BICEP #6

This session covers adjuncts, alcoholic and clove-like off flavors and BJCP Categories 12 & 13 - Porters, & Stouts

Key to Abbreviations and Text

Bolded Text (except for headers) is important information which you should know for the exam.

Italic Text is "just for fun" and won't be covered on any of the exams.

***** This material might appear on the Online Qualifier Exam.

† This material might appear on the Tasting Exam.

‡ This material will be (or might be) tested on the Written Proficiency Exam.

Part 1: Adjuncts*‡

For purposes of this class, an "adjunct" is any material added to the mash, wort or raw beer which boosts the original gravity (O.G.), alters the final gravity (F.G.) of the finished beer or which alters the beer's aroma, appearance, flavor or mouthfeel.

While the Bavarian (later German) Reinheitsgebot law forbids beer from being made from anything other than malt, hops, water and yeast, brewers have actually been using other materials in their beer ever since beer was invented. And, despite the common prejudice that adjuncts make a beer somehow inferior, they are commonly used to make many excellent styles of beer. Common classes of adjuncts are given below:

A. Unmalted Grains: Adjunct grains are any *unmalted* grains (or similar materials) added to the grist before or during mashing. Because the grains are unmalted, they have no diastatic power - that is, insufficient amylase enzymes to convert their starches to fermentable sugars. To overcome this limitation, adjunct grains must be mashed along with highly diastatic pale malts. These malts have high levels of diastatic enzymes, allowing them to convert not only their own starches to sugars, but also the starches present in the adjunct grains.

Adjunct grains and similar materials are widely used in commercial brewing, especially "industrial" or "macro" brewing, because most of these materials are much cheaper than malt. Since big breweries use thousands of tons of malt per year, and most consumers will not notice if the beer is made using 5-10% rice or corn, the cost savings can be significant. Historically, however, adjunct grains such as wheat were more expensive than barley, so beers made with those grains were premium products.

For homebrewers, who aren't so concerned with cost, there are two good reasons to use adjuncts, authenticity and distinctiveness. When brewing certain styles of beer, adjunct grains help define the parameters of the style. This is especially true for certain historical American styles or clones of certain commercial beers. Certain adjunct fermentables also impart distinctive characteristics to a beer's aroma, appearance, flavor and mouthfeel.

Type of Adjuncts: Adjunct grains are available in a variety of forms, ranging from raw to highly-processed. When working with adjunct grains, you must first determine if the grains have been previously gelatinized or not.

1) Whole grains: In their simplest form, adjunct grains are whole, raw grains such as seed corn, millet or whole buckwheat. Whole grains require the most processing before they can be used in brewing, but are less expensive than other options. Before they can be used in brewing, whole grains must be ground into grits, soaked in water and cooked into porridge. Cooking gelatinize starches within each grain so that diastatic enzymes in the mash can act on them. Whole grains might retain elements of the seed which are undesirable in brewing, such as husks, germ and bran.

If cooked at temperatures above approximately 168-170 °F, unless they have very thin husks (e.g., corn, millet), or are low in polyphenols (e.g., rice, oats), unprocessed grains can also impart unwanted tannins to your beer. In addition to causing chill haze, tannins can also cause unpleasant astringency.

The bran and the germ can impart oils and fats which interfere with beer head retention and flavor stability. De-husked whole grains don't impart harsh flavors to the beer, but the lack of husks means that a stuck mash is more likely, while the bran and germ can still impart oils. Like whole grains, they must be ground to grits and then cooked before being added to the mash.

2) Partially processed grains: Partially processed grains are raw grains which have been winnowed to remove the husk and possibly milled to remove the germ and bran, leaving behind just the starchy endosperm. In some cases, they have been pre-

Why use Malt?

Question: If adjunct grains are cheaper, and don't detract from flavor, why use malt at all?

Answer: Some grain-based alcoholic beverages don't use malt! Saké is the best-known example of this. It is made by soaking steamed rice in a liquid infused with *koji* - *Aspergillus* fungus. The fungus produces amylase enzymes which break down rice starches so they can be consumed by yeast as fermentation proceeds.

In countries where there is a tax on barley malt, as in Japan, brewers regularly make fermented beverages using mostly, or entirely, unmalted adjunct grains or other fermentable materials. Because they are taxed at a lower rate, these products can be sold very cheaply.

In the U.S. industrial brewers don't use entirely adjunct grains plus amylase enzymes to brew their beer, because, by law, beer must be made from grist which contains at least 50% malt and 1 lb. of hops per 100 barrels. Since "malt beverages" are typically taxed at a lower rate than wines or distilled spirits, brewers have an incentive to make their products using at least the legal minimum amount of malt. Of course, that doesn't keep big breweries from producing malt-based "alco-pops" which push the limits of law.

Such beverages don't taste like beer, though! Barley and barley malt have unique grainy flavors and aromas which most adjunct grains lack. Any alcoholic beverage which contains more than about 10-20% adjuncts will start to taste less like beer and more like something else, perhaps, not as tasty. Since most people are fairly conservative in their tastes, even the most cost-conscious industrial breweries brew products which taste more or less like beer, because that's what their customers expect.

Technically, any beer brewed using more than about 40% adjunct grains often has insufficient Free Amino Nitrogen (FAN) levels for optimal yeast health. Additions of yeast nutrient can correct this problem, but can also cause flavor instability problems in the finished product.

ground. Examples: pearled barley, white rice, corn grits, buckwheat groats or cornmeal.

Milled or "pearled" grains, such as white rice or pearled barley, must still be ground and pre-cooked and can cause a stuck mash if they constitute more than 20% of the grist. This limitation can be overcome by using rice hulls for up to 10% of the total grist, to add extra "filter" material to the mash. De-husked, de-branned grains which have been milled into meal are sometimes called grits (as opposed to corn grits, which have been gelatinized). They must also be cooked, and might cause a stuck mash, but are otherwise suitable for brewing.

3) Processed grains: Processed grains have been winnowed, milled and pre-cooked so that their starches are already gelatinized, making them "mash-ready". In many cases, they are also pre-ground. While such grains might need to be ground or pre-soaked they can be added directly to the mash without cooking them first. Examples: couscous, rolled oats (oatmeal), hominy corn grits, puffed rice.

Flaked grains, such as rolled oats, are de-husked, milled grains which have been moistened and pressed between rollers. The heat from processing gelatinizes the starches within the grain, so they can be added directly to the mash. Torrefied grains, such as puffed rice or puffed wheat, have been dehusked, milled and then steamed under pressure to gelatinize their starches. They are then "popped" by suddenly reducing the pressure, making the water within the grain suddenly evaporate. Torrefied grains are fully gelatinized and can be added directly to the mash. Refined starches, such as instant potatoes, have also undergone extensive processing and are gelatinized. Such starches are very easy to use and can be directly added to the mash, but can easily contribute to a stuck mash.[1]

Note that not all flours or grits are gelatinized! For example, corn starch is just very finely ground corn flour and is not pre-gelatinized. Likewise, corn grits and potato starch aren't necessarily pre-cooked. A rule of thumb when using products from the grocery or health food store is: "The more thoroughly pre-gelatinized products have been cooked, the shorter their listed cooking time." For example, "instant" oatmeal works better when added directly to the mash than "old-fashioned" rolled oats.

The most common brewing grains - barley, corn, oats and rye - are available in flaked or torrefied form from maltsters and brewing supply stores. These materials can be added directly to the mash tun (although some brewers grind them beforehand). Commercial brewers who don't have the ability to do a cereal mash must use flaked or torrefied grains. While they are more expensive than unprocessed or partially processed adjuncts, they are much more convenient in terms of time, labor required and equipment needed.

Sensory Characteristics of Adjunct Grains in Beer: Certain grains impart distinctive characteristics to beer.

1) Corn: This grain is commonly used in "macro" American lagers, such as Standard American Lager and Dark American Lager, but is also a signature grain in many Cream Ale and Classic American Pilsner recipes. In small amounts, it might be present in some commercial brands of English ales. Aroma and Flavor: Sweet and dimethyl Sulfide (DMS) notes.

2) Oats: Small amounts of unmalted oats are sometimes added to some varieties of Stout to increase body or to Belgian Witbier to improve mouthfeel. Oats are a signature ingredient in Oatmeal Stout. Aroma and Flavor: Nutty, grainy and/or earthy notes. Appearance: Suspended proteins and starches impart haziness or cloudiness while increasing head size and retention. Mouthfeel: Smooth, creamy, silky or "oily" mouthfeel and fuller "chewy" body due to higher protein levels and/or suspended starch.

3) Rye: Unmalted rye is sometimes added to American or Belgian specialty beers. Malted rye is a signature ingredient in American Rye Beer and German Roggenbier. Aroma and Flavor: Rich, sour, spicy, slightly peppery or "dry" notes reminiscent of pumpernickel bread. Appearance: Suspended

Starch Gelatinization Temperatures

Starch	° F	° C
Arrow root (maranta)	149-185	65-85
Barley	140-144	60-62
Barley malt	147-153	64-67
Barley†	140-150	60-65
Large starch granules	140-154	60-65
Maize*	144-171	62-77
Maize*†	143-165	62-72
Millets*	129-176	54-80
Oats†	127-138	53-59
Potato	133-160	56-71
Rice*	142-180	61-82
Rice, long grain	160-165	71-74
Rice, short grain*	149-154	65-68
Rice†	154-172	68-78
Rye	120-142	49-61
Rye†	135-158	57-70
Small starch granules	124-198	51-92
Sorghum*	124-167	69-75
Tapioca	145-176	63-80
Waxy corn (amylose free)*	144-176	62-80
Wheat	126-151	52-66
Wheat†	136-147	58-64

Table adapated from Palmer, *How to Brew and* http://braukaiser.com/wiki/index.php?title=Starch_Conversion, accessed 8/31/2010. I have not attempted to reconcile conflicting data.

† Palmer, How to Brew.

* Benefits from pre-boiling.

What is Gelatinization?

Starch Gelatinization occurs when starch molecules are exposed to water and heat, allowing hydrogen bonding sites to engage more water. This increases randomness in the molecule's general structure and decreases the number and size of crystalline regions, which don't allow water to enter. Practically, gelatinization makes starches soften and swell as they absorb water, bursting starch granules so that they can absorb even more water. In brewing, this is important because the amylase enzymes responsible for starch conversion are water-borne.

In cooking, among other things, starch gelatinization makes dry grain products edible. It also makes sauces thicken, custards gel and popcorn pop.

Different starches gelatinize at different temperatures. Gelatinization temperature and speed is also affected by things such as pH and presence of other chemicals, such as sucrose.

proteins and starches impart haziness or cloudiness while increasing head size and retention. Mouthfeel: Smooth, creamy or "chewy" notes due to higher protein levels and/or suspended starch.

4) Sorghum: *This grain is used commercially to make gluten-free beers, it is also used to make some African and Asian indigenous beers: Aroma and Flavor: distinctive sour, earthy notes.*

5) Wheat: Unmalted wheat is sometimes added to American Wheat Beer. It is a signature ingredient in Belgian Wit and Lambics. Wheat malt forms the majority of the grist in German wheat beers. Aroma and Flavor: Sour and/or bready notes. Appearance*:* Suspended proteins and starches impart haziness or cloudiness while increasing head size and retention. *Mouthfeel:* Smooth, creamy or "chewy" notes due to higher protein levels and/or suspended starch.

B. Sugars and Syrups: The next most commonly used types of adjunct after unmalted grains are sugars and syrups. These are used for the same reason as adjunct grains are used - to reduce malt usage and to impart distinctive character to beer.

Since sugars and syrups are almost entirely fermentable (effectively 100% starch conversion) a proportionately smaller mass of sugar needs to be used to achieve the same original gravity. For the same reason, sugars and syrups usually result in thinner bodied beers, although there are exceptions. Technically, dry malt extract and malt syrups could count as adjunct sugars and syrups since they are added during the wort boil rather than being produced during the mashing process.

Depending on the composition of the wort used to make them, malt extracts have a fermentability of about 60-85%. Pure sugars and sugar syrups usually have a fermentability of 96-100%. Brown sugars such as piloncillo, jaggery or turbinado - but not the colored white sugar sold as brown sugar in U.S. supermarkets - typically has a fermentability of about 95%. Molasses has a fermentability of approximately 50-80% based on its type.

Honey has a fermentability of about 80-95% depending on its water content. Maple syrup has a fermentability of about 65%.

Many styles of English beer incorporate up to 10% sugar or glucose syrup. Traditionally, homebrewed versions of English beers often use demerara (AKA turbinado, muscovado) sugar or invert sugar syrup (e.g., Lyle's Golden Syrup™). Darker English beers might use a small amount of molasses.

Belgian strong ales can incorporate up to 20% Candi (i.e., rock crystal) sugar or glucose syrup, although some darker Belgian ales (e.g., Tripels or Belgian dark strong ales) use more deeply caramelized sugars. Some American adjunct lagers use some percentage of corn or rice syrup. Specialty beers might include 2-15% sugar and will be made using ingredients which emphasize the specialty sugar character, particularly in beers made using brown sugar, molasses and/or honey. Gluten-free beers are made using 100% rice and/or sorghum syrups.

Any sugar or syrup other than white sugar or corn sugar will impart a bit of its own flavor to the beer. Belgian strong ales get a bit of their character from the slightly- to moderately-caramelized sugars used to produce them.

Above about 40% sugar or syrup, though, the finished beer will be very thin bodied and will often have a cidery aroma and flavor. At that level, Free Amino Nitrogen (FAN) levels in the wort will be low enough that the brewer might need to add yeast nutrient in order to get the wort to ferment properly.

The exceptions are that dextrin sugar (AKA maltodextrin) and lactose (AKA milk sugar) sugars aren't fermentable by brewing yeast strains, so they make beer seem fuller bodied and sweeter than it otherwise would be.

Dextrin sugar is a simple way for extract or partial-grain brewers to make fuller-bodied beers; it is typically added at a ratio of 1 oz. to 1 lb. per 5 gallons, depending on the fullness of body desired. Lactose or Milk Sugar has a similar effect on the finished beer. It is traditionally used in milk stouts.

C. Fining Agents: A number of materials, which are technically considered adjuncts, are used to clarify wort or raw beer. These will be dealt with in a later lecture.

D. Heading Agents: *Some commercial adjunct lagers add heading agents to their beers to aid head formation and retention. They are not generally necessary for beers made using at least 90% malt.*

One common heading agent is an enzyme called pepsin, which is derived from pork. Other popular heading agents include alginates (derived from seaweed), iron salts, and various gums (e.g., guar gum).

Heading agents make the mouthfeel seem a bit "softer" and creamier, while contributing to larger, longer-lasting head.

E. Coloring Agents: *Some commercial beers add coloring agents, either to make the color of the beer consistent from batch to batch, or to make a light-colored beer seem darker (possibly fooling drinkers into thinking it is maltier and fuller-bodied that it actually is). Caramel color is typically used, although brewers who comply with the Reinheitsgebot use products derived from ground, debittered dark malt (one brand is Sinamar® which is produced by Weyermann).*

Homebrewers generally aren't concerned about color consistency, so they seldom use coloring agents.

F. Herbs and Spices: Herbs and Spices are added to some Belgian and specialty beers. These will be covered in a later lecture.

G. Fruits: Fruits are added to some specialty beers. These will be covered in a later lecture.

H. Vegetables: *Vegetables, especially starchy vegetables such as pumpkins, are added to some specialty beers.* These will be covered in a later lecture.

Sugar and Syrup Varieties

Sugar	Yield	O.G. (lb./5 gal.)	Color (SRM)	Max.	Notes
Brown Sugar, Dark	100%	1.0046	50	10%	Gives a rich caramel sweet flavor. Used in Scottish ales, some old ales and some specialty beers.
Brown Sugar, Light	100%	1.0046	8	10%	Imparts a subtle caramel sweet flavor. Used in Scottish ales, some old ales and some specialty beers.
Candi Sugar, Amber	75-80%	1.0036	75	20%	Crystallized sucrose used in many Belgian ales. Thins body. Gives a lightly caramel, fruity character to beer.
Candi Sugar, Dark	75-80%	1.0036	275	20%	Crystallized sucrose used in many Belgian ales. Thins body. Gives a rich caramel, rummy flavor to beer.
Candi Sugar, Light	75-80%	1.0036	0.5	20%	Crystallized sucrose used in many Belgian ales. Thins body.
Corn Sugar (Dextrose)	90%	1.0042	0	5%	Widely used for bottling at rate of approximately 2/3 cup per 5 gallons of beer. Slightly sweeter and more fermentable by yeast but otherwise identical to white sugar.
Corn Syrup	78%	1.036	1	10%	Syrup derived from corn with many of the same properties as corn sugar. Used to boost gravity without adding body or flavor in some adjunct lagers. Otherwise identical to corn sugar.
Date Syrup	80-95%	1.0036-1.0046	1	10%	Sugar derived from dates. Relatively mild flavor. Otherwise similar to honey.
Demerera Sugar (AKA Barbados, Muscovado)	95-100%	1.044-46	2-25	10%	Dark, unrefined brown sugar that contains molasses and other dark impurities. Adds slight sweetness, fruity, rummy and caramel notes. Used in English brown ales, milds, old ales, porters and stouts.
Dextrin	5%	1.0005	0	10%	Not very fermentable. Used to boost body and aid head retention. Can cause haze if used in excessive amounts.
Golden Syrup, Lyle's	100%	1.0046	50	10%	Mostly invert sugar solution. Delicate taste. Used for some homebrewed English ales, especially pale ales.
Honey	80-95%	1.0036-1.0046	1	100%	Lightens beer flavor and body and imparts distinctive aromas and flavors. Many varieties. For best results pasteurize at low temperatures, add to primary or secondary fermenter, and ferment slowly at cooler temperatures to limit loss of aromatics. A beer with more than about 30% honey, or where honey character dominates is a braggot. A 100% honey beer is actually a form of mead.
Invert Sugar	100%	1.0046	0	10%	White sugar which has been heated in the presence of a mild acid (e.g., lemon juice) to turn it into glucose and fructose. It is used to increase starting gravity in some Belgian and English ales. It is otherwise identical to white sugar.
Jaggery	95-100%	1.044-46	2-25	10%	Indian refined palm sugar. Similar to brown sugar but gives a slightly creamy flavor. Used in specialty beers.
Maple Syrup	65%	1.0030	35	10%	Adds dry, woodsy flavor if added to boil. If added to secondary or at bottling, it will give maple flavor. Used for some specialty beers. Works well for brown ales, porters and stouts.
Milk Sugar (Lactose)	75%	1.0035	0	10%	Boosts body and gives a milk-like sweetness. Not fully fermentable. Used for porters and sweet stouts. Can cause problems for lactose-intolerant folk.
Molasses, American	78%	1.0036	80	5%	Imparts a strong, sweet flavor. Often incorporates a high percentage of corn syrup. Used primarily in stouts and porters.
Molasses, Blackstrap	55%	1.0023	80	5%	Very full flavor, noticeably tarry notes, may be astringent.
Molasses, Dark	60%	1.0030	80	5%	Very full rummy flavor, slightly tarry notes.
Molasses, Light	65%	1.0030	80	5%	Full, rummy flavor.
Piloncillo (AKA Panella)	95-100%	1.044-46	2-25	10%	South American partially-refined sugar. Similar to brown sugar but gives a slightly more buttery flavor. Used in specialty beers.
Rice Syrup, Brown	100%	1.0046	2	100%	Used to boost gravity and lighten body of adjunct lagers. Neutral flavor, can be substituted for liquid malt extract. Commonly used to make gluten-free beers.
Rice Syrup, Light	100%	1.0045	1	100%	Used to boost gravity and lighten body of adjunct lagers. Neutral flavor, can be substituted for liquid malt extract. Commonly used for adjunct lagers or to make gluten-free beers.
Sorghum Syrup, White	72-75%		2-3	100%	Neutral flavor, can be substituted for liquid malt extract. Commonly used to make gluten-free beers.
Sugar, Table (Sucrose)	100%	1.0046	1	10%	White table sugar, or sucrose primarily is used to lighten the body and colour. Using too much will add a cider flavor to beer.
White Sugar	100%	1.0046	0	7%	Common household sugar. Lightens beer flavor and body. Can contribute a cider-like flavor if used in quantities much above 10%, especially in ales or in beer with low FAN.

Part 2: Off-Flavors

Alcoholic

Detected In: Aroma, flavor, mouthfeel (as warming).

Described As: The general effect of ethanol and higher alcohols.

Typical Origins: Yeast activity.

Typical Concentrations in Beer: ?

Beer Flavor Wheel Number: 0110

Discussion: See Ethanol, Fusel Alcohol and Solventy.

Ethanol

Detected In: Appearance, Aroma, flavor, mouthfeel.

Described As: Alcoholic, spicy, peppery or vinous in aroma and flavor. Burning, numbing, prickly and/or warming in mouthfeel. Can also be detected as a prickliness, warming, pepperiness or pain in the nasal passages. High alcohol beer (above ~8% ABV) might have distinct alcoholic "legs" which become visible when the beer is swirled in the glass and then allowed to settle.

Typical Origins: Yeast.

Typical Concentrations in Beer: 25,000-50,000 mg/l.

Perception Threshold: 5,000-13,000 mg/l. (About 6% ABV in beer).

Beer Flavor Wheel Number: 0110.

Discussion: Yeast produces ethanol (along with carbon dioxide) as a major product of anaerobic respiration during fermentation. Acetate and various fusel ("higher") alcohols are produced as minor respiratory byproducts during the metabolism of amino acids. Ethanol, acetate and fusel alcohols can all react chemically with oxoacids to produce esters. Ethanol is detectable at 1.5-2% ABV. Also see Fusel Alcohol and Solventy.

Increased By: Yeast strain (beyond about 9% alcohol). High-gravity/highly-fermentable wort. Proper fermentation temperature for yeast strain. Higher fermentation temperatures. Longer fermentation times (if "feeding" a high-alcohol fermentation).

Decreased By: Improper choice of yeast strain. Poor yeast health/quality. Low fermentation temperatures. Prematurely removing yeast from fermenting wort (e.g., filtering or fining).

To Avoid or Control: Proper wort gravity. Proper level of fermentable sugars in wort. Proper yeast selection. Proper yeast health. Proper fermentation temperature for yeast strain.

When Are Alcoholic Notes Appropriate?: Low to medium-high levels of ethanol aroma, flavor and mouthfeel are desirable in any strong beer, specifically Bocks, Scotch Ale (Wee Heavy), Baltic Porter, Foreign Extra Stout, American Stout, Russian Imperial Stout, Weizenbock, Saison, Bière de Garde, Strong Belgian Ales and Strong Ales.

Very low ethanol notes are acceptable in Vienna Lager, Munich Dunkel, Cream Ale, American Wheat/Rye Beer, English Pale Ale, Irish Red Ale, American Pale Ale, American Amber Ale, American Brown Ale, Robust Porter, English IPA, American IPA and Belgian Pale Ale.

Detectable levels of alcohol are a fault in low-alcohol beers, specifically English Ordinary Bitter, Mild and Berlinerweisse.

Some Alcohols in Beer

Alcohol	Threshold	Character
Ethanol	14,000 mg/l	Alcoholic
Iso-Amylalcohol	50	Alcohol, bananas, vinous
Iso-Butanol	100	"
Phenylethanol	40-100	Roses, perfume
Propanol	600	"
Tryosol	200	Bitter

Fusel Alcohols (AKA Fusel Oils, Higher Alcohols)

Detected In: Aroma, flavor, mouthfeel.

Described As: Alcoholic, "harsh," solventy, spicy or vinous in flavor and aroma, sometimes reminiscent of cheap distilled liquors (e.g., cheap vodka or rum). Some fusel alcohols might have an initial sweetness, but a harsh aftertaste. Fusels are detected in mouthfeel as burning, harsh, hot, numbing or prickly sensations. Can also be detected as a prickliness, warming, pepperiness or pain in the nasal passages.

Typical Origins: Yeast.

Typical Concentrations in Beer: Variable, usually ~5-100 mg/l.

Perception Threshold: Variable, usually ~50-200 mg/l.

Beer Flavor Wheel Numbers: 0110, 0120.

Discussion: Various fusel ("higher") alcohols are produced as minor respiratory byproducts by yeast during the metabolism of amino acids. Acetate and fusel alcohols can all react chemically with oxoacids to produce esters.

* Yeast can convert amino acids in the wort into higher alcohols by deamination (i.e., removing amine groups), decarboxylation and reduction.

* Metabolism or oxidation of hydroxy acids or ketoacids can form higher alcohols.

* Higher alcohols can be produced from sugars which are converted to acetate and then to higher alcohols.

* Acetate and fusel alcohols can all react chemically with oxoacids to produce esters. Oxidation of beer due to aging can convert fusel alcohols to esters.

In well-made beer fusels are usually present in sub-threshold concentrations. Distressed or wild yeast might metabolize fatty acids (carried into the wort as trub from the hot and cold break) as a source of oxygen and carbon, producing a greater fraction of long chain alcohols and raising fusels to detectable levels. Likewise, high gravity worts, high fermentation temperatures and high concentrations of alcohol also encourage yeast to produce higher alcohols.

In beer, even if it's not harsh or unpleasant, strong alcoholic notes are usually due to elevated levels of higher alcohols. Pure ethanol has little aroma or flavor of its own and is mostly detected in mouthfeel. Fusel alcohol concentrations in top-fermented beers should not exceed 100 mg/l. Fusel alcohol concentrations in bottom-fermented beers should not exceed 60-90 mg/l.

Solventy notes can also be produced by very high levels of ethyl acetate and similar esters (see Esters).

While technically alcohols, Phenolic compounds are described in their own sections. Also see Ethanol and Solventy.

Alcohols in Beer

Alcohol	Flavor	Detectable range
2-phenylethanol	Roses, bitter, perfumed	8-35
4-vinyl guaiacol	Clove-like	0.05-0.55
Cis-3-hexen-1-ol	Fresh cut grass	0.025
Ethanol	Alcoholic, strong	<5,000 - 100,000 mg/l
Glycerol	Sweetish, viscous	1,300-2,000
Isoamyl alcohol	Vinous, banana, sweet	30-70
Isobutanol	Alcoholic	80-100
n-propanol	Alcoholic	~600
Phenol	Phenol	0.01-0.05
Propan-1-ol	Alcoholic	3-16
Tyrosol	Bitter	3-40

Increased By: * Increased fermentation temperature. * Pitching temperatures above 8 °C (46.4 °F). Wild yeast infection. * Poor Yeast Management:- Underpitching. