MICRO-ORGANISMS IMPORTANT IN FOOD MICROBIOLOGY

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Summary

In addition to natural microflora determined by type of plant or animal and environmental conditions, every food may be contaminated from outside sources on the way from the field to the processing plant, or during storage, transport and distribution. There are thousands of different types of micro-organisms everywhere in air, soil and water, and consequently on foods, and in the digestive tract of animals and human. Fortunately, the majority of micro-organisms perform useful functions in the environment and also in some branches of of food industry, such as production of wine, beer, bakery products, dairy products etc. On the other hand unwanted spoilage of foods

is generally caused by micro-organisms and contamination of food with pathogens causes food safety problems.

The micro-organisms occurring on and/or in foods are from a practical point of view divided into three groups: molds, yeast and bacteria. Molds are generally concerned in the spoilage of foods; their use in the food industry is limited (e.g. mold ripened cheese). Yeasts are the most widely used micro-organisms in the food industry due to their ability to ferment sugars to ethanol and carbon-dioxide. Some types of yeast, such as baker's yeasts are grown industrially, and some may be used as protein sources, mainly in animal feed.

Bacteria important in food micribiology may be divided into groups according to the product of fermentation, e.g. lactic acid bacteria, acetic acid bacteria, propionic acid bacteria.. Bearing in mind the food constituent attacked (used as food for micro-organisms), proteolytic, saccharolytic and lipolytic bacteria may be distinguished.

Their systematic classification is based primarily on morphological and physiological properties (e.g. aerobic and anaerobic bacteria, gas forming bacteria, etc.). Lactic acid bacteria are widely used in the dairy industry, and acetic acid bacteria in vinegar production. Many bacteria are known as micro-organisms that cause spoilage and some are pathogens (e.g.salmonellae, staphylococci, etc.).

1. Introduction

Both foods of plant and animal origin normally carry a microflora on the surface of their parts. Animals also have an intestinal microflora. Both animals and plants may also become contaminated from outside sources. The inner, healthy tissues of plants and animals, however, have been reported to contain few living micro-organisms, or none.

The fruit or vegetable is harvested, milk is drawn, fish and other products are obtained from natural waters, and animals are collected and slaughtered—all carrying their usual microflora. After initial handling, further contamination begins and it continues while the product is being processed and prepared.

Foods may be contaminated by each other and by pieces of equipment with which they come in contact. Air, dust, water, and ingredients may add their quota of contaminants. Whenever food is handled personally by human beings, there is always the possibility of addition of human pathogens. (Sources of microbial contamination of foods are treated in detail in *Spoilage and Preservation of Food*).

In the framework of this article a brief overview will be given about micro-organisms that play an important role in production, storage and consumption of foods. Their occurrence, characteristics used for identification, conditions of growth and eventual industrial use will be treated (foodborne pathogens will be discussed in a separate chapter *Foodborne Diseases*).

Micro-organisms will be discussed in three arbitrary groups, normally used by food microbiologists: molds, yeasts and bacteria.

2. Molds

The term ***mold*** is applied to certain multicellular, filamentous fungi whose growth on foods is usually readily recognized by its fuzzy or cottony appearance. Generally molds are concerned in the spoilage of foods; moldy or mildewed food is considered unfit to eat. On the other hand some of molds are used in manufacture of different foods and are ingredients of some foods. Some kinds of cheese are mold-ripened (e.g. Roquefort, Camembert). Molds are grown as feed and food and are employed to produce products used in foods, such as amylases and other enzymes for bread making or citric acid used in soft drinks. Molds are major contributors in the ripening of many oriental foods. A species of *Bothrytis cinerea,* is responsible for the noble rot of grape. Molds are used for production of several antibiotics.

2.1. Morphological Characteristics

The gross appearance of a mold growing on a food is often enough to indicate its genus. Some molds are fluffy, others are compact. Some look velvety on the upper surface, some dry and powdery, and others wet or gelatinous. Pigments in the mycelium—red, purple, gray, black, etc.—are also characteristic. Some molds are restricted in size, but others seem limited only by the food or container.

Macroscopically the mold consists of a mass of branching, interwined filaments called *hyphae (*singular hypha), and the whole mass of these hyphae is known as a *mycelium.* Hyphae may be classed as *vegetative* or *fertile* based on their biological function. The vegetative hyphae or growing hyphae are concerned with the nutrition of the mold and the fertile ones with the production of reproductive parts. The hyphae of some molds are full and smooth, but the hyphae of others are characteristically thin and ragged. A few kinds of molds produce *sclerotia* (singular sclerotium) which are tightly packed masses of hyphae, often thick-walled, within the mycelium. These sclerotia are considerably more resistant to heat and other adverse conditions than the rest of the mycelium and for this reason may be important in some processed food products.

With microscopic study, further details of molds may be recognized. In the group of molds called *septate* the hyphae are divided by cross-walls into cells. The hyphae of the *nonseptate* group consist apparently of cylinders without cross walls.

