

# Cereal Nutrition

Information for Senior Students

*Sourced from BRI*



For thousands of years, seven cereals - wheat, rice, maize (or corn), Barley, oats, millets and rye – have provided much of the food eaten by human beings. Cereals have been called the “seeds of civilization” – for civilization arose only when nomadic hunter- gatherers learnt how to farm cereal crops and thus settle permanently. The early civilizations of ancient times depended on one, perhaps two, cereals for their nourishment. Wheat and barley were the staple (main) foods of the great cultures of Egypt, Greece and Rome. Rice was the staple of Asia and maize of the Americas. Oats and Rye were predominant in colder regions of Europe. Millets (including sorghum) have been important in Africa and parts of Asia.

Cereals are the most important crop domesticated and harvested by man. Traditional food patterns, handed down by each generation, have been built around a cereal, accompanied by small quantities of legumes, green leaves and animal foods. Such traditional combinations of foods have provided an excellent nutritional balance, and enabled the people consuming them to survive.

## **Bread & Cereals meet Dietary Guidelines**

During the 20<sup>th</sup> century, the consumption of staple cereal foods has been declining in affluent countries, like Australia, the U.K., the U.S.A., Canada and Sweden. Australians now eat half as much bread as they did 60 years ago. In its place, foods of inferior nutritional value – high in fat, sugar and salt – are often consumed.

In an effort to improve food habits, the governments of several developed countries have recently published dietary goals or guidelines. All such goals recommend that people should:

- Decrease their consumption of fat
- Decrease consumption of refined sugar
- INCREASE CONSUMPTION OF COMPLEX CARBOHYDRATES AND DIETARY FIBRE from WHOLEGRAIN CEREALS, BREAD, VEGETABLES AND FRUITS.

These recommendations constitute a return to the traditional cereal-based diets of former days.

Of the 10 sets of dietary guidelines which have been published, from those of Sweden in 1968 to the Australian ones in 1979, all include recommendations for increased consumption of cereal products, cereal products, preferably wholegrain, and foods containing complex carbohydrates, grain products, more bread or increased wholegrain cereals.

The dietary guidelines are revolutionary in the teaching of nutrition. Since the 1930's, nutrition education has emphasised animal foods like meat, milk and cheese – all foods with a high fat content and completely lacking in fibre. To comply with the dietary guidelines, nutrition teaching should now emphasise bread, cereals, vegetables and fruits. The Australian Government Commonwealth Department of Health has therefore, placed bread and cereals in the first position as the No 1 group in their “Five Food Groups” nutrition guide.

### Production of Cereals

	<b>WORLD CEREAL PRODUCTION, 1981* (thousand tonnes)</b>	<b>AUSTRALIAN CEREAL PRODUCTION, 1983-84** (thousand tonnes)</b>
<b>Wheat</b>	458,195	21,764
<b>Rice</b>	413,785	632
<b>Maize</b>	451,704	238
<b>Barley</b>	158,488	4,890
<b>Millets &amp; Sorghum</b>	101,637	1,885 (grain sorghum)
<b>Oats</b>	44,024	2,296
<b>Rye</b>	24,473	30
* Source: Food and Agriculture Organisation Production Yearbook 1981.		
**Source: Australian Bureau of Statistics, Australian Farming in Brief 1984.		

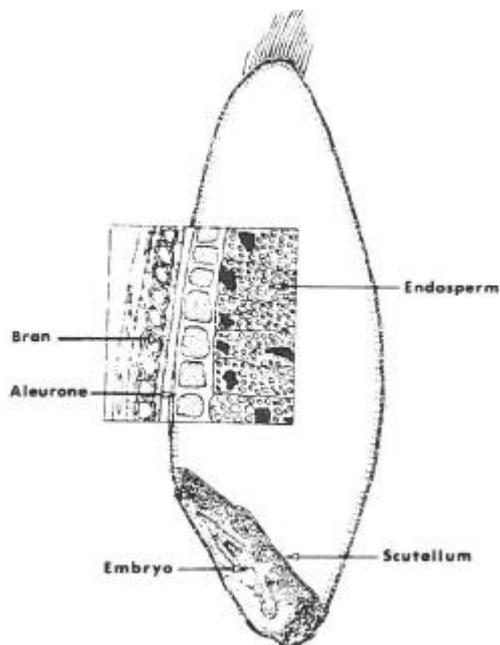
Wheat and rice are the two most important world cereal crops entering into international world trade. The other cereal crops are usually produced and consumed locally. In Australia, production of wheat far exceeds all other cereal crops. About 80% of our total wheat crop is exported to countries such as China, the U. S. S. R., Egypt, Iran, Iraq, Japan and Indonesia.

