Consortium for Educational Communication

Module on

Barley and Oats

By

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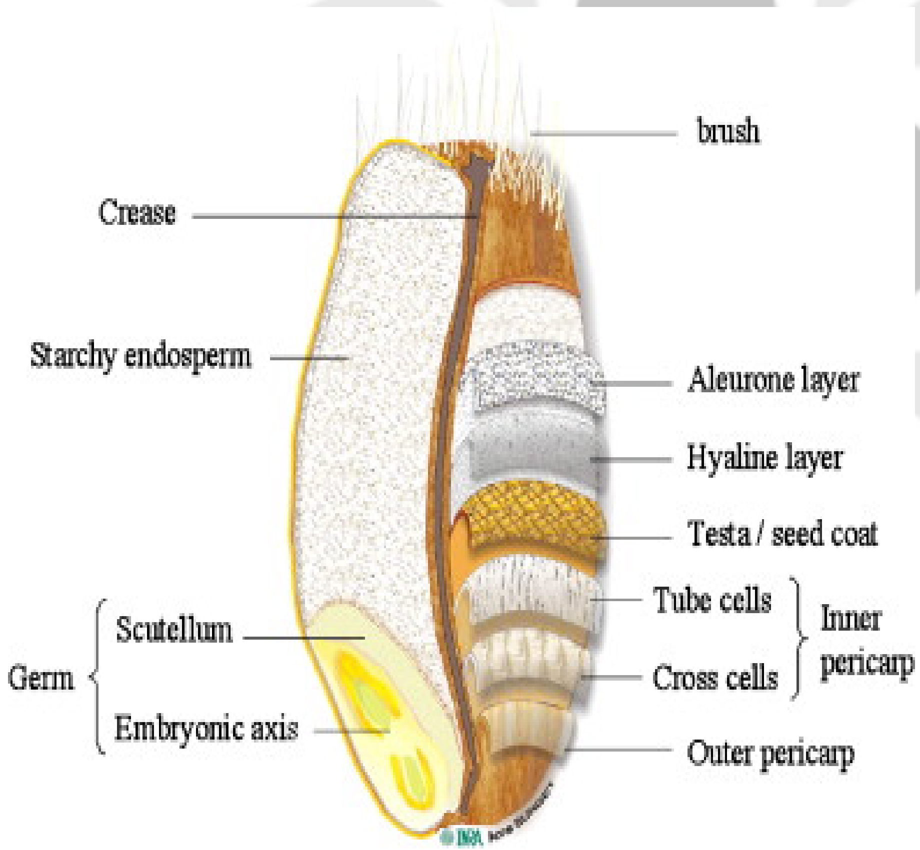
Introduction

Barley is a member of the *grass family*. It is a self-pollinating, diploid species with 14 chromosomes. The wild ancestor of domesticated barley, *Hordeum vulgare* subsp. *spontaneum*, is abundant in grasslands and woodlands throughout the Fertile Crescent area of Western Asia and northeast Africa, and is abundant in disturbed habitats, roadsides and orchards. The cereal is not grown in humid tropical and semitropical regions. Outside this region, the wild barley is less common and is usually found in disturbed habitats. However, in a study of genome-wide diversity markers, Tibet was found to be an additional center of domestication of cultivated barley. Barley is the world's fourth most important cereal crop, in terms of quantity produced (136 million tons) and in area of cultivation (566,000 km^2) after wheat, maize (corn), and rice. Barley probably came into cultivation about 10,000 years ago. Barleys are annual grasses that may be autumn or spring sown (winter and spring forms). The old English word for 'barley' was *baer.*

Grain Structure

Barley grains are roughly cigar shaped, larger and more pointed than wheat, with a shallow furrow running along the ventral side. The kernel of covered barley consists of the caryopsis and the flowering glumes. The husks consist of two membranous sheaths that completely enclose the caryopsis. One of the husks, the lemma, is extended into a long, thin awn. It is the awn that gives a barley grain its characteristic brush like or bearded appearance. In some novel "varieties" the lemma bears three awns, is extended as a complex structure called a hood, or it is not extended at all. In barley, the husks are cemented to the kernel and remain attached after threshing. The husks protect the kernel from mechanical injury during commercial malting; strengthen the texture of barley steeped to moisture of about 42%, and to contribute to a more uniform germination of the kernels. The husks are also important as a filtration bed in the separation of extract components during mashing and contribute to the flavor and astringency of beer. Cross cells are in a double layer and their walls do not appear beaded. Only one cellular testa is present. Two to four aleurone layers are present, cells being smaller about 30μm in each direction.The main types of cultivated covered barleys, depending on the arrangement of grains in the ear, are two rowed and six rowed. The axis of the barley ear has nodes throughout its length; the nodes alternate from side to side. In the six-rowed types of barleys, three kernels develop on each node-one central kernel and two lateral kernels. In the two-rowed barleys, the lateral kernels are sterile and only the central kernel develops.