The reproductive parts or structures of molds are the *spores*, which are mainly asexual. Such spores are produced in large numbers and are readily spread by air. Spores that settle on favorable substrates can initiate a new phase of growth and develop into a new mycelium.

2.2. Physiological Characteristics

In general, molds require less moisture than bacteria and yeasts. Molds differ considerably among themselves as to optimum water activity and range of water activity for germination of spores. The minimum water activity for spore germination has been found to be as low as 0.62 for some molds and as high as 0.93 for others. Each mold has an optimum of water activity and a range of water activity for growth. The reduction of water activity below the optimum for a mold delays the germination of the spores and reduce the growth rate.

Most molds grow well at ordinary room temperatures and are classified as *mesophilic*. The optimum is for most molds between 25 and 30 ^{o}C. Nevertheless it should be noted that some molds grow fairly well at temperatures of freezing or just above, and others can grow slowly at sub-zero temperatures.

Molds require free oxygen for growth. This is why molds grow on the surface of contaminated food. Most molds grow over a wide range of pH, but some are favored by acid foods such as the majority of fruits.

2.3. Classification of Molds and Molds of Industrial Importance.

It is beyond the scope of this article to discuss in detail the complicated system of classification of molds. In the following only genera of industrial importance will be shortly overviewed.

Genus ***Mucor*** (*Mucor racemosus, Mucor rouxii).* Mucors are involved in the spoilage of some foods and in the manufacture of others e.g. oriental fermented foods.

Genus ***Rhizopus.*** *Rhizopus nigricans,* sometimes called „bread mold", is very common and is involved in the spoilage of many foods such as berries, fruits, vegetables, bread, etc.

Genus ***Aspergillus.*** The members of this genus are very widespread. Many are involved in the spoilage of foods and some are useful in preparation of fermented foods. Many groups and hundreds of aspergillus species are known. *Aspergillus niger* is the leading species important for food microbiologists. Selected strains are used for commercial production of citric and gluconic acids.

Genus ***Penicillium.*** This is another widespread genus important in foods. *Penicillium expansum*, a green spored species, causes soft rot of fruits. *Penicillium camemberti* with grayish conidia, useful in the ripening of Camembert cheese, and *Penicillium roqueforti*, used in ripening of blue cheeses, are also weel known members of this genus.

Genus ***Bothrytis.*** The species *Bothrytis cinerea* causes the noble rot of grape in some wine producing areas such as Tokay (Hungary).

Genus ***Alternaria.*** Molds of this genus are common causes of the spoilage of foods. *Alternaria citri*, *Alternaria tenuis* and *Alternaria brassicae* are the common species.

Genus ***Neurospora (Monilia).*** The species of this genus grow on various foods.

2.4. Citric Acid Production by Fungi

Since the early demonstration by Wehmer in 1893 of the presence of citric acid in culture media containing sugar and inorganic salts with species of *Penicillium*, a variety of fungi were screened for citric acid production. At present *Aspergillus niger* is most commonly used for industrial production of citric acid. Normally the strains of *Aspergillus niger* need a fairly high initial concentration (16-18%) of sugars in the medium. A higher concentration leads to greater amounts of residual sugar, making the process uneconomic. On the other hand, lower sugar concentration means lower yield as well as accumulation of oxalic acid. When molasses is used, it is diluted to a sugar content of 16-20% and adjusted to pH of 5.5 to 6.5. Nitrogen sources are assured by inorganic salts (e.g. ammonium nitrate). Addition of phosphate is also common.

The citric acid fermentation is an aerobic fermentation, thus a satisfactory oxygen supply is essential. Citric acid is precipitated from filtered fermentation liquor in the form of calcium citrate. The filtered and washed calcium citrate is treated with sulfuric acid. After removal of calcium sulfate the citric acid containing liquid is purified and then concentrated in a vacuum and finally crystallized.

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Biographical Sketch

Radomir Lasztity D.Sc. is a Professor of the Department of Biochemistry and Food Technology at Budapest University of Technology and Economics. He was born in 1929 in Deszk, Hungary. He received his M.Sc. degree in Chemical Engineering in 1951 and his D.Sc. degree in Chemical Science in 1968. He is honorary president of the International Association for Cereal Science and Technology (ICC) and deputy technical director. He was acting chairman of the Codex Committee on Methods of Analysis and Sampling of the FAO/WHO Food Standard Program in the period 1975 to 1988. Dr Lasztity is a member of the Food Chemistry Division of the Federation of European Chemical Societies., and a member of the editorial boards of several international scientific journals. Among other awards he has received the Bailey and Schweitzer Medal of the ICC, the State Prize of the Hungarian Republic, and the Golden Medal of the Czech Academy of Sciences. His main research activities are chemistry and biochemistry of food proteins, food analysis and food quality control. He has published more than 800 articles in Hungarian and overseas journals. He is the author/editor of more than twenty books and textbooks [*Chemistry of cereal proteins(1984, 2nd ed. 1996), Amino Acid Composition and Biological Value of Cereal Proteins (1985), Cereal Chemistry (1999), Use of Yeast Biomass in Food Production (1991), Gluten Proteins (1987)*].