### Structure & Anatomy of Cereals

Cereals are classified botanically as the Gramineae (or Poaceae) family. The cereal grains are in fact seeds, each of which has the potential to grow into a new plant. All cereal grains are similar in structure and anatomy. Each grain or kernel basically consists of:

The ENDOSPERM, which comprises 83% of the grain by weight, is a reserve of carbohydrate and protein for the growing plant.

The BRAN LAYERS, about 12 – 13% of the grain, form an outer protective coat which keeps the seed's food reserve intact and prevents attack by insects.



The ALEURONE is a single square-shaped layer of cells surrounding the endosperm.

The GERM, only 2 – 3% of the grain, is the growing point from which the new plant will develop. It consists of the EMBRYO, which contains the undeveloped root and shoot, and the SCUTELLUM, a layer between the embryo and the endosperm, which transfers stored food to the embryo during germination.

Cereal grains give high yields and are fairly easy to collect. Because of their low (12%) moisture content, they can be stored for long periods without spoiling. These factors have helped make cereals a major food for animals and man.

### Food Uses of Cereals

All cereals can be milled or ground to form flour or wholemeal. Maize, barley, oats and millet are usually ground and cooked a porridge (gruel) or baked as flat, round “pancakes”. Rice is polished or pearled to remove the bran and steamed and eaten as cooked grain. Only wheat and, to a lesser extent, rye, is milled into flour to make bread and other baked products.

Gluten, the unique combination of proteins found in wheat and rye flours, has the ability to stretch and retain gases produced by yeast and other leavening agents, forming the basic structure of bread and baked products. Other cereals do not contain proteins of the gluten type and it is not possible to make satisfactory, leavened products with flours milled from rice, maize, millet, barley or oats alone. Mixtures of wheaten flour and these cereals make acceptable products.

### Nutritional value of cereals

Cereals are nutritious foods, essential to a balanced healthy diet. In nutritional value, the 7 cereals are fairly similar. They provide a wide range of several important nutrients, rather than being rich sources of any one nutrient (see Table next page). The milling of cereals for flour removes some of the bran and germ, which contain a proportion of the grain’s vitamins, minerals and dietary fibre. Lightly milled cereals of high extraction rate have a higher content of nutrients. When rice is polished, all the bran and germ are removed. Cereals supply the following nutrients:

COMPLEX CARBOHYDRATES (or polysaccharides, including starch) which provide energy for growth, physical exercise and study, maintain blood glucose level, and regulate metabolism of fats. DIETARY FIBRE aids regular bowel functioning and may help prevent certain bowel diseases.

PROTEIN, which is needed for growth and continuous replacement of body cells and fluids throughout life. Excess protein is used as energy or stores as body fat (like carbohydrate).

CALCIUM, a mineral required for healthy teeth and bones, muscle contraction and certain enzymes.

IRON, a mineral required for red blood cells and certain enzymes and co-factors.

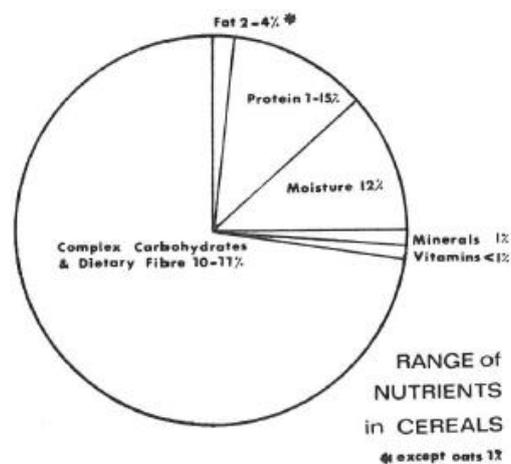
Small amounts of OTHER MINERALS, such as phosphorus, potassium, zinc, magnesium, manganese and copper.