The color of the grain in covered barleys depends on the color of the caryopsis and the second husk (the palea). Color in the caryopsis is due to anthocyanin pigments or to a black melanin like compound. Anthocyanin, when present, is red in the pericarp and blue in the aleurone layer. The husk constitutes about 11% of the grain. The proportion varies according to type, variety, grain size and climatic conditions. Large kernels have fewer husks than small kernels. The husk in two rowed barleys is generally lower than in six rowed barleys.



Cross section of barley grain

Chemical composition of Barley

Barley grain is rich in starch and sugars, relatively poor in protein and very low in fat. The husk is mostly composed of lignin, pentosans, mannan, uronic acid, hemicelluloses and cellulose fibers. The starchy endosperm is composed of about 85-89% starch enclosed in cell walls. Barley samples usually have nitrogen contents in the range of 1.3% to 2.5% dry matter. For feed purposes and for making enzyme rich malts, high nitrogen grains are preferable, but to produce high quality, pale malts lower nitrogen contents are required (e.g.,1.4% -1.65%; 8.75%-10.3% “protein”).Barley proteins are not “balanced” for the nutrition of monogastric animals, being particularly poor in lysine. The total lipid content of barley is usually about 3.5%, 2.5% being neutral lipids that are concentrated in the embryo and the aleurone layer. β-glucans make up 75% of cell wall and the rest is arabinoxylan. Embryo consists of about 7% cellulose, 14- 17% lipids, 14-15% sucrose, 5-10% raffinose, 5-10% ash and 34% proteins. Barley grains contain many other substances in smaller amounts including a range of vitamins, minerals, and phenolic minerals. The phenolic materials in barleys are varied; about 100 have been detected. The proanthocyanidins (polymeric flavonoid compounds) have attracted the most interest. The proanthocyanidins (“anthocyanigins”) have tanning properties and influence haze formation and probably other characteristics in beers and malt vinegars.

Typically,in plump two-rowed barleys, the husk and pericarp together made up 9% to 14% of the grains dry weight, the testa plus the nucellar cuticle plus the pigment strand 1% to 3%, the embryo (axis plus scutellum) 2% to 5%, the aleurone layer 8% to 15%, and the starchy endosperm around 75%.

Pigments in Barley

Anthocyanins of the cyanidin type can be found in the green organs of barley cultivars; catechins are located in the seed coat and mature kernel. Tannins complex with proteins and often account for off- colors that are noted especially during processing.

Health Benefits Barley

- Barley is rich in dietary fiber, which gives food to the friendly bacteria present in the large intestine. These bacteria ferment the insoluble fiber content of the barley to form butyric acid. The acid, in turn, functions as the main fuel for intestinal cells. Besides this, it is functional in maintaining a healthy colon.
- The dietary fiber in barley aids the production of acetic acids and propionic acid as well, which sever as the fuel for liver and muscle cells. Propionic acid also restricts the action of HMG-CoA reductase, which is involved in cholesterol production in the liver. In this way, barley helps in reducing the cholesterol

level in blood.

- The friendly bacteria that are fed by barley's insoluble fiber also help in removing the pathogenic bacteria from the body.
- Barley is rich in niacin, which is highly effective in reducing the risk of cardiovascular diseases. It prevents the oxidation of LDL, by free radicals. Niacin also lowers the assembling of platelets, which can lead to the clotting of blood.
- The cereal is effective against diseases like atherosclerosis, diabetes, insulin resistance and ischemic stroke.
- Barley's rich content of insoluble fiber helps women fight against the formation of gallstones.
- It is rich in phosphorous, which has an integral part in the formation of body cells' structure. Phosphorous is required for the formation of mineral matrix of the bones. Besides, it is an important component of compounds like ATP, nucleic acids and lipid-containing structures, like nervous system and cell membranes.
- Barley helps in maintaining a healthy intestine. It helps in decreasing the transit time of fecal stuffs and also increases the bulk. As a result, the risk of colon cancer and hemorrhoids get reduced to a considerable extent.
- The cereal contains copper, which reduces the symptoms of

rheumatoid arthritis. Copper is also required for the activity of lysyl oxidase, an enzyme required for the cross-linking of collagen and elastin. These substances provide the basic substance and flexibility to bones, joints and blood vessels.

