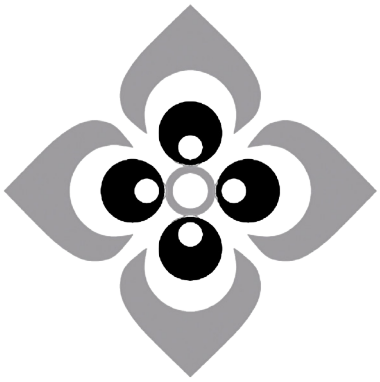

Consortium for Educational Communication

Module
on
Introduction to cereal technology

By

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Text:

Introduction

A cereal is generally defined as a grass grown for its small, edible seed. All cereals belong to monocots, and members of the grass family *Gramineae*. Cereals have been the most important sources of plant food for human and livestock. Probably, these were the first crops to be domesticated and cultivated in an organised manner which we today call as agriculture. Cereals from the main bulk of the food supply consumed by mankind especially in developing countries as they are the inexpensive source of food energy & protein. They are also good source of micronutrients such as calcium, iron and vitamins of group B. They are used directly or in modified form. Cereals are also used as animal feed and hence, converted into meat, milk and eggs. They are also used for industrial purposes.

The principal cereal grains grown in the world are corn, rice, wheat, sorghum, barley, oats, rye and millets. List of crops which are considered as cereals are listed in **table 1.** A new cereal of considerable interest is triticale which is a cross hybrid of wheat and rye. Different cereals grow under different agro-climatic conditions e.g. sorghum and millets grow well in semi-arid conditions, deep water rice in arid regions, while rye and oats require cold climates. Cereal plants range in height from 30 cm (e.g., teff) to 300 cm (pearl millet and sorghum). Most cereals are thin-stemmed grassy plants, but maize, sorghum and pearl millet have thick stems more similar to sugarcane than grass. Cereal crops provide the farmer with straw for fodder and thatch, as well as grain for the family and the market. The original ancestors of cereals have been lost over a period of time. The development of all the major cereals occurred long before recorded history as all the oldest civilizations were already familiar with several kinds of barley, wheat and other grains.

There are many reasons why cereals are such important crops. Many of these grasses are available in the different world climates. The northern regions have barley and rye, the temperate regions have wheat and the tropics and warmer temperate areas have rice and maize. Cereals, also have a wide range of soil and moisture requirements.They can be cultivated with a small amount of effort and give a high yield **(table. 2**).The grains are relatively easy to handle and store because of their low water content, with high food value. Cereals contain a higher percentage of carbohydrates than any other food plants as well as a considerable

amount of protein and some fats and small amount of vitamins too.

Cereal yield changed very little during the first half of the twentieth century, but have more than trebled since then. There are number of factors which have contributed to this trend. The rediscovery of Mendel's work provided the scientific basis on which cereal breeding could develop, first within the public sector and more recently by private companies. Grain is often harvested at moisture contents of around 16 to 20%. At these moisture levels stored grain is extremely susceptible to fungal contamination and deterioration. For safe storage the grain has to be dried within the range 13 to 15%.

India has reached to a level of self-sufficiency in the production of cereals after the green revolution.

Types of cereals:

Cereal Grains

There are different types of grains found within the true cereal grains which are from the botanical family 'Poaceae' including wheat, oats, rice, corn (maize), barley, sorghum, rye, and millet. Within these groups there are also varieties such as farro, freekeh, emmer and spelt which are all types of wheat as well as new grains like triticale which is a mixture of wheat and rye.

Pseudo-Cereal Grains

The 'pseudo-cereal' group are not part of the Poaceae botanical family, in which 'true' grains belong, however they are nutritionally similar and used in similar ways to 'true' grains. Many of these, such as amaranth, buckwheat and quinoa (pronounced 'keen-wah'), Pseudo-cereals are increasingly being used in the manufacture of new forms of breads, flatbreads, crisp breads, pasta, breakfast cereals and snack bars as well as on their own as alternatives to rice, pasta and couscous.

