##  Sengamala Thayaar Educational Trust Women’s College

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**FOOD MICROBIOLOGY AND SANITATION**

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**FOOD MICROBIOLOGY AND SANITATION**

**The Microbiology of Cereals and Cereal Products**

Cereals and cereal products are significant and important human food resources and livestock feeds worldwide. Cereal grains and legumes are food staples in many, if not most, countries and cultures and are the raw materials of many of our foods and certain beverages. The main cereal grains used for foods include corn (maize), wheat, barley, rice, oats, rye, millet, and sorghum. Soybeans are not a cereal product, but rather, are legumes or a pulse, but are often considered with cereals because of their importance as a food source.

Examples of cereal products derived from cereal grains include wheat, rye, and oat flours and semolina, cornmeal, corn grits, doughs, breads, breakfast cereals, pasta, snack foods, dry mixes, cakes, pastries, and tortillas. In addition, cereal products are used as ingredients in numerous products, such as batters and coatings, thickeners and sweeteners, processed meats, infant foods, confectionary products, and beverages such as beer.

Because of their extensive use as human foods and livestock feeds, the microbiology and safety of cereal grains and cereal products is a very important area. The sources of microbial contamination of cereals are many, but all are traceable to the environment in which grains are grown, handled, and processed. Microorganisms that contaminate cereal grains may come from air, dust, soil, water, insects, rodents, birds, animals, humans, storage and shipping containers, and handling and processing equipment. Many factors that are a part of the environment influence microbial contamination of cereals, including rainfall, drought, humidity, temperature, sunlight, frost, soil conditions, wind, insect, bird and rodent activity, harvesting equipment, use of chemicals in production versus organic production, storage and handling, and moisture control.

The microflora of cereals and cereal products is varied and includes molds, yeasts, bacteria (psychrotrophic, mesophilic, and thermophilic/thermoduric), lactic acid bacteria, rope-forming bacteria (*Bacillus spp.*), bacterial pathogens, coliforms, and Enterococci. Bacterial pathogens that contaminate cereal grains and cereal products and cause problems include *Bacillus cereus*, *Clostridium botulinum*, *Clostridium perfringens*, *Escherichia coli*, [*Salmonella*](http://www.cdc.gov/salmonella/), and *Staphylococcus aureus*. Coliforms and enterococci also occur as indicators of unsanitary handling and processing conditions and possible fecal contamination.

Bacteria are frequent surface contaminants of cereal grains. For bacteria to grow in cereal grains, they require high moisture or water activity (aw) in equilibrium, with high relative humidity. Generally, bacteria are not significantly involved in the spoilage of dry grain and become a spoilage factor only after extensive deterioration of the grain has occurred and high moisture conditions exist. However, bacterial pathogens and spoilage bacteria, such as spore-forming bacteria that cause ropiness in bread, may survive and carry through to processed products and become problems. Lactic acid bacteria may also be present in the raw grain and carry over into flour and cornmeal and spoil doughs prepared with them. Yeasts present on cereal grains may also carry through into processed products. The main spoilage organisms in cereal grains, however, are molds.



*click for large version*

**Figure 1.** The chemical structure of aflatoxin.

There are more than 150 species of filamentous fungi and yeasts on cereal grains. But again, the most important of these are the filamentous fungi or molds. The filamentous fungi that occur on cereal grains are divided into two groups, depending on when they predominate in grain in relation to available moisture in the grain. These groups have been referred to as field fungi and storage fungi. Field fungi invade grain in the field when the grain is high in moisture (18 to 30%, i.e., at high aw) and at high relative humidities (90 to 100%). Field fungi include species of *Alternaria*, *Cladosporium*, *Fusarium*, and *Helminthosporium*. Storage fungi invade grain in storage at lower moisture contents (14 to 16%), lower aw and lower relative humidities (65 to 90%). These main storage fungi are species of Eurotium, Aspergillus, and Penicillium. To prevent spoilage by storage fungi, the moisture content of starchy cereal grains should be below 14.0%, soybeans 12.0%, and other oilseeds, such as peanuts, and sunflower seeds, 8.5%. Certain molds, such as *Eurotium glaucus*, may initiate growth at low aw and moisture contents (i.e., 15 to 16% moisture) and through their respiration increase aw and raise the moisture content, facilitating molds to grow, thus ultimately leading to spoilage.

Food waste is one of the most prominent waste streams across Middle East, especially in GCC region.  The mushrooming of hotels, restaurants, fast-food joints and cafeterias in the Middle East region has resulted in the generation of huge quantities of food wastes. The proportion of food waste in municipal waste stream is gradually increasing and hence a proper food waste management strategy needs to be devised to ensure its eco-friendly and sustainable disposal in the Middle East.

Food waste is an untapped energy source that mostly ends up rotting in landfills, thereby releasing greenhouse gases into the atmosphere. Food waste includes organic wastes generated in hotels, restaurants, canteens, cafeterias, shopping malls and industrial parks in the form of leftover food, vegetable refuse, stale cooked and uncooked food, meat, teabags, napkins, extracted tea powder, milk products etc. It is difficult to treat or recycle food waste since it contains high levels of sodium salt and moisture, and is mixed with other waste during collection.

Food waste can be recycled by two main pathways:

* **Composting**: A treatment that breaks down biodegradable waste by naturally occurring micro-organisms with oxygen, in an enclosed vessel or tunnel or pit
* **Anaerobic digestion or biogas technology**: A treatment that breaks down biodegradable waste in the absence of oxygen, producing a renewable energy (biogas) that can be used to generate electricity and heat.

**Composting**

​​Composting provides an alternative to landfill disposal of food waste, however it requires large areas of land, produces volatile organic compounds and consumes energy. Compost is organic material that can be used as a soil amendment or as a medium to grow plants. Mature compost is a stable material with a content called humus that is dark brown or black and has a soil-like, earthy smell. It is created by: combining organic wastes (e.g., yard trimmings, food wastes, manures) in proper ratios into piles, rows, or vessels; adding bulking agents (e.g., wood chips) as necessary to accelerate the breakdown of organic materials; and allowing the finished material to fully stabilize and mature through a curing process.

**Anaerobic Digestion**

Anaerobic digestion has been successfully used in several European and Asian countries to stabilize food wastes, and to provide beneficial end-products. Sweden, Austria, Denmark, Germany and England have led the way in developing new advanced biogas technologies and setting up new projects for conversion of food waste into energy. The relevance of biogas technology lies in the fact that it makes the best possible utilization of various organic wastes as a renewable source of clean energy. A biogas plant is a decentralized energy system, which can lead to self-sufficiency in heat and power needs, and at the same time reduces environmental pollution.

Of the different types of organic wastes available, food waste holds the highest potential in terms of economic exploitation as it contains high amount of carbon and can be efficiently converted into biogas and organic fertilizer. Food waste can either be utilized as a single substrate in a biogas plant, or can be co-digested with organic wastes like cow manure, poultry litter, sewage, crop residues, abattoir wastes etc.