THIAMIN (vitamin B<sub>1</sub>) involved in the metabolism of food and the release of energy for the body.

RIBOFLAVIN (vitamin B<sub>2</sub>) and NIACIN, needed for the release and utilization of energy from food.

Small amounts of OTHER B vitamins, such as pyridoxine (B<sub>6</sub>), folic acid, vitamin B<sub>12</sub> and pantothenic acid.

VITAMIN E (particularly in wholegrain products) which is needed for maintenance of cell membranes and functions as an antioxidant.



In the Third World (developing) countries, which include large parts of Africa and Asia, cereals provide more than 70% of the energy in the diet. As a country becomes more affluent, the consumption of cereals declines, although they still make important contributions to the nutrient intake. In Australia, bread and cereals supply 25% of the energy, 25% of the protein, 30% of the iron, 50% of the thiamin intake in the diet, as well as smaller contributions of other vitamins, minerals and fibre. Bread and cereals are the most important source of thiamin in the Australian diet and the second major source of protein, after meat. Unfortunately, they have acquired a poor reputation as foods. Because of their carbohydrate content, they were regarded as too "fattening" and were limited or avoided by the weight conscious. However, the publicity given to dietary fibre in recent years has highlighted the importance of cereals, particularly wholegrain varieties. Whole cereals contain 3 – 15% dietary fibre, which generally makes them bulky and satisfying. With the exception of oats, they are low in fat containing only about 2 – 4%.

NUTRITIONAL VALUE OF CEREALS <sup>1</sup>									
CEREAL	ENERGY	PROTEIN <sup>2</sup>	FAT	CARBO-HYDRATE & FIBRE	CALCIUM	IRON	THIAMIN	RIBO-FLAVIN	NIACIN
	<b>kJ</b>	<b>g</b>			<b>mg</b>				
Wheat -Hard	1,390	13.8	2.0	70	37	4.1	0.45	0.13	5.4
Wheat - Soft	1,390	10.5	1.9	74	35	3.9	0.38	0.08	4.3
Rice	1,495	7.5	1.8	77	15	1.4	0.33	0.05	4.6
Maize	1,490	9.5	4.3	73	10	2.3	0.45	0.11	2.0
Barley	1,390	11.0	1.8	73	33	3.6	0.46	0.12	5.5
Rye	1,335	11.0	1.9	73	38	3.7	0.41	0.16	1.3
Oats	1,625	11.2	7.5	70	60	5.0	0.50	0.15	1.0
Millet	1,485	9.7	3.4	73	32	4.5	0.50	0.12	3.5

<sup>1</sup>Per 100 g. <sup>2</sup>Protein content has been calculated as Nitrogen x 5.83.

Source: Aykroyd, W. R. and Doughty, J. (1970). Wheat in Human Nutrition, Nutritional Series No. 23, F.A.O. Rome

#### PROTEIN CONTENT OF CEREALS

The protein content of cereals ranges from 7 – 15%, a satisfactory value in relation to their energy value. For cereals, the % comparison of protein-energy to total energy is about 13%, which compares favourably with the protein-energy in the theoretical average Australian diet of 12.5%. The poor reputation of cereal proteins is derived from the relatively low proportion of several essential AMINO ACIDS, particularly LYSINE. However, when people eat the traditional food combinations of their country, lysine deficiency does not occur. Different civilizations have developed traditional food patterns, which always include a lysine-rich source of protein (like milk, legumes, fish or meat) in combination with a cereal (see below).