Important cereals of the world:

Rice (*Oryza sativa*) crop originated in Asia and has been a staple food there since the Ice Age in the North. The geographical site of original rice domestication is yet not sure. Actual rice grains and husk have been excavated in India that were more than 4500 years old and in China more than 5000 years. According to ancient Greek writers, rice reached Europe around 3000 B.C having been brought from India by Alexander the Great.

Wheat (*Triticum aestivum, Triticum durum*) is the earliest field crop used for human food processing. The cultivation of wheat reaches far back into history as it was predominate source of food for human. The precise origin

of the wheat cultivation is unclear, but it is thought that man has been cultivating and processing the wheat for at least 12,000-17,000 years.

Corn or Maize (*Zea mays*) is native to the America. Corn originated in Mexico, evolving from the wild grass *Teosinte*. Archaeological evidence suggests that corn was domesticated and grown as early as 5000 B.C. in Mexico. Following Columbus discovery of America, corn was transplanted to Spain from where it quickly spread across Europe, Africa and Asia. This is the largest crop grown in the world.

Sorghum (*Sorghum bicolor)* also called great millet, Indian millet, milo, durra, orshallu. The plant likely originated in Africa, where it is a major food crop, and has numerous varieties, including grain sorghums, used for food; grass sorghums, grown for hay and fodder; and broomcorn, used in making brooms and brushes.

Barley (*Hardeum vulgare*) is among the most ancient of the cereal crops. The original area of cultivation has been reported to be in the Fertile Crescent of the Middle East, in present day Lebanon, Iran, Iraq, and Turkey. There is now considerable evidence that barley was under cultivation in India and China considerably later then in Middle East. Barley played an important role in ancient Greek culture as a staple bread making grain, as well as an important food for athletes, who attributed much of their strength to their barley containing training diets. Gladiators were known as *hordearii*, which means eaters of barley. In almost every culture through the ages, barley foods are described as having almost mystical properties, and barley is often referred to as the king of grains.

Oat (*Avena sativa*) Domesticated oats appear relatively late, and far from the Near East, in Bronze Age Europe. Oats, like rye, are usually considered a secondary crop, i.e., derived from a weed of the primary cereal fields of wheat and barley. As these cereals spread westwards into cooler, wetter areas, this may have favoured the oat to its domestication. They have a lower summer heat requirement and greater tolerance of rain than other cereals, such as wheat, rye or barleyand are important in areas with cool, wet summers, such as Northwest Europe and even Iceland.

Structure of Cereal Grains

Cereal grains are the fruit of plants belonging to the grass family (*Gramineae*). Botanically, cereal grains are a dry fruit called a caryopsis. (Fig. 1: **S**tructure of cereals). The caryopsis fruit has a thin, dry wall which is fused together with the seed coat. Kernel structure is important with respect to minimizing damage during grain harvest, drying, handling, storage, milling, and germination and in enhancing nutritional value. There are a few important

structural features that the cereal grains have in common. All the cereal grains are plant seeds and contain three distinct anatomical portions a large centrally located starch endosperm, which also is rich in protein, protective outer layers such as hull and bran, and an embryo or germ.

The seed portion of cereals consists of numerous components which basically include three parts: a seed coat or testa (bran), storage organ or nutritive reserve for the seed (endosperm), and a miniature plant or germ. The fruit tissue consists of a layer of epidermis and several thin inner layers a few cells thick. The aleurone layer which is just below the seed coat, is only a few cells thick, but is rich in oil, minerals, protein and vitamins. Starch and protein are located in the endosperm which represents the bulk of the grain and is sometimes the only part of the cereal consumed. Starch is arranged in the form of sub-cellular structures called granules that are embedded in a matrix of protein. The developing endosperm contains protein bodies which become a continuous phase as the grain matures. There is generally a gradient of more protein and less starch per cell from the outer to the inner region of the endosperm.

Chemical Composition of Cereals

Cereals are of plant origin which yield edible grains, consumed directly or in modified form as major part of diet and also as feed to livestock. Rice and wheat are most important cereals forming part of human food. The major constituents of the principal cereals are listed in **table 3**.

