



Brewing Grains



Brewing grains are the heart and soul of beer. Next to water they make up the bulk of brewing ingredients. Brewing grains provide the sugars that yeast ferment. They are the primary source of beer color and a major contributor to beer flavor, aroma, and body. Proteins in the grains give structure to beer foam and minerals deliver many of the nutrients essential to yeast growth. By far the most common brewing grain is malted barley or barley *malt*, but a variety of other grains, both malted and unmalted, are also used including wheat, corn, rice, rye, and oats.

What is Malt?

To put it plainly, *malt* is cereal grain that has undergone the *malting process*. In the simplest terms, malting is the controlled germination and kilning of grain. Malting develops the *diastatic enzymes* that accomplish the conversion of starch to sugar during brewing and begins a limited process of conversion that makes the starches more accessible to the brewer. Malting also gives brewing grains their distinctive colors and flavors.

Only the highest quality grain, called *brewing grade*, is selected for malting. Brewing grade grain is selected for, among other things, high starch content, uniform kernel size, low nitrogen content, and high *diastatic power*. Diastatic power is the ability of grains to break down complex starch molecules into simpler sugars for brewing. It is determined by the amount of diastatic enzymes in the grain.



Barley is the most commonly malted grain, but other grains like wheat and rye are also malted. Because of process variations, malts of similar types from different maltsters provide very different flavors to beer. Brewers take great care in selecting the proper malts from specific maltsters to achieve their desired result.

Malted grain is used in a number of applications besides beer brewing, including whiskey production, malted milkshakes, malt vinegar, and Whoppers™ candies.



The Malting Process

Malting is a three-step process consisting of steeping and germination, drying, and finally kilning.

- *Steeping and Germination* – The malting process begins when the grains are steeped for thirty-eight to forty-six hours until they have absorbed almost 50% of their initial weight in water. They are then drained and moved to a germination room where they are kept at a constant humidity and temperature for almost four days. They are turned periodically to maintain an even grain bed temperature of 60° to 75° Fahrenheit (all temperatures are given in Fahrenheit), which promotes germination. The germination step takes advantage of the plant's natural growth cycle, activating enzymes already present in the grain that begin the process of unpacking and breaking down the proteins and starches at the kernel's center. The degree to which this breakdown occurs is referred to as *modification*. Most brewing malt produced today is highly modified, meaning a significant amount of enzyme development and starch conversion has taken place, making these essential elements easily accessible to the brewer.
- *Drying* – Once the maltster determines that the grains, now called *green malt*, are sufficiently modified, they are moved to a kiln and carefully dried to about 4% moisture content. Drying takes place over a period of twenty-four to thirty-six hours at a temperature of 122° to 158°. For some types of malt this is the end of the process. These are called *base malts*.
- *Kilning* – After drying some grains are heated in kilns at higher temperatures and for longer periods of time. This extended kilning gives these malts the unique colors and flavors. Lower temperature and shorter duration kilning results in light colored grains with more subtle flavor characteristics. Longer kilning times and higher temperatures result in dark colored malts with more intense flavors. Two chemical reactions are involved in the development of these colors and flavors, *caramelization* and *Maillard reactions*. Caramelization is the decomposition of sugar at high heat. It results in sweet flavors like toffee, molasses, and raisin. The Maillard reaction is the darkening that results from interactions of amino acids and sugars. It is the same reaction that makes toasted bread brown or creates grill marks on meat. Maillard reactions result in the bready, toasty, and biscuity flavors associated with baking. Malts that have undergone kilning or roasting are called *specialty grains*.



Types of Malt

Malts fall into four categories based on the length of time, temperature, and moisture level during kilning. These four categories are *base malts*, *crystal or caramel malts*, *toasted malts*, and *roasted malts*.

- *Base Malts* – Low temperature and short duration kilning makes base malts the lightest colored of the brewing malts. Because high temperature kilning eventually destroys grain starches and denatures the diastatic enzymes, the low-level kilning of base malts allows them to retain the highest level of potential sugar and the highest degree of diastatic power of all the malt types. This means that they contribute a large amount of sugar to the beer and are able to convert not only their own starches but also those of other grains with lower diastatic power. For this reason, base malts make up the bulk of the grain bill for any brewing recipe, usually at least 85%. Because of the high enzyme content of these grains, base malts are always made from barley or wheat. Common base malts are pilsner malt, pale ale malt, Munich malt, and Vienna malt. Base malts are the source of most of the sugars in beer and impart a soft, grainy, sweetness. Munich and Vienna malts are kilned at slightly higher temperatures for darker color and toastier flavor. Some beer styles that commonly contain only base malts are Pilsner, Munich Dunkel, and Cream Ale.
- *Caramel or Crystal Malts* – *Caramel* and *Crystal* are two names for the same type of malt. Caramel is the American version and Crystal is the English. To create caramel malts the green malt is moved to a roaster after germination instead of being dried. In the roaster the grains are heated to between 150° and 158° Fahrenheit, the temperature at which certain of the diastatic enzymes are activated. These enzymes convert the starches into sugars inside the grain, leaving them in a semi-liquid state. After conversion the grains are roasted at temperatures between 220° and 320° according to the amount of color and flavor desired. This high temperature roasting causes caramelization of the sugars into less fermentable forms and darkening of the grain through the Maillard reaction. Lighter caramel malts impart honey and caramel flavors while the darker caramel malts give richer toffee, burnt sugar, and raisin flavors. Malt color is described in *degrees Lovibond* named after the inventor of an early method of measuring the color of beer. Lower Lovibond numbers designate lighter grains and higher numbers are darker. Caramel malts are identified by their Lovibond rating and range from Caramel 10° L to Caramel 120° L and Special B 150° L. Caramel malts are prominent in American Amber Ales, English Bitters, and Scottish ales.





- *Toasted Malts* – Toasted malts are made by kilning fully dried base malts at temperatures up to 335°. The higher temperature, low-moisture kilning increases the Maillard reaction with less caramelization, giving these grains medium to dark brown colors and toasty, nutty, and biscuity flavors. Examples of toasted malts are amber malt, brown malt, Victory malt, and aromatic malt. Toasted malts are used for Brown Ales and to add malt complexity in American Pale Ales or Bocks.
- *Roasted Malts* – Roasted malts are the darkest and most intensely flavored of the malts. They are what give Stouts and Porters their black color and robust roasty flavor. To produce them green malt is first kilned at temperatures around 165° with low moisture. Once the grains have dried, the temperature is slowly raised to between 420° and 480°. This process causes some caramelization, but the majority of color and flavor comes from the Maillard reaction. At these temperatures the grain can burn. To prevent this they are sprayed lightly with water. High temperature roasting turns these grains black and gives them intense chocolate, coffee, and roasted flavors. Because of their intensity a little bit goes a long way. Roasted grains typically make up only a very small percentage of the grain bill in any beer recipe, around 3% to 5%. Greater amounts are used in some Stouts. Miniscule amounts can be used to darken beer color with minimal effect on flavor. Roasted grains include black patent malt, chocolate malt, and Weyermann Carafa®. One of the roasted grains, roasted barley, is not malt at all, but is actually made by roasting raw barley. Beers that use roasted malt include Stouts and Porters. They are often used in very small amounts in Scottish Ales and Brown Ales.

Malted Grains

Malted Barley

By far the preferred grain for brewing is barley. Barley is a member of the grass family and is the fifth largest cultivated cereal crop in the world. It is also one of the oldest, with evidence of cultivation in the Near East going back more than eight thousand years. The use of wild barley has been dated back to 23,000 BC. Barley is grown primarily in cooler temperate regions with top producers including Russia, Canada, Spain, and Germany. The majority of the domestic barley crop is grown in the North Central states of North and South Dakota, Montana, and Idaho. There are three types of cultivated barley, two-row, four-row, and six-row, referring to the number of kernel rows on each stalk. Only two and six-row barley are appropriate for brewing, with the majority of malting barley being two-row. Varieties of barley commonly used for brewing include Harrington, Klages, Halcyon, and the much sought after English Marris Otter.





Of all the cereal grains, barley is particularly well suited to brewing. It has a short germination period, which makes it good for malting. It has a high starch content that translates into higher yields of extracted sugar in the brewing process. Barley has a low protein content, which reduces haze in beer, and a high level of diastatic enzymes for starch conversion. The majority of barley used in brewing is malted, but it is also used raw or unmalted.

Other Malted Grains

Besides malted barley, brewers also use malted wheat, rye, and oats. They serve a number of uses including enhancement of body and increase of head formation and retention. They also contribute unique flavor characteristics.

- *Wheat* – Of these other malted grains wheat is the most common. Evidence shows that wheat was domesticated around the same time as barley. It is the third most cultivated cereal grain, with the leading producers being China, India, the United States, and Russia. Wheat has higher protein content than barley, which produces beers with a fuller mouthfeel and a rich, creamy head, but can also result in hazy beers. Wheat malt has enough diastatic power to convert its own starch, meaning that large amounts can be used to make wheat beers. By law a German wheat beer must contain at least 50% wheat. Many contain as much as 70%.
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- *Oats & Rye* – Rye is seeing increasing use in the craft beer industry. It is closely related to wheat and barley and is grown all over the world. The leading producers of rye are Russia, Poland, and Germany. A small amount of rye is grown in the United States. Rye brings a unique spicy flavor to beer that cannot be achieved with any other grain. Oats are grown in temperate zones with cool, wet summers. The leading producers are Russia, Canada, and the United States. Oats are high in protein, fat, and oil that make them less suitable to brewing than other malts as they can negatively affect head formation and retention. They are used primarily in oatmeal stouts where they give a full, rich mouthfeel and cookie dough flavors and aromas. The use of malted oats in beer is rare with only one English maltster, Thomas Fawcett & Sons, still producing them. Both oats and rye are low in diastatic enzymes meaning they must be used in conjunction with malted barley for proper starch conversion to occur.

Unmalted Grains

In addition to the malted grains, brewers also use a variety of unmalted grains called *adjuncts*. These include rice, corn, barley, wheat, rye, and oats. Adjuncts serve a variety of purposes such as lightening body and color, increasing body, adding complexity to flavor and aroma, and making gluten free beers.



In order for enzymatic conversion to occur, grain starches must be *gelatinized*, meaning their structure must be broken down by heat and water. Each grain has a different temperature at which gelatinization occurs. Unmalted grains generally have a higher gelatinization temperature than malted grains, meaning special steps must be taken to make the starches available for conversion. If raw grains are used brewers must perform what is called a *cereal mash* that involves boiling them with a portion of the barley malt to achieve gelatinization and begin conversion. Another option is to use flaked or rolled grains, like oatmeal, which are gelatinized during processing, and thus don't require special procedures. Adjunct grains generally have little or no diastatic power and so must be used with base malts for starch conversion.

- *Corn* – Corn is a common adjunct in American Lagers as well as English Bitters and Milds. Originally introduced into American Lagers as a way to balance the high protein content of the six-row barley that American brewers had available to them, it is now mostly used to lighten color and body without sacrificing alcohol content. Used in small amounts, it has relatively little effect on flavor. In larger amounts it can impart a pleasant corny character. Corn is available to brewers in either a flaked version or as corn grits.
 - *Rice* – Like corn, rice is used to lighten color and body. It has less affect on flavor than corn and results in drier beers. Rice is a common ingredient in American and Japanese Lagers. Several craft brewers have also started using rice to make lighter beers. Rice is available to brewers as flaked rice or dehydrated rice syrup solids.
 - *Wheat* – Unmalted wheat gives a sharper “wheat” character to beers than malted wheat. With more intact starches and proteins than malted wheat, it can result in hazy beers, but can also enhance mouthfeel and head retention. Unmalted wheat is commonly used in wheat beers and is essential to brewing Lambic, Belgian Wit, and Berliner Weiss. The flaked version is most common, *torrified wheat* is also used. Torrified wheat has been puffed like Rice Krispies™. This breaks down the cellular structure for easier starch conversion that can mean higher sugar yields for the brewer.
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- *Barley* – Flaked barley has higher protein content than malted barley and is used to enhance body and head retention.
 - *Rye* – Like unmalted wheat, unmalted rye produces a sharper, spicy rye character. It also contains more proteins that enhance body and head retention. Unmalted rye is normally used in flaked form.
 - *Oats* – Flaked oats are used primarily in stouts to enhance body and head retention, but brewers are increasingly experimenting with raw oats in other styles such as IPAs and Porters. Flaked oats also provide a soft bready or cookie dough flavor in Oatmeal Stouts. Oats contain more fat than other grains and give a distinctive “oily” mouthfeel.