#### TRADITIONAL FOOD COMBINATIONS

<u>Europe and Western Asia</u> Wheat, oats or rye & peas, vegetables, meat and/or milk	Bread and cheese, breakfast cereal with milk, soup with croutons, pasta with cheese or meat, noodles and soup, milk-enriched breads.
<u>South-East Asia</u> Rice & vegetables, soybeans and/or meat	Steamed rice with meat (Nasi Goreng), rice-bean casserole, curry and rice, rice and dahl (lentils), rice and milk pudding, paella, risotto.
<u>Africa</u> Millets & beans and/or meat	Injera millet bread with soup or stew, couscous with meat.
<u>Central America</u> Maize & beans and/or meat	Tortillas and beans, cornbread, tacos, hominy with cheese.

A cereal-based diet can satisfy adult protein requirements if consumed in quantities sufficient to meet energy needs. Small children, pregnant and lactating women may require additional supplements of protein or energy.

### **Wheat** (genus *Triticum*)

Wheat was first cultivated about 7000 B.C. in the valley of the Tigris and spread to other parts of Asia Minor, then Egypt and Europe. Today it is grown on all continents. The wheat plant is very adaptable and grows well under varied conditions of soil and climate. In Australia, wheat was first grown successfully in 1790 near Parramatta and production began soon after. In 1979 – 80 Australia ranked eighth in world wheat production and second as an exporter (after U. S. A.)

The genus *Triticum* can be classified into three distinct groups.

- i. Common or bread wheats (*Triticum aestivum*, synonymous with *T. vulgare*), are the most widely grown and economically important. They are the source of FLOUR for BREAD and for biscuits, cakes and pastries.
- ii. Durum wheats (*T. durum*) are best suited for the production of pasta.
- iii. Primitive wheats, such as Einkorn and Emmer, were used for human food in prehistoric times. They are still grown in a few countries today.

### **FOOD USES**

Wheat is most important as a human food and, to a lesser extent, as animal feed. Generally, wheat has been ground into a meal or flour and used to make breads, wither unleavened or leavened. Unleavened bread is made by mixing flour with water to make a dough, shaping the dough and then baking it on hot stones, on a hot plate or in an oven. Examples of unleavened breads include the Jewish *matzoh*, baked to commemorate the exodus of the Jews from Egypt, and some varieties of *chappatis*, this round, flat breads about 25 centimetres in diameter which originated in India. *Parathas* and *puris* are similar to chappatis.

Leavened bread is baked from a dough of flour, water, yeast and salt. Originally, wild yeasts in the air settled on the dough, resulting in natural fermentation. Small pieces of dough were set aside to become “starters” for fermenting subsequent batches. However, today, modern bread is leavened with cultivated strains of yeast. (*Saccharomyces cerevisiae*). Examples of leavened breads are the familiar sliced breads of many affluent countries, French sticks, Italian, Vienna, Cobs, Baps, Tanks and Plaits. In the Middle East, bread is known as Khobbiz. Several distinctive types are baked e.g. round flatbreads approximately 25 cm in diameter (*pitta*, *mafroud* or *lebarni*), elongated flatbreads (*balady*, *tannour* or *barbary*) and small crisp rolls (*sumoon* or *sumooli*). In India and Pakistan, *naan* is popular. Steamed buns, such as *pau*, are made in China.

Breakfast cereals are prepared from whole wheat grains that have been puffed, shredded, flaked or compressed into blocks. Wheat flour is the basis of a wide variety of cakes, biscuits and pastries, and of noodles. Pasta products are made from wheaten semolina which is extended in the required shape and size.

### **Rice** (genus *Oryza*)

Rice originated in Asia about 3000 B.C. and is a staple food in China, Japan, India, Burma and South-East Asia. Cultivation of rice in Australia began in 1942 in the Murrumbidgee Irrigation Area (N.S.W.). Today, Australia ranks seventh as a rice-exporting nation.

Rice is grown by 2 systems:

1. In fields of standing water, where it is known as *paddy rice*. Ninety per cent of rice is grown this way.
2. On dry land where it is called “upland rice”.

In Asia, rice is produced on small farms, planting, harvesting and threshing being carried out by hand. In Australia, large commercial farms employ aerial sowing, followed by combine harvesting.