Carbohydrates: In adult diet out of the total calories are recommended are derived mainly from carbohydrates present in cereals. Carbohydrates constitute 80 percent of the dry matter of cereals. Whole grains provide about 350 Kcals per 100g. Cereals provide 70-80 percent of the daily energy intake of large section of the population in India. Cereal grains are largely composed of starch, a complex carbohydrate. Other carbohydrate constituents present are cellulose, hemicellulose and pentosans which constitute dietary fibre. Due to high fibre content, whole cereals are considered important for the maintenance of good health. Small amount of dextrin, sucrose, raffinose, glucose and galactose are also present.

Protein: The protein content of cereals varies as they contain 6-12 g protein per 100g and can easily meet more than 50 percent of the daily protein requirement of an adult. Cereal protein consists of albumin, globulin, prolamine and glutelins. The quality of cereal protein is lower than the animal protein because cereal proteins lacks the essential amino acid lysine. Among cereals, rice protein is of better quality than others. Hence, cereals should be taken in combination with the legumes or milk and milk products.

Fat: Cereals are generally considered to have low fat content as determined by ether extraction which represents only free fat. Recent studies have shown that cereals contain much more fats if bound fat is also taken into account. The total fat thus may vary from 2 to 5 percent per 100g. Cereals like wheat, rice and barley contain 1 to 1.7 percent fat. The fat content is higher in maize (3.6 percent), oats (4 to 6 percent) and Bajra (5.0 percent). Germ and bran of the grain contain higher concentration of fat than other parts. For example, wheat germ contains 7.4 percent fat while the bran and endosperm contain 3 to 5 and 0.8 to 1.5 percent fat, respectively. Rice bran contains 16.2 percent fat while in maize, it is mainly present in germ i.e. 35 percent. Therefore, upon separation and removal of germ from the endosperm as in milling of cereals, keeping quality of milled products is improved. In general, cereals contain triglycerides of palmitic, oleic and linoleic acids. They also have some amount of phospholipids and lecithin.

Recent researchers suggest that for reducing calories from fat, people should be encouraged to replace fat with cereals, as they are low fat and high in fibre content. Moreover, cereals contain the polyunsaturated fatty acids which are healthier. Considering the amount of cereals consumed, it is estimated that fat content in cereals in our diet can meet more than 50 percent of our essential fatty acid requirement.

Minerals: The ash content of cereals varies from 0.6 to 3.3 percent. The husk of cereals grains is rich in minerals. Rich husk contains about 22.5 percent ash content which is 96 percent silica.

In cereals, calcium and iron are not present is good amount but the grains contribute significantly due to fairly large amounts of cereals consumed daily. Among cereals rice is poorer in these two minerals as these are lost during milling and polishing. Millets contain good amount of minerals and fibre. Rye, oats and ragi are very good sources of calcium. As the main storage form of phosphorus present in cereals is phytin, hence it affects adversely the bioavailability of minerals especially calcium, magnesium phosphorus, zinc and iron. Some trace minerals i.e. copper, zinc and manganese are present in small amounts in cereals.

Vitamins: Whole cereal grains are important sources of B-vitamins. Removal of bran from cereals, polishing and refining of these grains especially rice reduce B-vitamin content to varying degrees depending upon the extent of refining and polishing. Therefore, high extraction wheat flour (maida) and pearl millets also contain less amount of B-vitamins.

Vitamin A and C are not present in cereals except yellow maize and

varieties of sorghum which do contain β-carotene. Oil from cereal germ is in Vitamin E form.

Enzymes: A number of enzymes viz. amylases, proteases, lipases and oxido-reductases present is cereals are important from the processing point of view. During germination and fermentation, these enzymes become active and influence the digestibility and availability of nutrients.

Processing of cereals:

All cereals needs to be processed. Any cereal cannot be consumed without processing. Each type of cereal requires a specific post-harvest treatment, however, there are certain general principles that apply to most of them. Cereals undergo a number of processing stages between harvest and consumption. This chain of processes is often referred as total post-harvest system. The post-harvest system can be split into three distinct areas.

The first is the preparation of harvested grain for storage. The second, which is referred to as primary processing, involves further treatment of the grain to clean it, remove the husk or reduce the size. The products from primary processing are still not consumable.

