Water microbiology is concerned with the microorganisms that live in water, or can be transported from one habitat to another by water. The presence of other disease causing microbes in water is unhealthy and even life threatening. For example, bacteria that live in the intestinal tracts of humans and other warm blooded animals, such as *Escherichia coli*, *Salmonella*, *Shigella*, and *Vibrio*, can contaminate water if feces enters the water.

- **Drinking Water as a Vehicle of Diseases:** Water is essential to life. An adequate, safe and accessible supply must be available to all. Improving access to safe drinking-water can result in significant benefits to health. Every effort should be made to achieve a drinking water quality as safe as possible. Many people struggle to obtain access to safe water. A clean and treated water supply to each house may be the norm. According to the WHO, the mortality of water associated diseases exceeds 5 million people per year. From these, more that 50% are microbial intestinal infections, with cholera standing out in the first place

Table 5.4: The most important bacterial diseases transmitted through water

Disease	**Causal bacterial agent**
Cholera	*Vibrio cholerae,* serovarieties O1 and O139
Gastroenteritis caused by vibrios	Mainly *Vibrio parahaemolyticus*
Bacillary dysentery or shigellosis	*Shigella dysenteriae*
Acute diarrheas and gastroenteritis	*Escherichia coli*

- **Air microbiology:** Is a scientific discipline that concerns the microorganisms, including bacteria, archaea, fungi and viruses, in the atmospheric air. It is a subdiscipline of environmental microbiology. Biological aerosols as a human hazard source. What types of dangers are connected to the presence of microorganisms in air? Infectious diseases (viral, bacterial, fungal and protozoan), Allergic diseases, Poisoning (exotoxins, endotoxins, mycotoxins). Bioaerosols may carry microorganisms other than those which evoke respiratory system diseases. The intestinal microorganisms contained in aerosols may, after settling down, get into the digestive system (e.g. by hands) causing various intestinal illnesses.
- **Infectious airborne diseases:** The mucous membrane of the respiratory system is a specific type of a 'gateway' for most airborne pathogenic microorganisms. Susceptibility to infections is increased by dust and gaseous air-pollution, e.g. SO2 reacts with water that is present in the respiratory system, creating H2SO4, which irritates the layer of mucous. Consequently, in areas of heavy air pollution, especially during smog, there is an increased rate of respiratory diseases. Bioaerosols may, among other things, carry

microbes that penetrate organs via the respiratory system. After settling, microbes from the air, may find their way onto the skin or, carried by hands, get into the digestive system (from there, carried by blood, to other systems, e.g. the nervous system).

5.4 Primary Sources of Microorganisms in Food:

- From the meat and poultry regulatory perspective, we will be addressing bacteria as a main source of food contamination. Keep in mind that there are other microorganisms like viruses, parasites, fungi, etc., that are able to contaminate food and cause food borne illnesses in animals and humans. Bacteria can be found virtually everywhere including humans and can enter food products through different routes. The following list outlines some of the most common ways in which microorganisms enter food products.
- Soil, water, and establishment environment: Many bacteria are carried in soil and water, which may contaminate food. In addition, the establishment environment is an important source of contamination because of the daily activities and pest infestation. *Listeria, Clostridium, Salmonella, and Escherichia* are good examples.
- **Animal feeds:** This is a source of salmonellae to poultry and other farm animals. It is a known source of Listeria monocytogenes to dairy and meat animals when fed silage. The organisms in dry animal feed are spread throughout the animal environment and may be expected to occur on animal hides, hair, feathers, etc.
- **Animal Hides:** The hide is a source of bacterial contamination of the general environment, hands of establishment employees, and skinned carcasses. Studies have shown that this may be a primary source for *E. coli O157:H7, Salmonella*, and *Listeria* in cattle.
- **Gastrointestinal Tract:** The intestinal biota consists of many organisms; notable among these are pathogens such as *Salmonella*, *Campylobacter*, *E. coli O157:H7*, and other microorganisms. Any or all of the *Enterobacteriaceae* may be expected in feces of livestock and poultry.
- **Food Handlers:** The microbiota on the hands and outer garments of handlers generally reflect the environment and habits of individuals (hygiene), and the organisms in question may be those from hides, gastrointestinal tracts, soil, water, dust, and other environmental sources.