After threshing, rice retains its outer husk, being known as *paddy rice* or *rough rice*. In rice-milling, the husk is easily removed, leaving the thin bran layer (*silverskin*) on brown rice. Brown rice usually undergoes an operation called pearling to remove the silverskin. Pearling leaves a white grain, sometimes further polished to give it an attractive sheen.

## FOOD USES

Rice is traditionally cooked by steaming it in water. Unlike other cereals, it is most frequently eaten as steamed grains to form the basic food of many countries e.g. in India with curry and vegetables, in southern China with meat and vegetables, in Italy as *risotto*, in Spain as *paella*. Only small quantities are ground into flour for making rice noodles or rice cakes. Rice is used to make *sake*, an alcoholic beverage popular in Japan. Rice meal or bran is a valuable animal feed and rice husks are important for building materials and fuel.

The thiamin-deficiency disease BERIBERI has been associated with diets relying heavily on polished rice. Beriberi can be prevented by eating lightly-milled rice or by parboiling (soaking and heating the unhusked grains to below boiling point, which causes diffusion of thiamin throughout the grain).

American wild rice (*Zizanea aquatic*) known as *Indian Rice* or *Tuscarora rice* is also a cereal. It is an annual aquatic grass, native to North America.

## Maize (genus *Zea*)

Maize was the only cereal systematically cultivated by the American Indians and originated about 5000 B. C. in Mexico. Brought to Europe by Columbus in the 16<sup>th</sup> century it became established in Europe and later in Africa and Asia. In Europe where all grains are collectively known as "corn", maize is the term used for this particular cereal, corn, however, is the accepted American name. The U.S.A. is the leading producer of maize and has developed hybrid varieties which give high yields. Maize is grown in Western Europe, Latin America and Africa. In Australia, maize is a relatively minor crop with Queensland as the principal producing State.

Maize has adapted to a wide range of environmental conditions. It has no strict growth requirements and matures rapidly. Its distinctive feature is the presence of male and female flowers in separate spikelets upon the same plant. Male flowers form the "tassel" at the top of the stem, female flowers are borne on the ears lower down the stem.

## FOOD USES

Maize is an important staple in Central and South America where it is traditionally soaked in lime water prior to cooking. This practice has been responsible for the lack of pellagra in these areas. PELLAGRA, the niacin-deficiency disease, occurs because the niacin is bound to a complex of cellulose and hemicellulose molecules which humans are unable to digest. The complex occurs in all cereals. However, unlike other cereals, maize has a very low content of tryptophan, an amino acid-precursor of niacin. The Lime water (alkali) releases much of the bound niacin. In parts of the U. S. A. and Europe, where this practice was not adopted, pellagra has been a problem.

In South East Africa, maize is boiled with water into a porridge called *mealie* like the Italian *polenta*. In Central America, maize meal is cooked into flat, thin cakes called *tortillas*. North Americans make it into corn bread, corn pone and hominy. Maize, particularly of the sweet-corn variety, can be cooked and eaten as a vegetable "on the cob". *Cornflakes* (a breakfast cereal) are produced by pre-cooking, flaking and toasting the grain. In countries where maize is widely grown, it is also the basis for starch (*cornflour*) and maize oil and is important for feeding livestock.

### Barley (genus *Hordeum*)

Barley was one of the first grains grown by man as a staple food. Remains of Stone Age barley cakes were found in Switzerland. Cultivation of barley was known to the ancient Egyptians and barley was used as a bread grain by the Greeks and Romans. Its use for bread later declined in Britain with the availability of wheat. Russia is the major producer of barley, followed by Canada, the U.S.A., France, Eastern Europe, the U. K. and West Germany. Three-quarters of Australia's crop is exported. Barley generally occurs as a covered caryopsis in which the husk adheres to the kernel after threshing, with either two-row or six-row arrangement of the grains on the spike. In some types, the husk is loose and is easily removed during threshing.