The third stage (secondary processing) transforms the grains into edible products. Primary processing involves several different processes, designed to clean, sort and remove the inedible fractions from the grains. Primary processing of cereals includes cleaning, grading, hulling, milling, pounding, grinding, tempering, parboiling, soaking, drying, sieving.

Secondary processing of cereals (or 'adding value' to cereals) is the utilization of the primary products (whole grains, flakes or flour) to make more interesting products and add variety to the diet. Secondary processing of cereals includes the following processes: cooking, fermentation, baking, puffing, flaking, frying and extrusion.

Decortication

Millet and some other coarse grains are usually dehulled and subjected to different treatments before consumption to improve their sensory and edible quality. It has been reported that the food uses of finger millet

are confined to flour-based products because, it has not been possible to decorticate millet similar to other cereals. This is mainly due to millet grains are small compared to other cereals. Though, with the recent hydrothermal treatment of millet hardens the endosperm texture and enabled its decortication. The decorticated millet could be cooked as discrete grain same like rice to get the final product with soft texture within five minutes. The pasting and the dough properties and also some of the functional characteristics of the product indicated its versatility for diversified food uses. However, decortication of hydrothermally processed finger millet caused significant changes in the nutrient contents. the various steps in processing of cereals can be studied as;

Milling and sieving

Millet grain are usually milled by a non-by a non-motorized grain mill that cranks by hand or another nonelectric method, especially in rural areas for household uses. However, a manual grain mill that has been attached to a gas or electric motor by a pulley system can also be used. However, a number of small machines which can be used at village levels are designed by CSIR-CFTRI, Mysuru.

Germination or malting

Germination or malting of cereal grains may result in some biochemical modifications and produce malt with improved nutritional quality that can be used in various traditional recipes. Fermentation and enzymatic hydrolyzation. Due to the importance in food preservation, fermentation is widely used throughout Asia and Africa where modern food preservation methods are still not common. It helps to preserve many food products, provides a wide variety of flavours, and significantly improves the nutritional properties of the raw material

Popping and puffing

This is a traditional food processing methods used for the preparation of expanded cereals and grain legumes to prepare ready-to eat-products. It has been reported that the traditional popping or puffing as well as contemporary methods i.e roller drying and extrusion cooking of cereal processing could be successfully applied to foxtail millet to prepare ready-to- eat products, thereby increasing its utilization as a food

Soaking and germination

Soaking of grains is a popular food preparation technique used for reducing antinutritional compounds such as phytic acid to improve

bioavailability of minerals. The degradation and leaching of phytates, and iron and zinc concentrations have been found to decrease after soaking of whole seeds, dehulled seeds, and flours of millet.

Conclusion:

Cereals are the only group of plants which is grown in the whole world. They are the largest carbohydrates crop of the world. There are consumed in various forms in the world. All the cereals are covered with a thick seed coat. Due to the varied structures, thickness and strength of the aleurone layer the processing of cereals are varied. The versatility of the grains are such that they can be mixed together for production of any neo product.

Table 1 List of Cereal Crops

Sl No	Common name	Botanical name
	Rice	mainly *Oryza sativa*
	Wheat, bread wheat	*Triticum aestivum*
	Durum wheat, macaroni wheat	*Triticum durum*
	Corn or maize	*Zea mays*
	Job's Tears, salay, adlay, tigbe, pawas	*Coix lachryma-jobi*
	Barley	*Hordeum vulgare*
	Millet	*there are 6 or more types listed in millets chapter*
	Sorghum	*Sorghum bicolor*
	Oat	*Avena sativa*
	Rye	*Secale cereale*
	Triticale	*Triticosecale*
	Teff, taf	*Eragrostis tef*
	Fonio	*Digitaria exilis*
	Wild rice, Canada rice, Indian rice	*Zizania* spp
	Spelt	*Triticum spelta*
	Canary grass	*Phalaris* sp.
Pseudocereals		
	Amaranth or Grain amaranth	*Amaranthus* spp.
	Buckwheat	*Fagopyrum esculentum*
	Chia	*Salvia hispanica*
	Kañiwa	*Chenopodium pallidicaule*
	Pitseed goosefoot	*Chenopodium berlandieri*
	Quinoa	*Chenopodium quinoa*

Table 2. The annual production of cereals in the world

Grain	Worldwide production (millions of metric tons)						Major countries where grown
Maize (corn)			872	888	851	205	A staple food of people in the Americas, Africa, and of livestock worldwide; often called corn in North America, Australia, and New Zealand. A large portion of maize crops are grown for purposes other than human consumption.

Rice			720	725	703	285	The primary cereal of tropical and some temperate regions. Most of South Asia and the Far East
Wheat	730		671	699	650	222	The primary cereal of temperate regions. It has a worldwide consumption but it is a staple food of North America, Europe, Australia, New Zealand, most of the Southern Cone and much of the Greater Middle East.
Barley	146	144	133	133	124	72	Grown for malting and livestock on land too poor or too cold for wheat.
	63	61	57	58	60	41	Important staple food in Asia and Africa and popular worldwide for livestock.
Millet	32	30	30	27	33	26	A group of similar but distinct cereals that form an important staple food in Asia and Africa.
Oats	22.5	23	21	22	20	50	Popular worldwide as a breakfast food and livestock feed. In human consumption, oats can be served as porridge as oatmeal although oats could be eaten various different forms other than rolled oats, including unprocessed oats.
Rye	15	16	15	13	12	12	Important in cold climates.
Triticale	14		14	13	14	35	Hybrid of wheat and rye, grown similarly to rye.
Fonio	0.6	0.6	0.59				Several varieties are grown as food crops in Africa.

Table 3. Proximate compositions of cereal grains

Cereal							
Wheat (*Triticum aestivum*, *Triticum durum*)	11	69	13		3	2	340
Rice (*Oryza sativa*, L.)	11	65	8		9	5	310
Corn (*Zea mays*, L.)	11	72	10		2	1	352
Sorghum (*Sorghum bicolor* L.)	11	70	12		2	1	348
Barley (*Hardeum vulgare* L.)	14	63	12		6	3	320

Oats (*Avena sativa*)	13	58	10		10	4	317
Rye (*Secale cereale*)	11	71	12		2	2	321

Fig 1: Structure of cereals

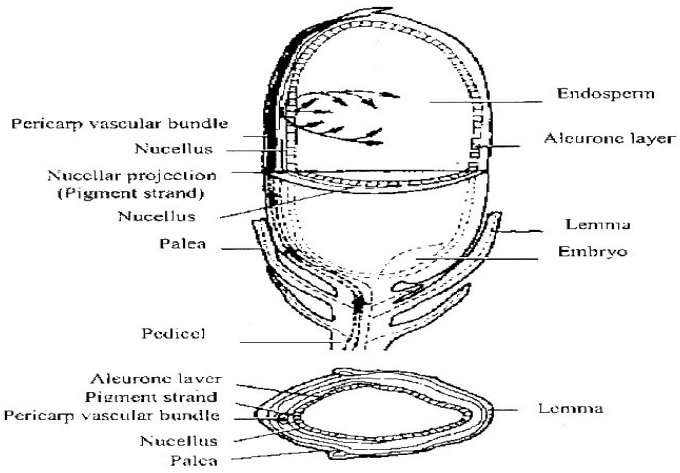


Fig. 3 Structure of the rice grain. (From Juliano, 1985.)

