MICROORGANISMS IN FOOD

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1. Introduction

Food serves as growth medium for different kinds of microorganisms. Microorganisms enter into food and grow as contaminants or intended additions. Growth of microorganisms in food may spoil food quality or improve depending on the types of microorganisms and the changes they bring about. Food are assessed for their quality in terms of physical, chemical, sensory and microbiological characteristics. Microbiological characteristics are assessed in terms of the microorganisms present in food, their characters, ability to change the quality, their influence on health of consumer.

It is necessary for food microbiologists to become acquainted with the microorganisms important in food at least to the extent that will enable them to identify the main types with their characteristics. Important microorganisms associated with food are bacteria, molds, yeasts and some viruses. Knowledge of general characters and primary identification methods is necessary for the people working with food microbiology.

2. Primary sources of microorganisms found in foods

Soil and Water. These two environments are placed together because many of the bacteria and fungi that inhabit both have a lot in common. Soil organisms may enter the atmosphere by the action of wind and later enter water bodies when it rains. They also enter water when rainwater flows over soils into bodies of water.

Plants and Plant Products. It may be assumed that many or most soil and water organisms contaminate plants. However, only a relatively small number find the plant environment suitable to their overall well-being. Those that persist on plant products do so by virtue of a capacity to adhere to plant surfaces so that they are not easily washed away and because they are able to obtain their nutritional requirements.

Food Utensils. When vegetables are harvested in containers and utensils, one would expect to find some or all of the surface organisms on the products to contaminate contact surfaces. As more and more vegetables are placed in the same containers, a normalization of the microbiota would be expected to occur. In a similar way, the cutting block in a meat market along with cutting knives and grinders are contaminated from initial samples, and this process leads to a buildup of organisms, thus ensuring a fairly constant level of contamination of meat-borne organisms.

Gastrointestinal Tract. The intestinal biota consists of many organisms that do not persist as long in waters as do others, and notable among these are pathogens such as salmonellae. Enterobacteriaceae members may be expected in fecal wastes, along with intestinal pathogens.

Food Handlers. The microbiota on the hands and outer garments of handlers generally reflect the environment and habits of individuals, and the organisms in question may be those from soil, water, dust, and other environmental sources. Additional important sources are those that are common in nasal cavities, the mouth, and on the skin, and those from the gastrointestinal tract that may enter foods through poor personal hygiene practices.

Animal Feeds. This is a source of salmonellae to poultry and other farm animals. In the case of some silage, it is a known source of *Listeria monocytogenes* to dairy and meat animals. The organisms in dry animal feed are spread throughout the animal environment and may be expected to occur on animal hides.

Animal Hides. In the case of milk cows, the types of organisms found in raw milk can be a reflection of the biota of the udder when proper procedures are not followed in milking and of the general environment of such animals. From both the udder and the hide, organisms can contaminate the general environment, milk containers, and the hands of handlers.

Air and Dust. Although most of the organisms found in air and dust in a food-processing operation, the ones that can persist include most of the Gram-positive organisms. Among fungi, a number of molds may be expected to occur in air and dust, along with some yeasts. In general, the types of organisms in air and dust would be those that are constantly reseeded to the environment.

3. Common foodborne bacteria

Bacteria are unicellular microorganisms with small cell size ranging from 0.5-1 μm width and 1-5 μm length. Several bacteria are spherical in shape called cocci with a diameter of 0.5-1 μm. Several other bacteria are with different morphological structures like, oval, rod, comma, spiral and spring like shapes. Bacteria grow on wide range of nutrients starting from simple elemental nutrients to complex animal fluids like foetal calf serum. Majority bacteria are useful to human welfare and some are harmful causing different infectious diseases. These are also important food contaminants and agents of food borne diseases and food poisoning. It is necessary to know about these organisms. Some of the common bacteria are as follows:

Acinetobacter. Gram-negative rods show some affinity to the family Neisseriaceae. They are strict aerobes that do not reduce nitrates. Although rod-shaped cells are formed in young cultures, old cultures contain many coccoid-shaped cells. They are widely distributed in soil and water and may be found on many foods, especially refrigerated fresh products.