#### FOOD USES

Barley is mainly used as an animal feed, particularly for pigs, and for malting. MALTING is a process in which barley grains are germinated and then dried and ground to produce malt flour. Malted grain is important in the brewing and baking industries because of its  $\alpha$  - amylase content. Malt is also used in the production of vinegar and for flavouring breakfast cereals. As a food, barley is consumed as a meal or flour, as barley groats and flakes and as pearl barley for thickening. Pearl Barley is the polished grain after removal of the bran.

### Oats (genus *Avena*)

Oats were originally cultivated by Europeans about 1000 B.C. and probably became established in Britain during the Bronze Age. Being an excellent feed for horses and other livestock, the "snob" instinct was aroused in certain groups, such as the Romans, who despised the Germans for eating oats as their horses did. The bulk of the oats crop is consumed on the farm where it is produced. The U. S. A. and the U. S. S. R. are the world's largest producers. In Australia, production is low, being largely consumed by livestock as green fodder, as ripened grain or as processed pellets.

Oats are grown in cooler, moister regions of the temperate zone. Like barley, they have a covered caryopsis i.e. the husk adheres to the grain after threshing.

### Millets & Sorghum (genus *Sorghum*)

Millets and sorghum, considered the oldest of all cereals, are believed to be of African origin. A number of species of millet are cultivated in the tropics and temperate zones:

Tropical Millets	Temperate Millets
Sorghum (great millet)	Common Millet
Finger Millet	Little Millet
Bulrush millet (pearl millet)	Foxtail millet
<i>Teff</i> (in Ethiopia)	Japanese millet
<i>Adlay</i> or <i>Job's tears</i> (in Philippines)	

Production of millet is important in Africa, parts of India, Pakistan and mainland China. In Australia, sorghum is grown mainly for stockfeed, commonly known as *milo* or *grain sorghum*. The millet grain is a naked caryopsis shaped like a sphere. SORGHUM (great millet) is exceptional in having larger seeds than the other millets. It is called *Kaffir corn* and *Guinea corn*.

## FOOD USES

The white-grained varieties of millet are preferred for eating purposes, whilst the red-grained varieties (bitter-tasting) are mainly used for making beer. In countries where they are staple foods, millet and sorghum seeds are pounded into flour, which is then mixed with water to make a porridge, or allowed to ferment slightly then baked into flat cakes.

### **Triticale** (genus *Triticosecale*)

Triticale is the first man-made cereal produced by cross-breeding of wheat (genus *Triticum*) and rye (genus *Secale*) that has competed successfully with traditional cereals. In the 1950's plant geneticists hoped that such a crossed single cereal with superior yield would incorporate the hardiness and disease resistance of rye with the milling and baking qualities of wheat. In 1965 the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico initiated a large-scale triticale breeding programme which subsequently isolated highly-fertile plants called the Armadillos in 1968. Co-operative programmes are continuing today in many other countries, including Australia. Aimed at improving triticale's breeding, adaptation nutritional value and utilisation.

Triticale closely resembles its parent species, wheat and rye, in structure and nutritional value. It is reported to have a higher lysine content than wheat, although lysine remains its first limiting amino acid, and similar vitamin and mineral content except for substantially lower amounts of niacin.

Triticale's extraction rate is lower than that of wheat, due to the presence of shrivelled kernels which prevent efficient separation into flour and bran. The texture and flavour of triticale breads resemble that of a light, rye bread. The first commercial bread to contain triticale – a blend of 35% triticale and 65% wheat flour – was marketed in the U. S. A. in 1975. The product is described as having a nutty taste, excellent keeping qualities and a golden colour. Triticale is particularly suitable for biscuit making and produces quite good cakes, pancakes and muffins. It has an important potential as an alternative feed grain to conventional cereals.

### **Buckwheat**

BUCKWHEAT is not a true cereal. It belongs to the Polygonaceae family but, like the cereals, its fruit is a dry grain, which can be ground into flour. Buckwheat flour is used to make pancakes and cakes, particularly in Europe and eastern Asia. *Kasha*, popular in eastern Europe, consists of buckwheat groats cooked in water like rice. In Japan it is processed into flour for noodles. Buckwheat is a hardy plant which can grow in poor soils or rocky areas where other grains fail.