GRAINS, PULSES, AND OILSEEDS

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Summary

Because of the diversity of the modes of cereal use, their classification and quality indices are regulated according to the end-use of cereals.

1. Introduction

More than two-thirds of the cultivated area of the world is planted with grain crops. They have a high food value in a multitude of products, in which they are excellent sources of energy with relatively good sources of inexpensive protein, minerals, and vitamins. Cereals can be processed into many products acceptable throughout the world. Most developing countries rely on cereals as their major food sources, providing more than half the calories consumed for human energy and well over two-thirds of their total food. The grain legumes (including soybeans and ground nuts) are ranked fifth in terms of annual grain production after wheat, rice, maize, and barley. They have a special place in the human diet, particularly in developing countries, because they contain nearly two to three times more protein than cereals.

Although in many countries the role of animal fat is the most important fat in the diet, oilseeds (and fruit) are the main sources of oil (and fat) consumed by the world population. The growing production and industrial processing of cereals, pulses, and oilseeds, and the rapid development of trade of these agricultural crops has resulted in an increasing interest in quality, quality control, and standardization at both national and international levels. In the framework of this chapter, the quality indices of cereals and cereal products will be treated first, keeping in mind their importance and the wide variety of commercial, cereal-based food products.

2. Cereal Grains

2.1 General Aspects of Quality Evaluation

Because of the diversity of the modes of cereal use, their classification and quality indices are regulated according to the end-use of cereals. Among cereals, the classification and quality control of wheat is the most developed. However, many of the wheat quality indices are interesting also for quality evaluation of other cereal grains. The requirements concerning quality may be divided into two groups: (1) general (commercial), and (2) end-use. Among the indices of commercial classification are: the specific weight or test weight (kg/hl), the color, the 1000 kernel weight (g), the moisture content, the waste, and foreign kernels. In addition, the percentage of damaged, underdeveloped, immature, insect-damaged, and sprouted kernels is controlled. In accordance with requirements mentioned above, the tests of grain quality important to producers and consumers are plumpness, soundness, cleanness, dryness, purity of type, and general condition.

One of the most widely used and simplest criteria of grain quality is the weight of the grain per unit of volume. In most countries using the metric system, the weight is expressed in kilograms per hectoliter. In the US and Canada, it is expressed as pound per bushel. Test weight is important for the farmer because grain is bought and sold on a minimum kilogram per hectoliter basis. Test weight is also important to the miller because flour yield is usually related to kilogram per hectoliter wheat. Kernel hardness is a characteristic commonly used in wheat and maize trade and classification. The term hardness means different things to different people. To some it means physical hardness; to others, the way wheat mills; to still others the amount of work required to grind grain. Those definitions are to some extent related, and instrumental methods of determination of hardness may be based on any of these definitions. The primary determinant of wheat hardness is genetically controlled and relates to factors that influence compactness of endosperm cell components. Environmental factors and protein content also determine wheat hardness. Thus wheat hardness can be considered to demote a wheat class and variety characteristics that may be modified by environmental factors and protein content.

As an example of commercial classification, that of US wheat will be shown. According to US standards, wheat is divided into seven classes on the basis of type and color:

- hard red spring

- durum
- hard red winter
- soft red winter
- white
- red durum
- mixed

Every class has subclasses, and the wheat in each subclass is sorted into a number of grades on the basis of sound quality and condition. The tests used for determination of grade include plumpness, soundness, clearness, dryness, and purity of class. Plumpness is measured by the weight/bushel (or kg/hectoliter). *Soundness* is indicated by the absence of musty, sour, or commercially objectionable odor and by the quantity of damaged kernels. Cleanliness is measured by the amount of foreign matter. *Dryness* is measured by the moisture content. Purity of type is measured by comparing classes of the same grain. According to the requirements of the European Economic Community, three factors determine quality of sound grain: moisture, Besatz (a mixture of part of a sample that does not constitute faultless specimens of the basic grain), and test weight (expressed as kg/hl).