5.5 Over View of Food Borne Pathogens:

Following is a list of three types of pathogens and infectious agents of public health concern

- **Gram Positive:**
  Listeria monocytogenes, Staphylococcus aureus, Bacillus cereus, B. anthracis, Clostridium botulinum, C. perfringens.
- **Gram Negative:**
  Salmonella spp, Campylobacter spp, Escherichia coli 0157:H7, Yersinia enterocolitica, Brucella spp
- **Viruses:**
  Hepatitis, Rotaviruses, Tapeworms, *Taenia spp*, Roundworms: *Trichinella spp*, Protozoa: -*Toxoplasma spp* -*Sarcocystis spp*.

5.6 Microbial Food Spoilage and Food Borne Diseases:

Food to become contaminated as it is produced and prepared. Many food borne microbes are present in healthy animals (usually in their intestines, hides, feathers, etc) raised for food. Meat and poultry carcasses can become contaminated during slaughter by contact with small amounts of intestinal contents or poor dressing procedures. Also, it has been shown scientifically that some Salmonella serotypes can infect a hen's ovary in such a manner that the internal contents of a normal looking egg can be contaminated with Salmonella even before the shell is formed.

In food processing, food borne microbes can be introduced from infected humans who handle the food, or by cross contamination from some other raw agricultural product and/or the establishment environment. For example, the unwashed hands of food handlers who are themselves infected can introduce bacteria and viruses. In the kitchen, microbes can be transferred from one food to another food by using the same knife, cutting board or other utensil to prepare both without washing the surface or utensil in between. The way that food is handled after it is contaminated can also make a difference in whether or not an outbreak occurs. Many microorganisms need to multiply to a larger number before enough are present in food to cause disease.

Given warm moist conditions and an ample supply of nutrients, one bacterium that reproduces by dividing itself every half hour can produce 17 million progeny in 12 hours. As a result, lightly contaminated food left out overnight can be highly infectious by the next day. If the food were refrigerated promptly, the bacteria would not multiply at all or at a very slow rate.

Microorganisms can cause a variety of effects in food products including spoilage, which primarily affects product quality, and food poisoning, which is generally caused by pathogens. As regulators, we are most concerned with the effects that microorganisms have on food that leads to food borne illness, because this affects public health.

A food borne illness (or disease) is exactly what the term indicates - a disease or illness caused by the consumption of contaminated foods or beverages. It would seem rather obvious that a food borne microbial pathogen, or a preformed microbial toxic product, or another poison such as a poisonous chemical that has somehow contaminated the food and/or beverage, leads to one of the many different food borne illnesses. There is no one "syndrome" that is representative of food borne illness/disease. Different diseases have many different symptoms. However, the microbe or toxin enters the body through the gastrointestinal tract, and often causes the first clinical signs such as nausea, vomiting, abdominal cramps and diarrhea, which are common symptoms in many food borne diseases.

5.7 General Principles and Techniques in Microbiological Examination of Foods:

Microbiological quality of foods: FOOD microbiology as applied to food processing uses microbial inoculants to enhance properties such as the taste, aroma, shelf-life, texture and nutritional value of foods. It may be necessary to carry out a microbiological examination of a food for one or more of a number of reasons. The determination of the microbiological quality of a food or food constituent may be required in order to estimate its shelf-life or its suitability for human consumption. Microbiology techniques are methods used for the study of microbes, including bacteria and microscopic fungi and protists.

They include methods to survey, culture, stain, identify, engineer and manipulate microbes.

5.8 Common Test Methods:

- Culture Media.
- Immunoassay.
- Polymerase chain reaction.

5.9 References:

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