Aeromonas. These are typically aquatic Gram-negative rods formerly in the family Vibrionaceae but now in the family Aeromonadaceae. As the generic name suggests, they produce copious quantities of gas from the fermented sugars. They are normal inhabitants of the intestines of fish, and some are fish pathogens.

Alcaligenes. Although Gram negative, these organisms sometimes stain Gram positive. They are rods that do not, as the generic name suggests, ferment sugars but instead produce alkaline reactions, especially in litmus milk. Nonpigmented, they are widely distributed in nature in decomposing matter of all types. Raw milk, poultry products, and fecal matter are common sources.

Arcobacter. They are Gram-negative curved or S-shaped rods that are quite similar to the campylobacters except they can grow at 15°C and are aerotolerant. They are found in poultry, raw milk, shellfish, and water; and in cattle and swine products.

Bacillus. These are Gram-positive spore-forming rods that are aerobes in contrast to the clostridia, which are anaerobes. Although most are mesophiles, psychrotrophs and thermophiles exist. The genus contains only two pathogens: *B. anthracis* (cause of anthrax) and *B. cereus*. Although most strains of the latter are nonpathogens, some cause foodborne gastroenteritis.

Burkholderia . Gram-negative rods that occur on plants (especially certain flowers), in raw milk, and cause vegetable spoilage. They are significant pathogens in cystic fibrosis patients. They were formerly classified in the genus *Pseudomonas*.

Campylobacter. These Gram-negative, spirally curved rods were formerly classified as vibrios. They are microaerophilic to anaerobic.

Carnobacterium This genus of Gram positive, catalase-negative rods were formed to accommodate some organisms previously classified as lactobacilli. They are heterofermentative, and most grow at 0°C and none at 45°C. Gas is produced from glucose by some species. They are found on vacuum-packaged meats and related products, as well as on fish and poultry meats.

Clostridium. These anaerobic spore-forming rods are widely distributed in nature, as are their aerobic counterparts, the bacilli. The genus contains many species, some of which cause disease in humans (*C. perfringens* causes food poisoning and botulism). Mesotrophic, psychrotrophic, and thermophilic species exist; they are important in the thermal canning of foods.

Corynebacterium. This is one of the true coryneform genera of Gram-positive, rod-shaped bacteria that are sometimes involved in the spoilage of vegetable and meat products.

Escherichia. This is clearly the most widely studied genus of all bacteria. Some strains known to cause foodborne gastroenteritis.

Flavobacterium. These Gram-negative rods are characterized by their production of yellow to red pigments on agar and by their association with plants. Some are mesotrophs, and others are psychrotrophs, where they participate in the spoilage of refrigerated meats and vegetables.

Hafnia. These Gram-negative enteric rods are important in the spoilage of refrigerated meat and vegetable products.

Lactobacillus. Gram-positive, catalase-negative rods that often occur in long chains. Although those in foods are typically microaerophilic, many true anaerobic strains exist, especially in the colon and the rumen. They typically occur on most, if not all, vegetables, along with some of the other lactic acid bacteria. Their occurrence in dairy products is common. Many fermented products are produced and are also common on refrigerator-stored, vacuum-packaged meats.

Listeria. This genus of six species of Gram-positive, nonsporing rods is closely related to *Brochothrix*. *L. monocytogenes* is known to cause listeriosis and common on dairy products.

Pantoea. This genus consists of Gram-negative, noncapsulated, nonsporing straight rods, most of which are motile by peritrichous flagella. They are widely distributed and are found on plants and in seeds, in soil, water, and human specimens.

Proteus. These enteric Gram-negative rods are aerobes that often display pleomorphism, hence the generic name. They are typical of enteric bacteria in being present in the intestinal tract of

humans and animals. They may be isolated from a variety of vegetable and meat products, especially those that undergo spoilage at temperatures in the mesophilic range.

Pseudomonas. These are typical soil and water bacteria and they are widely distributed among fresh foods, especially vegetables, meats, poultry, and seafood products. Although once the largest genus of foodborne bacteria, the genus has been delimited by the transfer of many former species.