Food uses of Barley

- The major use of barley is as a component of animal feeds**.** It is also used in some foods for humans. Naked grains are used in human foods in the former USSR, the Himalayan regions, Japan, China, and Korea. Husked barleys are milled and breads from the flours are used in Europe, especially by the urban poor.
- Barley flakes may be used in soups or in breakfast cereals and occasionally, in brewing as a mash tun adjunct.
- Barley may be roasted and ground, the products being extracted with hot water to provide the basis of hot drinks used-worldwide as a caffeine- free “health” drink.
- Malt flour is a source of α-amylase and other enzymes, so used in baking.
- Barley malts are also used in the preparation of malted drinks-beers, whiskies, malt extracts and malt vinegar.

OATS

Avena sativa L. (Gramineae), commonly known as Oat, Groats, Haber, Hafer, Avena, Straw, Oatmeal, is a species of cereal grain grown for its seed (Coffman, 1977; Gibbs Russell et al., 1990; Suttie, 2004). The word Avena is derived from the Sanskrit word "avi," meaning "sheep" or "avasa," meaning "foodstuff". Oats are hexaploid crop, which evolved from three distinct diploid progenitor species through natural interspecific hybridization and polyploidization (Leggett & Thomas, 1995).An important characteristic, which distinguishes A.*sativa* from the many wild oat species is that A.*sativa* does not shed its grain on ripening. Oats are a temperate crop and compared with other cereals grow well in damp,marginal upland areas.Oats are grown throughout the temperate climate regions of the Northern and Southern hemispheres.Depending on variety, oats may be sown in the autumn (winter types) or in the spring (spring types).The winter types can tolerate mild frosts, but oats are not as winter hardy as rye, wheat, or barley.Thus only the spring types are grown in regions that experience harsh winters.

Avena sativa L. is an annual grass about 1.5 meters high; culms tufted or solitary, erect or bent at the base, smooth. The leaves are non-articulate, green, and the sheaths rounded on the back, the ligules are blunt and membranous. The inflorescence is a diffuse panicle with 2–3 florets. Its lemma's are rarely awed. The grain is tightly enclosed by the hard lemma and palea. Seed size varies with the cultivar; it is commonly about 30,000 seeds per kilogram crop (Gibbs Russell et al., 1990).