In the European Market, according to the Commission Regulation (EC), wheat has to meet minimum requirements to be sold as food-wheat (as follows):

- normal color, sound, smell, free of living insects
- no sticky dough
- broken kernels, maximum of 5%
- shrunken and insect-infested kernels, maximum of 12%
- sprouted kernels, maximum of 6%
- falling number, minimum 180 sec
- protein content, minimum 9%

Chemical composition of cereals (Table 1) is characterized by high carbohydrate (mainly starch) and moderate protein content. Lipid content is low. Among minor components, minerals, fiber, and vitamins are the most important.

Cereal grain	**Protein**	**Fat**	**Starch**	**Fiber**	**Ash**
Wheat	12.2	1.9	71.9	1.9	1.7
Rye	11.6	1.7	71.9	1.9	2.0
Barley	10.9	2.3	73.5	4.3	2.4
Oats	11.3	5.8	55.5	10.9	3.2
Maize	10.2	4.6	79.5	2.3	1.3
Millet	10.3	4.5	58.9	8.7	4.7
Sorghum	11.0	3.5	65.0	4.9	2.6
Rice	8.1	1.2	75.8	0.5	1.4

Table 1. Average gross composition of cereal grains (per cent dry weight basis)

The various groups of components are not uniformly distributed in the different botanical parts of the kernel. The hulls and bran are high in fiber and minerals, and the germ is characterized by its higher protein and high oil content. The endosperm contains the overwhelming part of starches lower in protein content and low in mineral constituents. Because of the relatively low lysine content (Table 2), the nutritive value of cereal proteins is moderate.

Amino acid	**Wheat**	**Rye**	**Rice**	**Maize**	**Barley**	**Millet**	**Sorghum**	**Oat**
Arginine	4.65	4.55	8.26	4.19	4.40	4.70	3.19	6.98
Cystine	2.36	2.65	1.07	1.55	2.50	2.19	1.73	1.73
Histidine	2.14	2.14	2.49	2.72	2.10	2.35	1.71	2.46
Isoleucine	3.39	4.21	3.71	3.68	3.80	4.55	3.77	3.90
Leucine	6.67	6.65	8.22	12.43	6.90	10.30	13.11	7.55
Lysine	2.50	3.40	3.69	2.67	3.50	3.05	2.24	4.51
Methionine	1.97	2.15	2.32	1.92	1.60	1.85	1.23	1.65
Phenylalanine	4.41	5.16	5.15	4.88	5.10	4.91	4.89	4.93
Threonine	2.96	3.26	3.91	3.60	3.50	3.19	3.64	3.64
Tryptophan	1.21	1.11	1.15	0.70	1.40	1.40	1.20	1.70
Tyrosine	3.19	2.16	3.49	3.83	2.50	3.70	3.41	3.61
Valine	4.41	5.22	5.51	4.85	5.40	5.31	4.51	5.24

Table 2. Amino acid content of cereals (g/100 g protein)

Generally, only the moisture and protein content is determined by the grading of cereal grains from chemical constituents.

2.2 Milling Properties of Wheat

The miller desires wheat that will mill easily and give high flour yield. The wheat kernels should be plump and uniformly large in size to permit ready separation of foreign material without loss of millable wheat. Thus the milling value of wheat is affected by wheat cleanliness, flour yield, wheat type (soft or hard), kernel uniformity and size, kernel weight, thickness of the pericarp and aleurone layers, and behavior during milling. Many attempts have been made to include various attributes in a single-value milling score, but such attempts have not been uniformly successful.

Experimental milling is generally used for evaluation of the milling value of wheat. The objective of the milling test is to prepare flour for evaluation of chemical, physical, and/or end-use properties, and also to screen wheat in plant breeding programs to eliminate selection of those with unsatisfactory milling properties.

