

# Barley

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## I. Scientific Classification and Etymology

**Kingdom:** Plantae - Plants

**Subkingdom:** Tracheobionta - Vascular plants

**Superdivision:** Spermatophyta - Seed plants

**Division:** Magnoliophyta - Flowering plants

**Class:** Liliopsida - Monocotyledons

**Subclass:** Commelinidae

**Order:** Cyperales

**Family:** Poaceae - Grass family

**Genus:** *Hordeum* – barley

**Species:** *H. vulgare*

Barley is a member of the grass family Triticeae (Appendix A). Wheat and rye also fall into this grass family. In total, there are thirty-one barley species. Of the thirty-one, three-fourths are perennial grasses, blooming every summer and dying back in the winter.

Although there are so many types of barley, scientists hypothesize that they all originated from one ancestor plant, the *Hordeum spontaneum*.<sup>1</sup>

Similar to wheat, the taxonomic classification of barley has been modified with increased knowledge of genetic relationships. This scientific evidence shows that wheat

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<sup>1</sup> Solomon Katz, *Encyclopedia of Food and Culture* (New York: Charles Scribner, 2003) p. 94

and barley are actually much more related than initially thought. The genetic relationships between the different types of barley are very similar. *H. vulgare* is a diploid with two sets of chromosomes. The barley plant is self-fertile. The male plant fertilizes its own or adjacent flowers on the same plant. This self-fertilization increases the chance of mutations being copied and passed down in newer generations<sup>2</sup>.

Barley grown for brewer's malt is called malting barley, as opposed to feed barley, and is divided into two general types: 2-row and 6-row. Once farmers had acquired a domesticated two-row form of barley, they selectively favored the six-row form. As a perennial, the barley plant blooms in spring and summer. Each node on the plant produces three flowers.<sup>3</sup> The most obvious difference between a head of 2-row barley and a head of 6-row barley is the arrangement of the kernels when the head is viewed down its axis. The significant differences are found upon closer examination. In general, 6-row malted barley has more protein and enzyme content than 2-row malted barley. Additionally, it is also thinner than two-row malt and contains less carbohydrate. There are also flavor differences between 2-row and 6-row. According to multiple sources, some brewers feel 2-row malt produces a fuller, stronger malt flavor and 6-row malt produces a grainier flavor in the finished beer.

## **II. Nutritional Information**

Barley has been cultivated and consumed by millions since the Stone Age. Because of its adaptability and durability, it can grow in so many locations. Although

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<sup>2</sup> Gomez-Macpherson, H. 2001. *Hordeum vulgare*. EcoPort Entity 1232, <http://www.ecoport.org>

<sup>3</sup> Katz, p. 95

today barley is more commonly used to make animal feed and in the malting of beer, it once was a main food staple for humans. In terms of food today, barley is used in lots of soups and also served as a side dish. By soaking barley over night, the cooking time is reduced<sup>4</sup>.

One cup (237 ml) of cooked pearled barley contains 193 calories, while the whole-grain (hulled) form contains 270 calories and contains as much protein as a cup (237 ml) of milk.<sup>5</sup>

Nutritional Information

<b>Serving</b>	1 CUP
<b>Calories</b>	193
<b>Protein</b>	3.5g
<b>Carbohydrate</b>	44.3g
<b>Total Fat</b>	.69g
<b>Fiber</b>	5.9g

<b>Water</b>	15%
<b>Nitrogenous compounds</b>	12.981%
<b>Gum</b>	6.744%
<b>Sugar</b>	3.2%
<b>Starch</b>	59.95%
<b>Fat</b>	2.17%

**III. Health Benefits and Concerns of Barley**

Barley has been proven to help improve certain health conditoin. At the same time, by eliminating barley and wheat from a person’s diet has also proven to help other

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<sup>4</sup> Fastnaught, C.E., 2001. Barley fibre. In Cho, S., Dreher, M. (Eds.). “Handbook of Dietary Fibre”. Marcel Dekker, (New York) p. 519-542.

<sup>5</sup> "Nutrition Notes." *National Barley Foods Council*. 20 Mar 2008 <<http://www.barleyfoods.org/index.html>>.

health issues. Celiac disease is an intestinal disorder induced by an intolerance to gluten which is found in barley, wheat and rye. Celiac disease is associated with osteoporosis and bone loss. According to research, greatly reducing barley, wheat and rye intake usually results in an improvement in gastrointestinal symptoms within a few weeks, although in some cases improvement may take many months. As a preventive measure, people prone to Celiac disease are advised to follow a gluten-free diet to ensure a normal bone density<sup>6</sup>.

Different from Celiac disease, high cholesterol can be improved with the inclusion of barley into a person's diet. In the cell wall of barley, beta-glucan can be found. This sugar complex is the key ingredient for cholesterol lowering effects in oat bran. Upping barley consumption increases beta-glucan and adds more soluble fiber into a person's system.<sup>7</sup>

One of barley's other nutritional benefits is its high fiber content. Barley has both soluble and insoluble fiber. Soluble fiber is effective in lowering blood cholesterol and can reduce the risk of heart disease. Additionally, soluble fiber is also beneficial in slowing the absorption of sugar and reducing the risk for developing type 2 diabetes. The insoluble fiber found in barley may be beneficial in helping the body maintain regular bowel function. Insoluble fiber may also help lower the risk for certain cancers such as colon cancer.<sup>8</sup>

In addition to its low fat and high fiber nutrients, barley also has many vitamins and antioxidants. Barley contains several vitamins and minerals including niacin (vitamin

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<sup>6</sup> Gabert, V.M., Jorgensen, H., Brunsgaard, G., Eggum, B.O., Jensen, J., 1996. *The nutritional value of new high-lysine barley varieties determined with rats and pigs.* Canadian Journal of Animal Science. 76, 443.

<sup>7</sup> Gabert p. 446

<sup>8</sup> "Nutrition Notes." *National Barley Foods Council.* 20 Mar 2008  
<<http://www.barleyfoods.org/index.html>>.

B3), thiamine (vitamin B1), selenium, iron, magnesium, zinc, phosphorus and copper.

The antioxidants in barley work to slow down the rate of oxidative damage by gathering up free radicals that form when body cells use oxygen<sup>9</sup>.

### III. Growing and Cultivation

There are two types of barley. The number of kernel rows in their head can distinguish the two types. The first type, *Hordeum vulgare* is the barley variety that is generally cultivated. This type is also called six-row barley. The second type is two-row barley. This type used to be classified as *Hordeum distichum* but now is also classed as *Hordeum vulgare*.<sup>10</sup>

Barley is the most hardy of all cereal grains, its limit of cultivation extending farther north than any other; and, at the same time, it can be profitably cultivated in sub-tropical countries. Barley is adaptable to various climates such as the Arctic regions and deserts but does not grow well in areas with high humidity<sup>11</sup>. Barley's germination time is anywhere from 1 to 3 days. Barley prefers to grow under cool conditions but is not particularly a good winter crop. Barley is a very hardy perennial with a relatively short growing season, maturing in about three months. Its hardy qualities permit barley to tolerate flooding, drought conditions, and even frost. An added bonus for the farmer is this grain's ability to resist insect infestation.<sup>12</sup>

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<sup>9</sup> Pins, J.J., Kaur, H., 2006. A review of the effects of barley beta-glucan on cardiovascular and diabetic risk. *Cereal Foods World* 51, p 8.

<sup>10</sup> Daniel Lapedes, *Encyclopedia of Food, Agriculture & Nutrition* (New York: McGraw-Hill, 1977) p. 84

<sup>11</sup> Andrew Smith, *The Oxford Encyclopedia of Food and Drink in America* (New York: Oxford University Press, 2004) pp. 77-85

<sup>12</sup> Smith, p. 78

## **Morphology**

Barley shares similar traits with wheat and rye's morphology. Barley has two types of root systems. The first is where seedling roots develop to a tillering stage. Tillers are shoots that sprout from the base of a grass. The second type starts at the tillering stage and then grows deeper crown roots, which anchor the plant in the soil and help absorb water and nutrients.<sup>13</sup>

On average the barley plant is approximately one meter tall. The stem of the plant has on average five to seven joints separated by the nodes, which grow the leaves. The leaves are linear lanceolate, meaning they are narrow and taper to a pointed apex. The leaves are formed of and formed of sheath, blade, auricles and ligule (appendage that looks like a strap).<sup>14</sup>

## **Physiology**

Barley has three distinct growth phases: vegetative phase, reproductive phase and grain filling phase.

- I. The first phase, the vegetative phase hosts the germination of the seed, the growth and emergence of seedlings and tillering phase where the roots begin to establish themselves in the soil. The budding of the small flowers marks the ending of the vegetative phase. The length of the first phase varies depending on climate and soil conditions, but generally lasts between five to ten days.

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<sup>13</sup> Lapedes, p. 83

<sup>14</sup> Lapedes, p 87

- II. The next phase, the reproductive phase includes the start of budding flowers, the stems elongate and the plant begins to stand tall. Later in the phase, the flowers begin to open and pollen grains begin to germinate.
- III. The third and final phase is grain filling. This phase is ten days long, where the grain matures with cellular divisions. Maturation occurs when the grain dries up, and shrinks, becoming difficult to break. Total maturity is reached when the last node on the barley head dries up. Harvest can begin before this stage, as long as there are installations available for drying the grain.<sup>15</sup>

## **Growing**

Barley should germinate simultaneously so that most of the crop is at the same maturity level during the reaping. On nutrient-rich soils, barley tends to grow too quickly, which in turn, produces an uneven growth of the crop. The best barley is grown on light, open and preferably calcareous soils. If a soil is too high in nutrients, wheat can be grown before the barley to reduce soil conditions.<sup>16</sup>

Barley is a rapidly growing and shallow-rooted plant. The upper layer of the soil must therefore be free from weeds, which would choke the barley plants. In most farming rotations barley is grown after turnips or wheat. The ground is left untouched and open to elements of winter before the soil is stirred with cultivator. The barley seeds are usually planted in March or early April. The seeds should be light in color and covered in a fine skin with small wrinkles. In early farming areas, seeding may take place as early as

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<sup>15</sup> Jack Harlan, *Distribution of wheats and barley*. Science 153.1074-80.

<sup>16</sup> Jack Harlan, p. 1078

February and rarely extends beyond the end of April. Nitrogen is often used as a fertilizer in order to maximize the barley's yield without damaging the crop or harming the consumer.

Compared to other grains, barley is the toughest grain in the field. Before exposing the endosperm, recognized as our familiar pearl barley, two inedible husks and another softer, edible coating called the aleurone are removed. The germ, layered between the two outer husks, is also discarded, leaving a pile of valuable nutrients in the bin that becomes animal feed rather than human food.

Barley may be subject to damage by a range of diseases, including powdery mildew, bacterial blight, and viral diseases.<sup>17</sup> These diseases are managed by a combination of strategies including the use of disease-resistant varieties, application of fungicides, tillage practices, timing of crop rotation and planting. Additionally, with the genetic modification, scientists are trying to make the plant more resistant to infections.

Bacterial blight is one of the more common diseases to strike barley. Bacterial blights first appear as small, water-soaked spots on the barley leaves. The small spots grow until they resemble large brown streaks down the leaf's veins. A bad infection of bacterial blight kills leaves. To avoid the problem, use clean seed, practice crop rotation, avoid overhead irrigation if blight becomes a problem, and eliminate crop residue<sup>18</sup>.

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<sup>17</sup> "Small Grain Barley Stripe." UC Pest Management Guidelines. February 2007. University of California Agriculture and Natural Resources. 31 Mar 2008 <<http://www.ipm.ucdavis.edu/PMG/r730100411.html>>.

<sup>18</sup> "Small Grain Barley Stripe." UC Pest Management Guidelines. February 2007. University of California Agriculture and Natural Resources. 31 Mar 2008 <<http://www.ipm.ucdavis.edu/PMG/r730100411.html>>.



#### IV. The Origin and History of Barley

Barley was one of the first agricultural domesticates together with wheat, peas (*Pisum sativum*), lentils (*Lens culinaris*), goats (*Capra aegagrus hircus*), sheep (*Ovis aries*), and cattle (*Bos taurus*) dating from about 10,000 years (Smith, 1998). Barley was first used as human food but evolved primarily into a feed, malting and brewing grain due in part to the rise in prominence of wheat and rice. Ancient texts from many cultures in Asia, Africa, and Europe refer to barley as an important dietary constituent<sup>19</sup>. The earliest remains of barley have been dated back to 8000 B.C. in Iran. Wild wheat was also found in these sites, however barley proved more abundant. Agriculture spread from western Asia, following Neolithic migrations south and west to North Africa, north and west to Asia minor and Europe, then to the rest of the world. Barley was recognized early on as a hearty tasting, high-energy food. For example, the Roman gladiators were known as “hordearii” or “barley men” for eating barley to boost energy levels.

Barley played a vital role in the establishment and growth of the Old World. According to multiple sources, there is overwhelming evidence proving that barley was very important crop, reaching back thousands of years. In the Bible barley is listed along with wheat, emmer, spelt, millet and sorghum.<sup>20</sup>

Ancient Hebrews revered barley as a very special plant along with grapes, figs, pomegranates, olives, and others. In 2800 B.C., the Chinese also saw barley as a very important crop similar to rice. Spreading to Europe, barley’s uses increased. In Greece, the traditional breads were made of both wheat and barley. Barley was ultimately a staple

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<sup>19</sup> Harlan, Jack R., and Daniel Zachary. 1966. *Distribution of wheats and barley*. Science 153.1074-80.

<sup>20</sup> Newman, C.W. and Newman, R.K., 2006. *A brief history of barley foods*. Cereal Foods World 51, 4-7.

food for ancient Greeks because of its ability to grow in dry and difficult climates. Today in Crete, barley bread is still prevalent. In Mesopotamia, roasted barley was sold in the streets and marketplaces. Additionally, barley was key in the fermentation to make beer all over the globe (see modern day uses for barley).<sup>21</sup>

Today, barley is the fourth largest grain crop after wheat, rice and corn. It is still grown in many different countries throughout the world (Appendix B). Like wheat in the western world and rice in the eastern world, barley production, because of its importance in malt beverages, is often a cultural, rather than economic phenomenon. Some of these locations include Europe, Ethiopia, Russia, China, India, Canada, the United States, and the Mediterranean areas that include Greece, Turkey, Iran, Syria, and Egypt.<sup>22</sup>

Due to the fact that barley adapts well to different types of environments, it is grown in many regions throughout the United States. In the United States, a total of 27 states grow barley to some extent. Major producing states include North Dakota, Idaho, Montana, Washington, Colorado, Wyoming, Virginia, Minnesota, Maryland, South Dakota, Oregon and Utah. According to the U.S. Grains Council Website, “Between 1999 and 2003, an average of 2 million hectares were planted to barley in the United States. Although this represents less than 2 percent of the total crop area in the country, the United States is the eighth-largest barley producing country in the world.”<sup>23</sup>

Compared to other global barley producers, the United States produces only 3-5 percent of the 130-155 million metric tons (approximately 6-7 billion bushels) of world

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<sup>21</sup> Andrew Smith, *The Oxford Encyclopedia of Food and Drink in America* (New York: Oxford University Press, 2004) p. (77-85)

<sup>22</sup> Lapedes, Daniel N. McGraw-Hill Encyclopedia of Food, Agriculture & Nutrition. New York: McGraw-Hill, 1977.

<sup>23</sup> Newman, p 5

barley output. Although this number is a small portion of total barley output, the U.S. is consistently one of the top ten world barley exporters. While we export, some countries only import barley because they cannot grow enough of it. Saudi Arabia, Japan, and China are the largest importers of the world's barley.<sup>24</sup> The barley imported is imported for a variety of uses: animal feed, human consumption, and barley malt for beer production.

Today, about two-thirds of the barley crop has been used for feed, one-third for malting and about 2% for food directly. However, throughout its history, it has remained a major food source for some cultures principally in Asia and northern Africa<sup>25</sup>. Barley is arguably the most widely adapted cereal grain species with production at higher latitudes and altitudes and farther into deserts than any other cereal crop. It is in extreme climates that barley remains a principal food source today<sup>26</sup>.

## **V. Barley in Malt and Beer Production**

Although the cultivation of barley parallels the domestication of animals, studies show that it was the early brewing of beer that really increased barley domestication. The beer making process requires just four ingredients: barley, water, hops, and yeast. Barley provides sugars and amino acids for yeast growth, and the yeast converts the sugars to ethyl alcohol in a process called fermentation. Before barley is used to make beer, it is converted to “malt” to render it a better substrate for brewing. Malting is essentially a

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<sup>24</sup> Lapedes, p. 86

<sup>25</sup> Newman, p. 7

<sup>26</sup> Marta Izydorczyk, "Evaluation of Contributions of Barley Polysaccharides, as Value Added Components, to Functional Properties of Model Starch and Food Systems." <<http://www.gov.mb.ca/agriculture/research/ardi/projects/98-013.html>> April 2002

process of shortened seed germination. When grain enters the malt house, it is first steeped in water for two to three days. After steeping, the barley is transferred to germination beds for three to four days. There the grain begins to produce enzymes capable of degrading the starch, protein, and the cell walls. The barley grains are then subjected to heat that kills the growing seedling and dries up the remnant grain, but leaves intact the components of the endosperm and as well as the enzymes capable of degrading them. The end product is malt. How the roasting step is carried out plays a large part in determining the color and flavor of the final product. Roasting stops the germination process, but - if stopped in time - leaves needed enzymes active.<sup>27</sup>

The malt is the key ingredient used by beer breweries for beer production. The roasted grain then goes through a process called 'mashing', in which the starches are converted to sugars and dissolved in hot water (to make wort) in the first phase of brewing. The mash is then transferred into to a container with a sieve on the bottom, called a lauter tun. Here the liquid fraction of the mash, called wort is separated from the residual solids by filtration. Traditionally, barley is used for beer production because the hulls of the barley malt settle in the lauter tun and participate in filtering out residual solids. The resultant wort contains the soluble amino acids and sugars liberated by enzyme action. Hop plant flowers are added to the wort and boiled. The hop oils add certain flavors to the beer and protect against contamination.<sup>28</sup> The wort is then cooled and transferred to a fermentation vessel, and inoculated with yeast. The yeast use sugars

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<sup>27</sup> Bendelow, V.M., LaBerge, D.E., 1979. *Relationship among barley, malt and beer phenolics*. Journal of the American Society of Brewing Chemists 37, 89-90.

<sup>28</sup> Andrew Smith, *The Oxford Encyclopedia of Food and Drink in America* (New York: Oxford University Press, 2004) p. (77-85)

and amino acids from the malt to grow, and as it grows the metabolism of the sugar maltose leads to the production of ethyl alcohol and carbon dioxide as by-products of the fermentation process. After fermentation, the yeast and other solids are allowed to settle out. This is followed by an aging process, carbonation, and packaging of the final product (Appendix C).<sup>29</sup>

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<sup>29</sup> Newman, R.K., Newman, C.W., 1991. *Barley as a food grain*. Cereal Foods World 36, 800-805.

## Appendix A



## Appendix B



Field of two-row barley which is commonly used in beer.

## Appendix C



Different types of beer depend on the malting process of the barley.



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