Salmonella. All members of this genus of Gram-negative enteric bacteria are considered to be human pathogens.

Serratia. These Gram-negative rods that belong to the family Enterobacteriaceae are aerobic and proteolytic, and they generally produce red pigments on culture media and in certain foods, although nonpigmented strains are common. *Serratia liquefaciens* is the most prevalent of the foodborne species; it causes spoilage of refrigerated vegetables and meat products.

Staphylococcus. These Gram-positive, catalase-positive cocci include *S. aureus*, which causes several disease syndromes in humans, including foodborne gastroenteritis.

Stenotrophomonas. These Gramnegative rods are common inhabitants of plants and they have been recovered from soil, water, and milk.

Vibrio. These Gram-negative straight or curved rods are members of the family Vibrionaceae. Several former species have been transferred to the genus *Listonella.* Several species cause gastroenteritis and other human illness.

Yersinia. This genus includes the agent of human plague, *Y. pestis,* and at least one species that causes foodborne gastroenteritis

4. Common genera of foodborne molds

Molds are filamentous fungi that grow in the form of a tangled mass that spreads rapidly and may cover several inches of area in 2 to 3 days. The total of the mass or any large portion of it is referred to as *mycelium*. Mycelium is composed of branches or filaments referred to as *hyphae*. Those of greatest importance in foods multiply by ascospores, zygospores, or conidia. Some of the common fungi are as follows:

Alternaria. Septate mycelia with conidiophores and large brown conidia are produced. The conidia have both cross and longitudinal septa and are variously shaped. They cause brown to black rots of stone fruits, apples, and figs. Stem-end rot and black rot of citrus fruits are also caused by species/strains of this genus. This is a field fungus that grows on wheat. Additionally, it is found on red meats. Some species produce mycotoxins.

Aspergillus. Chains of conidia are produced. Where cleistothecia with ascospores are developed, the perfect stage of those found in foods. The aspergilli appear yellow to green to black on a large number of foods. Black rot of peaches, citrus fruits, and figs is one of the fruit spoilage conditions produced. They are found on country-cured hams and on bacon. Some species cause spoilage of oils, such as palm, peanut, and corn. *A. oryzae* and *A. soyae* are involved in the shogu fermentation and the former in koji. *A. glaucus* produces a fermented fish product. The *A. glaucus–A. restrictus* group contains storage fungi that invade seeds, soybeans, and common beans. Several species produce aflatoxins, and others produce ochratoxin A and sterigmatocystin.

Botrytis. Long, slender, and often pigmented conidiophores are produced. Mycelium is septate; conidia are borne on apical cells and are gray in color, although black, irregular sclerotia are sometimes produced. *B. cinerea* is the most common in foods. They are notable as the cause of gray mold rot of apples, pears, raspberries, strawberries, grapes, blueberries, citrus, and some stone fruits.

Fusarium. Extensive mycelium is produced that is cottony with tinges of pink, red, purple, or brown. Septate fusiform to sickle-shaped conidia (macroconidia) are produced. They cause brown rot of citrus fruits and pineapples and soft rot of figs. As field fungi, some grow on barley and wheat grains. Some species produce zearalenone, fumonisins, and trichothecenes.

Geotrichum It is variously referred to as "dairy mold" because it imparts flavor and aroma to many types of cheese, and as "machinery mold" because it builds up on food contact equipment in food-processing plants, especially tomato canning plants. They cause sour rot of citrus fruits and peaches and the spoilage of dairy cream. They are widespread and have been found on meats and many vegetables. Some participate in the fermentation of gari.

Mucor. It is found in fermented foods, bacon, and many vegetables. One species ferments soybean whey curd.

Penicillium. It has been involved in the spoilage of fruit juice concentrates. It produces heat-resistant spores. Typical colors on foods are blue to blue-green. Blue and green mold rots of citrus fruits and blue mold rot of apples, grapes, pears, and stone fruits, are caused by some species. One species, *P. roqueforti*, produces blue cheese. Some species produce citrinin, yellow rice toxin, ochratoxin A, rubratoxin B, and other mycotoxins.