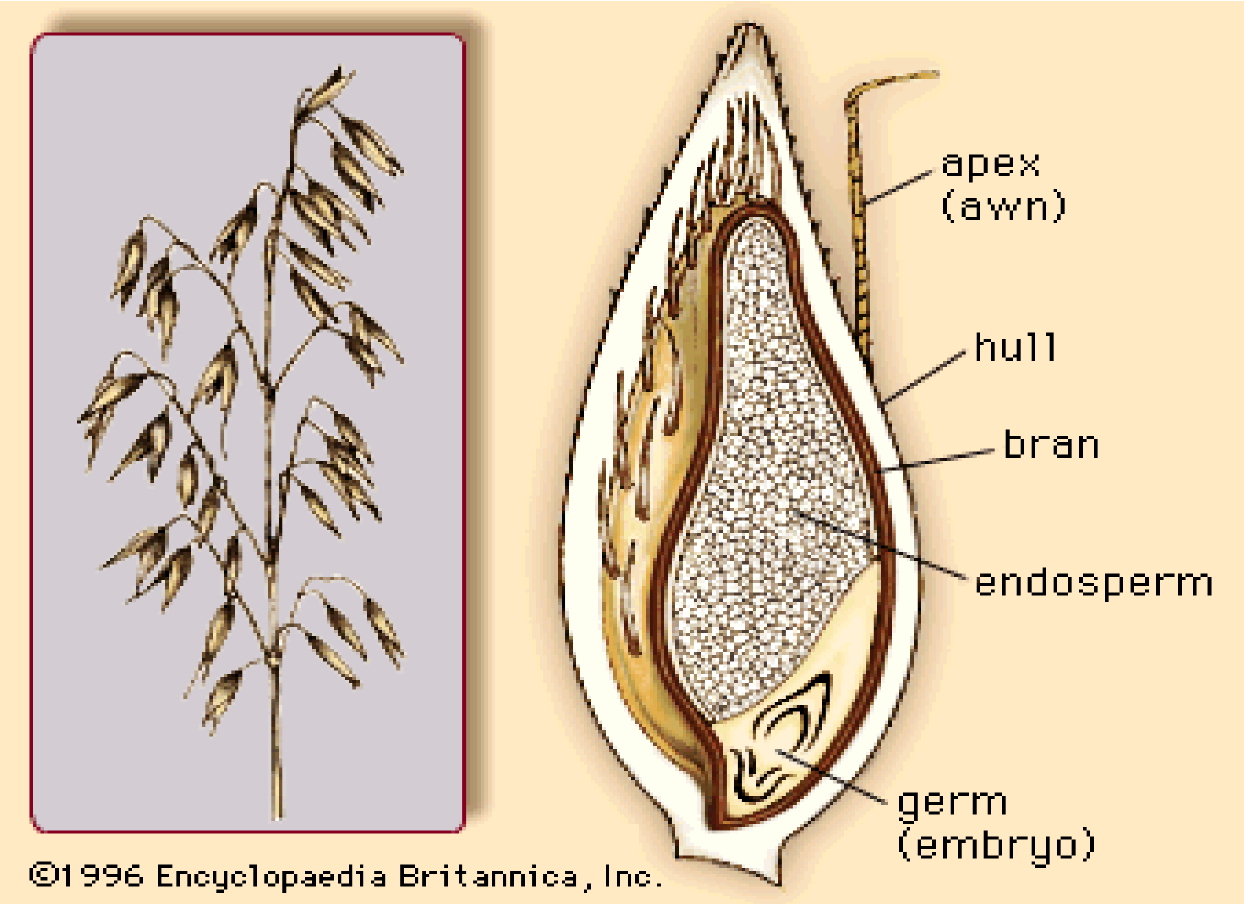
PRODUCTION

Oat is produced in various countries around the world. According to the UN Food and Agriculture organization (FAO-STAT, 2009) the total world production of oats in the year 2008 was around 25.8 million metric tons (mmt); Russia being the top producer (5.8 mmt) followed by Canada (4.2 mmt), United States (1.3 mmt), Poland (1.2 mmt), Finland (1.2 mmt), Australia (1.2 mmt), Ukraine (0.9 mmt), Germany, Belarus, and China, (0.8, 0.6, and 0.4 mmt, respectively).

Structure of Oats

The common varieties of oats have the fruit (caryopsis) enveloped by a hull composed of certain floral envelopes. Naked or hull less oat varieties are not extensively grown. In light, thin oats, hulls may comprise as much as 45% of the grain; in very heavy or plump oats, they may represent only 20%. The hull normally makes up approximately 30% of the grain. Oat kernels, obtained by removing hulls, are called groats. Thegroat is considered the whole grain of oats.It is elongated—spindle shaped, up to about

0.5 inch in lengthand0.125 inch or less in width. It is generally covered with fine, silky hairs and includes the seed coat layers of cells, starchy endosperm and the embryo. Only two pericarp layers can be distinguished in oats, an epidermis with many trichomes on the outer surface and a hypodermis consisting of an irregular, branching collection of worm -like cells with long axes lying in all directions. The testa comprises a single cellular layer with cuticle. In cross section the nucellar epidermis can be seen as a thin colorless membrane.In endosperm there is a single aleurone layer. The cell walls are not thick. Starch granules are polydelphous consisting of many tiny granuli which fit together to form a spherical structure. Endosperm cells of the oats have relatively high oil content.



Cross section of oats grain

Chemical composition of Oats

The various components in Oats are not uniformly distributed in the kernel. The hull and bran are high in cellulose, pentosans, and ash; the germ is high in oil and rich in proteins,sugars, and, generally ash.The endosperm contains the starch,haslower protein content than the germ and the bran and is low in fat and ash. Oat groats have relatively good amino acid balance, high in gobulin (salt –soluble fraction) and low in prolamins (alcohol-soluble fraction).Various lipids like sterylesters, triglycerides, partial glycerides, free fatty acids, glycolipids, and phospholipids were separated from oat (Hutchinson and Martin, 1955). Oats also contain significant amounts of dietary fiber, which is high in soluble fiber (Welch,1995).This soluble fiber, which is composed mainly of β-glucan, is also known as oat gum. Oats also contribute significant amounts of dietary minerals (Mg, P,Fe,Cu and Zn) and vitamins (thiamine,vitaminE,folate,niacin) (Welch, 1995).

Oat grain composition

Component	% Age
Moisture	13.3
Protien	13
Lipids	7.5
Fiber	10.3
Ash	3.1
Calcium	60
Phosphorus (mg/ 100g)	372
Iron(mg/ 100g)	3.8
Zinc(mg/ 100g)	3.9
Niacin (mg/ 100g)	1.3
Thiamin (mg/100g)	0.50

Avenanthramides in oats

Avenanthramides are phenolic compounds and consist of anthranilic and hydroanthranilic acid linked to one of several hydroxycinnamic acids through anamide bond. Oats is the only source of avenanthramides.The three most predominant avenanthramides in oats are avenanthramide 1,3& 4 .Its levelsrange from 40 -132 micro g/g in the oat grain. It is heat suitable during processing.