2.3 Special Aspects of Quality of Nonwheat Cereals

Among other cereals in the framework of this chapter, rice will be treated as most important for human nutrition. Although other cereals are also used for food purposes (directly or indirectly—e.g., beer production), in a majority of countries these are primarily feeds or components of feed mixtures. Rice is the staple of the great part of the world population. For dehusked rice, brown rice is milled to separate the bran from the endosperm. The Food and Agricultural Organization (FAO) revised model for grading rice in international trade defines four types of milled rice: (1) undermilled, in which part of the germ and most or of all of the pericarp have been removed; (2) reasonably well milled, in which the germ and pericarp and most of the aleurone have been removed; (3) well milled, in which the germ, the pericarp, and nearly all of the aleurone layer have been removed; and (4) extra well milled rice, which contains the starchy endosperm only.

Rice hardness is important from the standpoint of changes after harvest: drying to safe moisture level in a manner that reduces the hazard of cracks and fissures, prevents losses in milling, maintains resistance to insects, and makes for ease of processing. Concerning cooking properties, the high-quality, long-grain rices cook dry and fluffy, and the cooked grains remain separate. Medium-grain and short-grain rices are rather moist and chewy after cooking, and the grains clump together.

Maize is used mainly for animal feeding. However, in several countries in Latin America, maize forms an important part of the diet, and considerable amounts of this cereal are used for industrial purposes (e.g., starch, starch syrup, industrial spirits, and so on), and in smaller quantities for human consumption (e.g., ready-to-eat breakfast cereals). In the US, the greatest producer of maize, about 80% of maize is used for feeding animals; about 15% for starch, corn syrup, and alcohol production; and the remaining for dry milled products (corn meal, flour, hominy grits, brewer’s grits, flakes) and breakfast cereals. The grading system is based on color (white, yellow), size and shape (dent, flint), hardness, test weight, amount of broken and damaged kernels, and moisture content.

A small proportion of oats is milled to provide products for the human diet: oat bread, oatmeal for porridge and oatcake baking, rolled oats for porridge, oat flour for baby foods, and for the manufacture of ready-to-eat breakfast cereals. Oat grains are classed as white, red, black, or mixed. In grading, the test weight, amount of sound kernels, quantity of damaged kernels, and foreign material is noted. Quality tests for milled oats products include determination of moisture, crude fiber, free fatty acids, and lipase activity. Raw oats normally contain an active lipase enzyme and, with the fat content of oat being some two to five times as high as that of wheat, it is desirable that the lipase should be inactivated during the processing of oats to prevent hydrolysis of fat, which would lead to the production of bitter-tasting fatty acids.

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Biographical Sketch

Radomir Lásztity D.Sc., Professor of the Department of Biochemistry and Food Technology at Budapest University of Technology and Economics, was born in 1929 in Deszk, Hungary, and completed his studies in 1951 at the Faculty of Chemical Engineering of the Technical University of Budapest. Dr. Lásztity received his M.Sc. degree in Chemical Engineering in 1951 and his D.Sc. degree in Chemical Science in 1968.

Dr. Lásztity is honorary president of ICC (International Association for Cereal Science and Technology). He was Chairman of the Codex Committee on Methods of Analysis and Sampling of the FAO/WHO Food Standard Program in the period 1975–1988. Dr. Lásztity is a member of the Food Division of the Federation of European Chemical Societies, and a member of the editorial boards of several international scientific journals. He was Vice-Rector of the Technical University from 1970 to 1976.

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.

Dr. Lásztity's main research activities are chemistry and biochemistry of food proteins, food analysis, and food control. The results of his research work have been published in more than 700 papers in foreign and Hungarian journals. He is the author of more than 20 books and textbooks (among them*: Chemistry of Cereal Proteins*, First and Second Editions in 1984 and 1996, respectively; *Amino Acid Composition and Biological Value of Cereal Proteins*, 1985; *Use of Yeast Biomass in Food Production*, 1991; *Gluten Proteins*, 1987; and *Cereal Chemistry*, 1999.)