Rhizopus. Nonseptate hyphae are produced that give rise to stolons and rhizoids. Sporangiophores typically develop in clusters from ends of stolons at the point of origin of rhizoids. *R. stolonifer* is by far the most common species in foods. Sometimes referred to as "bread molds," they produce watery soft rot of apples, pears, stone fruits, grapes, figs, and others. Some cause "black spot" of beef and frozen mutton. They may be found on bacon and other processed meats. Some produce pectinases, and *R. oligosporus* is important in the production of oncom, bongkrek, and tempeh.

Trichothecium. Septate hyphae that bear long, slender, and simple conidiophores are produced. *T. roseum* is the only species, and it is pink in color and causes pink rot of fruits. It also causes soft rot of cucurbits and is common on barley, wheat, corn, and pecans. Some produce mycotoxins.

5. Common genera of foodborne yeasts

Yeasts may be viewed as being unicellular fungi in contrast to the molds, which are multicellular; however, this is not a precise definition, as many of what are commonly regarded as yeasts actually produce mycelia to varying degrees. Some of the common yeast are as follows:

Brettanomyces. These ascosporogenous yeasts shows terminal budding, and produce acetic acid from glucose only under aerobic conditions. They cause spoilage of beer, wine, soft drinks, and pickles, and some are involved in after fermentation of some beers and ales.

Candida. Members of this genus are the most common yeasts in fresh ground beef and poultry, and *C. tropicalis* is the most prevalent in foods in general. Some members are involved in the

fermentation of cacao beans, as a component of kefir grains, and in many other products, including beers, ales, and fruit juices.

Debaryomyces. These ascosporogenous yeasts sometimes produce a pseudomycelium and reproduce by multilateral budding. They are one of the two most prevalent yeast genera in dairy products.

Kluyveromyces. These ascospore-forming yeasts reproduce by multilateral budding, and the spores are spherical. It is one of the two most prevalent yeasts in dairy products. *Kluyveromyces* spp. produce *β*-galactosidase and are vigorous fermenters of sugars, including lactose. *Kluyveromyces* spp. contains coenzyme Q and is involved in the fermentation of kumiss. It is also used for lactase production from whey and as the organism of choice for producing yeast cells from whey. They are found on a wide variety of fruits, and also cause cheese spoilage.

Pichia. This is the largest genus of true yeasts. *Pichia* spp. typically form films on liquid media and are known to be important in producing indigenous foods in various parts of the world. Some have been found on fresh fish and shrimp, and they are known to grow in olive brines and to cause spoilage of pickles.

Rhodotorula. These yeasts are anamorphs of Basidiomycetes. They produce pink to red pigments, and most are orange or salmon pink in color. The genus contains many psychrotrophic species that are found on fresh poultry, shrimp, fish, and beef. Some grow on the surface of butter.

Saccharomyces. These ascosporogenous yeasts multiply by budding and produce spherical spores in asci. All bakers', brewers', wine, and champagne yeasts are *S. cerevisiae*. They are found in kefir grains and can be isolated from a wide range of foods, such as dry-cured salami and numerous fruits.

6. Common viruses on foods

Viruses account for most food poisoning cases where a specific contaminant is found. Noroviruses (=Norwalk-like viruses, caliciviruses) are a group of viruses that cause a mild illness. It is the most common viral cause of adult food poisoning and is transmitted from water, shellfish, and vegetables contaminated by feces, as well as from person to person.

Rotavirus: It is the most common cause of food poisoning in infants and children and is transmitted from person to person by fecal contamination of food and shared play areas.

Hepatitis A: Causes moderate illness with sudden onset of fever, loss of appetite, abdominal pain, and feeling of tiredness followed by jaundice, which is a yellowing of the eyes and skin. It is transmitted from person to person by fecal contamination of food.

Conclusion: Except for a few sterile foods, all foods harbor one or more types of microorganisms. Some of them have desirable roles in food, such as in the production of naturally fermented food, whereas others cause food spoilage and foodborne diseases.