8 Cereals and cereal products

1 Introduction

Cereals are the most efficient human food source, in terms of both energy supply and nutrition. People of all races rely on cereals as their main staple diet, with more than half of the world’s population eating rice as their principal food. Therefore, producers, processors, the public and governmental authorities need to be aware of the spoilage, adulteration, and public health problems of these basic foods. This chapter covers only the major grains in commercial production, with less emphasis on small-scale farming and processing (Iizuka, 1957, 1958). For reviews of the microbiology of fermented Oriental and Indian cereal products see Hesseltine (1965, 1979) and Beuchat (1987). Cereals are also the basis for many animal feeds (see Chapter 4), but this chapter covers only human foods.

A Definitions

Cereals are the fruiting structure of a variety of grasses. The cereal grains discussed here include wheat, maize, oats, rye, rice, barley, millet, and sorghum. Fresh sweet corn, although technically a cereal, is treated as a vegetable in Chapter 5 because it is not used in dry form. These principal cereal products are utilized in several ways:

Flour is made by grinding cereals and is used in a variety of products.

Batter is a pourable mixture of flour, milk or water, and other ingredients such as sugar, salt, eggs, leavening agents, and fat. Batters are baked or cooked to produce cakes or muffins, or they are used to coat other foods such as meats, fish or vegetables.

Sponge is a batter to which yeast is added. In the sponge process, the yeast is allowed to work in a batter-like mixture before other ingredients are added.

Dough differs from batter in that it is stiff enough to be handled. In addition to the ingredients listed under batter, dough may contain bakers’ yeast.

Bread is produced by fermentation of dough with yeast to produce an aerated mix, which is then heated (baked) to produce a rigid, somewhat dried product. Some types of bread are produced without yeast, especially in the Middle East.

Pasta is produced from wheat flour, water, semolina, farina, and other ingredients mixed to form a stiff dough of about 30% moisture. The dough is extruded or rolled into a variety of shapes and forms. Some pasta is filled with meat or cheese mixtures. Pasta may be stored frozen or chilled, or dried at about 40°C to a 10–12% moisture level.

Noodles are a form of pasta containing added egg or egg yolk. Noodles are also made from rice.

Pastries are cakes muffins, donuts, and flaky products made from dough or batter and baked. Filled products are dough shells filled with custard, fruit, cream or imitation cream, honey, nuts, meats, spicy fillings or sauces, sometimes topped with sugar, fruit or meringue. Fillings may be fully cooked by baking with the casing (e.g. fruit pies) or cooked separately in bulk and filled into a baked casing (e.g. eclairs or cream pies) or spread onto a baked cake (e.g. cream cakes).

The principal microorganisms of concern are fungi and spore-forming bacteria.

Field fungi are found on or in grains at the time of harvest. Some are pathogenic on the grain and may cause blights, blemishes or discoloration, or produce mycotoxins. Few are able to grow below 0.90 \( a_w \).
Storage fungi invade grains after harvest, causing loss of quality, weight, germinability, and nutrient value. Most are xerophilic and some produce mycotoxins.

Invasive fungi are those that grow within the kernel of grains, and hence are important in causing deterioration. They are usually detected by surface sterilizing and direct plating of grains on suitable agar media.

Contaminant fungi are found superficially on grains, and are of little consequence unless the grain is ground into flour or used as a raw material without heat processing. They are usually detected by dilution plating techniques.

Bacteria of concern are spore-formers, which survive cooking, e.g. Bacillus cereus, and non-sporeformers such as salmonellae, which may contaminate grains and flour. Such species may grow in pasta doughs during manufacture, particularly if moisture distribution is uneven, resulting in wet spots.

B Important properties

Although cereals and cereal products provide a rich source of nutrients for microbial growth, the reduced water activity of cereals and cereal product prevents the growth of most bacteria. Cereals contain carbohydrates, protein, fat, and fiber (Table 8.1), as well as minerals and vitamins, especially the B group, D and E, and have a near-neutral pH.

Baked cereal products are rarely associated with bacterial foodborne illness. Temperatures required for structural functionality inactivate vegetative bacteria and fungi; therefore interior portions of baked products are essentially free from vegetative pathogens. Bacterial spores may survive cooking procedures, however, the baking process removes water from the product, which reduces the water activity, particularly on the surface. At these reduced water activities, products typically spoil owing to fungal growth before growth of pathogens occurs. Moist cereal products such as boiled rice, raw moist dough, and batters can support bacterial growth if not controlled appropriately. Extending shelf-life of baked products using techniques that inhibit fungal growth must be carefully studied to assure that growth of potential pathogens is controlled.

Fungi present a more significant problem for cereals in all parts of the world. Being more tolerant to reduced water activity than bacteria, fungi can grow and cause spoilage in a wide variety of cereal products. More significant is the ability of fungi to produce mycotoxins before harvest, during drying or during improper drying and storage.

C Methods of processing

Kent and Evers (1994) describe general methods used for cereal processing. Harvesting and milling are steps common to most cereal grains. Milled cereals are mixed with other ingredients and converted into a variety of products through baking, boiling, frying, extrusion and fermentation. These processes are described in greater detail in the individual product category sections.

### Table 8.1 Proximate analysis of representative food grains

<table>
<thead>
<tr>
<th>Cereal grain</th>
<th>Carbohydrate (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Fiber (%)</th>
<th>Water (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat (hard)</td>
<td>69.0</td>
<td>14.0</td>
<td>2.2</td>
<td>2.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Maize (dry)</td>
<td>72.2</td>
<td>8.9</td>
<td>3.9</td>
<td>2.0</td>
<td>13.8</td>
</tr>
<tr>
<td>Rice (brown)</td>
<td>77.4</td>
<td>7.5</td>
<td>1.9</td>
<td>0.9</td>
<td>12.0</td>
</tr>
<tr>
<td>Oats (rolled)</td>
<td>68.2</td>
<td>14.2</td>
<td>7.4</td>
<td>1.2</td>
<td>8.3</td>
</tr>
<tr>
<td>Rye</td>
<td>73.4</td>
<td>12.1</td>
<td>1.7</td>
<td>2.0</td>
<td>11.0</td>
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</tbody>
</table>