

The Science of Brewing:

How 4 simple ingredients become the best beverage in the world

Part 1: Barley

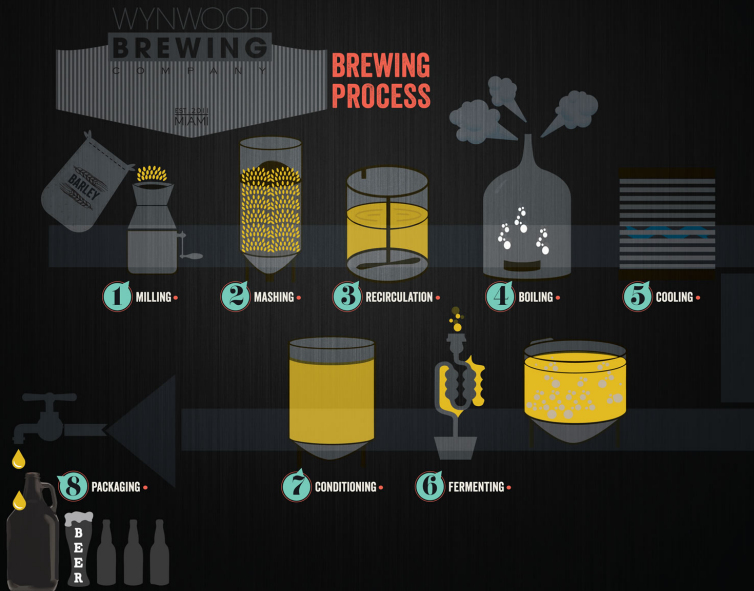
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March 31, 2017

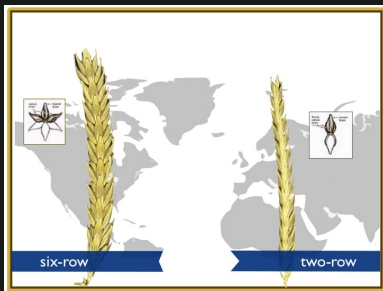
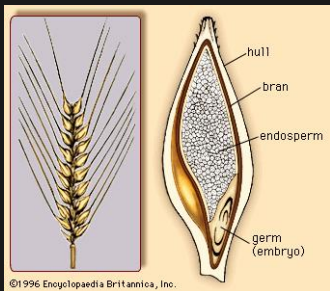
Ingredients

- Barley
- Hops
- Water
- Yeast



Barley

- . *Hordeum vulgare*
- . 4th Most Produced Grain



2-row vs 6-row

	Two Row	Six Row
Lineage	ancestral	derived
<i>vsr1</i> locus	WT	mutant
Where	old world	new world
Protein vs Carbs	more sugar	more protein/enzymes
Starch Conversion	less yield per head	2-4% lower extraction
Germination Time	2 days	4 days
Diastic Power	++	+++

Malting

- . Dry: Grains are dried to encourage natural dormancy
- . Steep: Hot water is added to grains to rehydrate the kernels for 2-3 days, encourage sprouting
- . Germinate: Embryo starts making enzymes and converting start reserves
- . Kiln: Germination is halted to preserve optimal sugar and enzyme content



Malt Types

Malt Type	Lovibond	Modification	Characteristics
Lager	2	++	neutral
Pale Ale	3	++	general purpose
Biscuit	25	++	bready
Victory	25	++	bready/nutty
Munich	10	++	oktoberfest
Vienna	4	++	bocks
Carapils	3	++	texture
Caramel 10	10	+	honey
Caramel 40	40	+	light caramel
Caramel 60	60	+	full caramel
Caramel 120	120	+	bittersweet caramel
Special B 220	220		plums, nutty bitter caramel
Chocolate	400		bittersweet chocolate
Black Patent	580		charcoal
Roast Barley	550		coffee, Guinness

Other Grains

Type	Characteristics
Wheat	crisp, wheaty
Rye	flavorful, spicy
Oats	creamy
Rice	clean
Corn	light

Mash

- Protein Rest 30-40°: Encourages proteases
- Mashing 60-70°: Encourage α and β amylases
- Hot Crash 75°: Denaturation of Enzymes

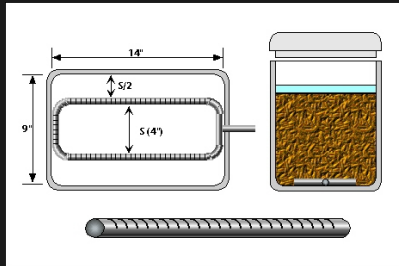
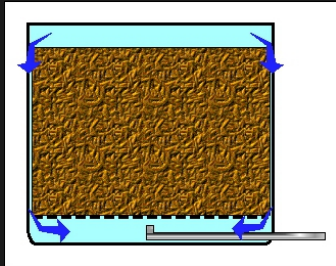
Enzymes