Therapeutic Effects of Oats

- Plasma cholesterol lowering

  Dietary oats have been shown in several studies to lower elevated plasma cholesterol, and in particular low–density lipoprotein cholesterol, which is a major risk factor for heart disease. The soluble fiber gum (β-glucan) is the major cholesterol- lowering components (Ripsin et al., 1992; Welch, Peterson, &Schramka,1988). For an oat product to be eligible for a claim under the FDA ruling, it must provide at least 3 g/day of β-glucan.

- Modulation of plasma glucose levels

  Reductions in postprandial blood glucose responses and associated decrease in insulin levels are important in the control of diabetes. The postprandial blood glucose response after consumption of oat products is low compared with many other foodstuffs (Wolever et al., 1994).Although many factors are responsible for this , the major factor is β-glucan gum, which increases digesta viscosity and modulates glucose uptake(Wood et al., 1994).

- Improving gastrointestinal function

  Foods high in dietary fiber exert a number of potentially beneficial effects on the gastrointestinal tract, including decreasing transit time and increasing fecal bulk (Hillemeier,1995). Oats are used in digestion problems including irritable bowel syndrome (IBS), diverticulosis, inflammatory bowel disease (IBD), diarrhea, and constipation Oats are also helpful in preventing colon cancer.

- Oats and celiac diseases

Celiac disease is characterized by a severe adverse immunological reaction of the intestinal mucosa to gliadins. Gliadins are a component of the gluten protein found in wheat, rye and barley, and these cereals are excluded from the diet of patients with celiac disease. Recent two studies have shownthat the consumption of oat products did not result in adverse effects in patients with celiac disease (Janatuninen et al., 1995; Srinavasan et al., 1996).

- Other potentially beneficial effects

Oats and oat products may also improve gastrointestinal health by providing a number of substrates for large bowl fermentation that confer beneficial effects on the intestinal mucosa.

Oats contain a wide range of nutrients and non-nutrient antioxidants, including copper, selenium, tocols, sterols, phenolics, phytate,andsaponin.Dietary antioxidants have the potential to alleviate damage to biological molecules such as DNA and lipids and thus may help to alleviate or to prevent diseases such as cancer or heart diseases.

Food uses of Oats

Oats have been included in the human diet in Europe since at least the first century AD, when it was consumed as porridge, gruel, and in types of bread (Ranhotra&Gelroth, 1995). However, oats persisted as a dietary staple only in Ireland, Scotland, and England where oats were used in porridges, oatcakes, haggis, puddings, scones, leavened baked goods, and fermented gel products. Oats are still consumed as traditional porridge and oatcake. However oats are used as ready to eat breakfast cereals, bakery goods, snack foods, infant foods and other products. They are also used as a whole groat product, they impart a characteristic nutty flavor, they have a comparatively high nutritional value and they give high therapeutic effects. However, oats lack gluten, and it is thus not possible to produce high quality leavened bread from oats without the addition of other materials. Oats are used as food and feed grains as livestock and human foods since ancient times. Some have been used as pasture, hay or silage.

Industrial uses of Oats and Barley

At present, few oats are used industrially. The industrial uses of oats have been reviewed by Pomeranz(1995). Oat hulls have also been used as a raw material for fermentation to furfural, a chemical solvent used in refining minerals and for making resin. The potential furfural content is found to be 22% in oat hulls. Oats have been used in a range of cosmetic products and cleansing agents including soaps and facial masks (Pomeranz,1995)

Various dry and wet milling processes have been developed for the separation of oats into a number of fractions, including oil, gum, starch, and protein. The oil is high in unsaturates and also contains galactolipids, which have applications as a viscosity reducing agent and emulsifier. The gum fraction, which is the main cholesterol-lowering agent, is made up of about 70% β-glucan and is highly viscous in aqueous solution. Oat gum has potential applications in cosmetics and as a hydrocolloid in a wide range of foodstuffs. Oat starch could also replace other starch sources in a wide range of applications. Oat protein isolates, including deamidated and acylated oat protein, have some interesting functional properties of use in food systems.These include high viscosity,good water and fat binding capacities, and good emulsifying power.Although a number of potential food applications have been developed for oat protein,current use is low.Ethanol obtained from the fermentation of cereals like oats and barley has been used for many years as motor fuel. Ethanol has higher octane number, thereby increasing engine power and reducing noise.Besides food use starch is used in paper industry. Starch is an excellent binder and is used in the manufacture of charcoal briquettes, ceramics, gypsum board and chalk.