A. Rice

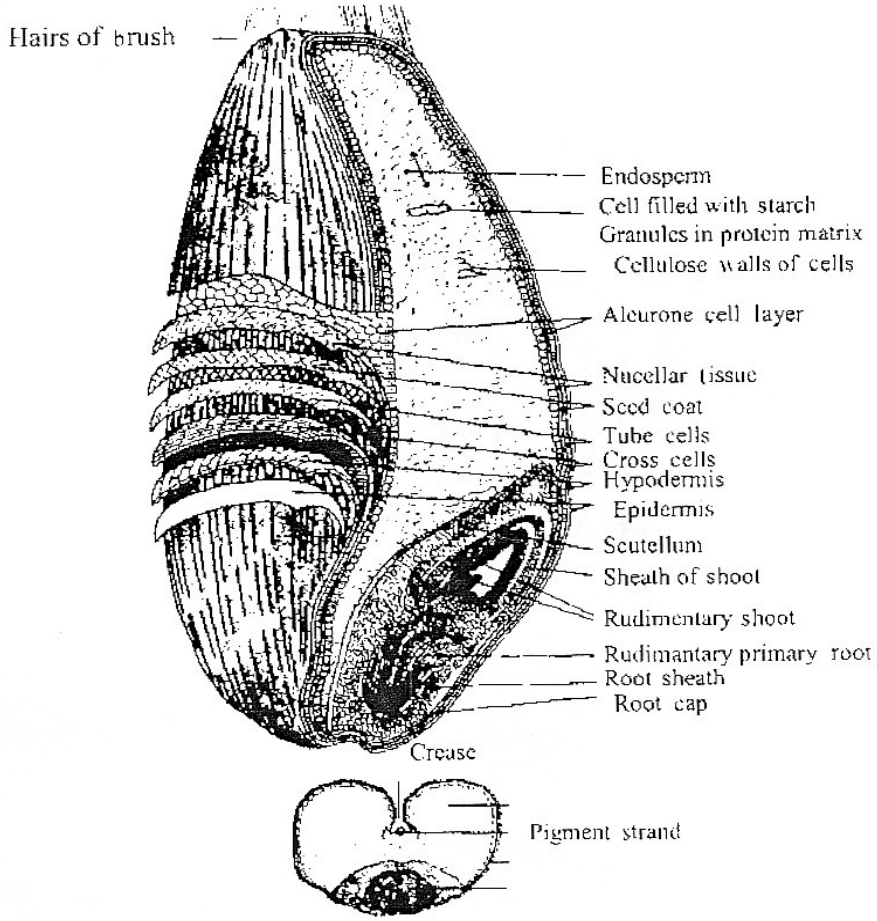


Fig. 1 Diagrammatic illustrations of wheat structure. (From Lasztity, 1999.)

B Wheat

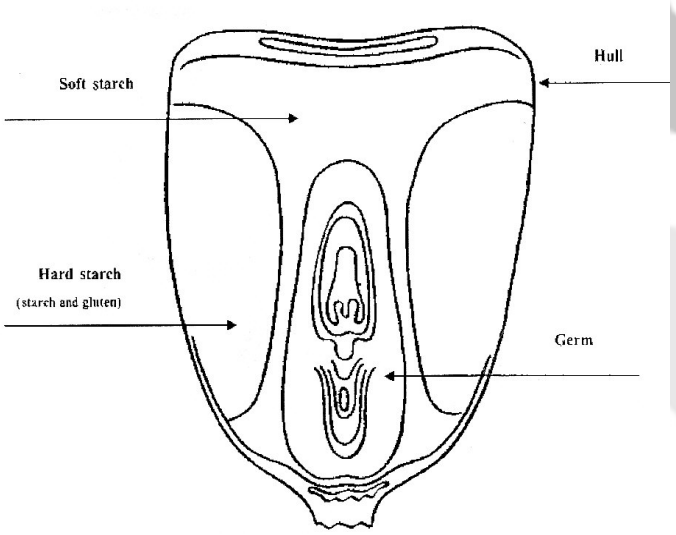


Fig. 2 Diagram of a corn kernel. (From Potter, 1986.)

C Maize

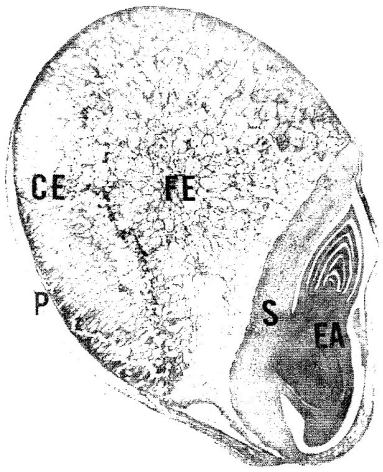


Fig. 7 Cross section of the sorghum grain: P, pericarp; CE, corneous endosperm; FE, floury endosperm; SA, stylar area; S, Scutellum; EA, embryonic axis. (From Hulse et al., 1980.)

D. Sorgum

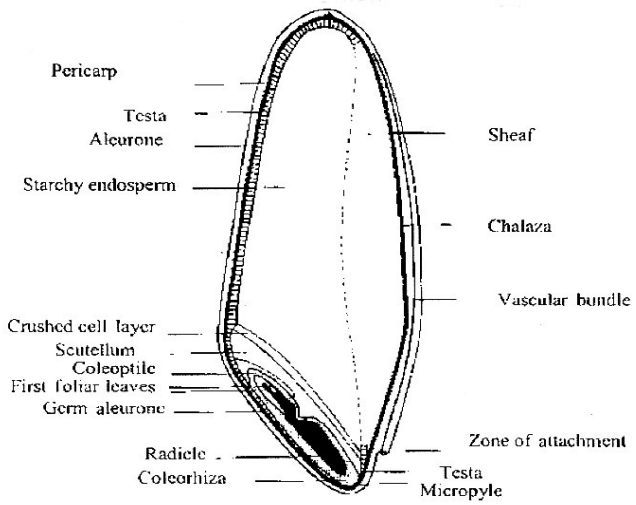
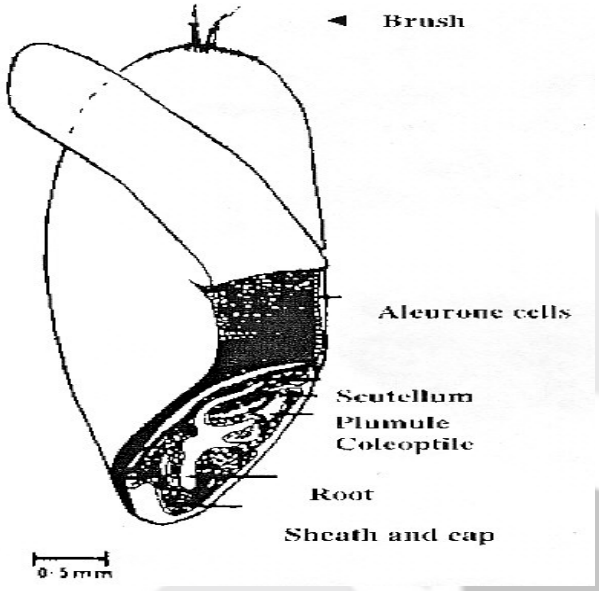


Fig. 4 Structure of the mature barley. (From MacGregor and Bhatty, 1993.)

E. Barley



F. Rye

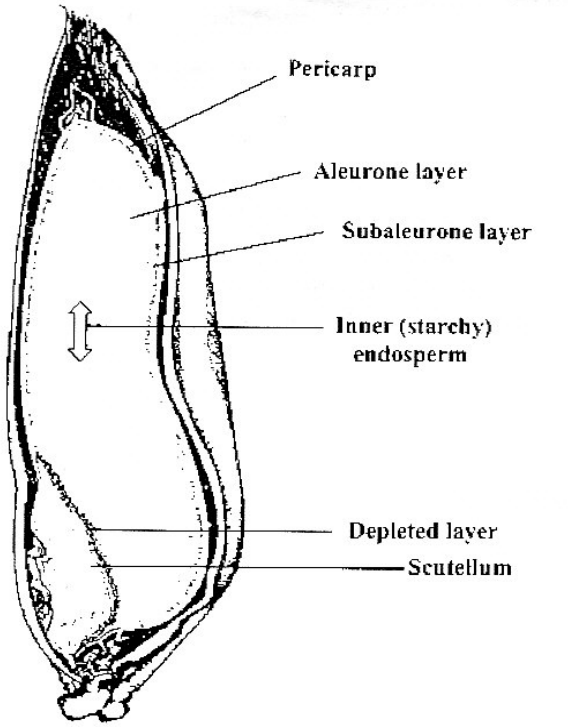


Fig. 5 Oat kernel structure. (From Webster, 1986.)

G. Oat