Table : Mash Enzymes and Their Optimal Temperatures

Enzyme	Temp (°C)	pH Range	Function
Debranching (var.)	35-45°	5.0-5.8	Solubilization of starches.
β Glucanase	35-45°	4.5-5.5	Best gum breaking rest.
Peptidase	45-55°	4.6-5.3	Produces Free Amino Nitrogen (FAN).
Protease	45-55°	4.6-5.3	Breaks up large proteins that form haze.
β Amylase	55-66°	5.0-5.5	Produces maltose.
α Amylase	67-72°	5.3-5.7	Produces a variety of sugars, including maltose.

After the Mash: Lautering

- . Goal is to achieve maximum extraction of sugars
- . Temp $> 77^{\circ}$ leads to tannin extraction from hulls
- . Sparging is the addition of more water to rinse grains
- . Aim for volume about 1.4x desired final volume
- . Grain husks create filter



BGCP Guidelines: 9E. Strong Scotch Ale

Aroma: Deeply malty, with caramel often apparent. Peaty, earthy and/or smoky secondary aromas may also be present, adding complexity. Caramelization. Hops very low to none.

Appearance: Light copper to dark brown color, often with deep ruby highlights. Clear. Usually has a large tan head, which may not persist in stronger versions.

Flavor: Richly malty with kettle caramelization often apparent. Hints of roasted malt or smoky flavor may be present, as may some nutty character, all of which may last into the finish. Hop flavors and bitterness are low to medium-low, so malt impression should dominate. Esters may suggest plums, raisins or dried fruit. The palate is usually full and sweet, but the finish may be sweet to medium-dry (from light use of roasted barley).

BGCP Guidelines: 9E. Strong Scotch Ale, cont.1

Mouthfeel: Medium-full to full-bodied, with some versions (but not all) having a thick, chewy viscosity. A smooth, alcoholic warmth is usually present and is quite welcome since it balances the malty sweetness. Moderate carbonation.

Overall Impression: Rich, malty and usually sweet, which can be suggestive of a dessert. Complex secondary malt flavors prevent a one-dimensional impression. Strength and maltiness can vary.

Comments: Also known as a “wee heavy.” Fermented at cooler temperatures than most ales, and with lower hopping rates, resulting in clean, intense malt flavors. Well suited to the region of origin, with abundant malt and cool fermentation and aging temperature. Hops, which are not native to Scotland and formerly expensive to import, were kept to a minimum.

BGCP Guidelines: 9E. Strong Scotch Ale, cont. 2

Ingredients: Well-modified pale malt, with up to 3% roasted barley. May use some crystal malt for color adjustment; sweetness usually comes not from crystal malts rather from low hopping, high mash temperatures, and kettle caramelization. A small proportion of smoked malt may add depth, though a peaty character (sometimes perceived as earthy or smoky) may also originate from the yeast and native water. Hop presence is minimal, although English varieties are most authentic. Fairly soft water is typical.

Commercial Examples: Traquair House Ale, Belhaven Wee Heavy, McEwan's Scotch Ale, Founders Dirty Bastard, MacAndrew's Scotch Ale, AleSmith Wee Heavy, Orkney Skull Splitter, Inveralmond Black Friar, Broughton Old Jock, Gordon Highland Scotch Ale, Dragonmead Under the Kilt

Microsoc Brew #2: Scotch Wee Heavy

The Grains:

- . 7kg Marris Otter (2row)
- . 250g Roasted Barley

The Mash:

- . 30min @ 40°
- . 40min @ 60°
- . 20min @ 70°

Microsoc Brew #2: Scotch Wee Heavy

The Boil:

- . 3/4 Volume for 60mins
- . 1/4 Volume for 30mins (kettle caramelization)
- . 75g Fuggles hops @ 60mins
- . 25g Fuggles hops @ flameout

The Fermentation:

- . Starter from 3/4 yeast (safbrew T-58)
- . Starter from 1/4 yeast (safbrew T-58) after 2 weeks

Estimated Final ABV: 9.0%

Sources

- <http://howtobrew.com/book/section-3/how-the-mash-works/mashing-defined>
- <https://www.britannica.com/plant/barley-cereal>
- <https://www.slideshare.net/kourtney-kathryn/advanced-foods-presentation-beer>
- <https://www.integrowmalt.com/about-integrow/malting-barley-storage.html>
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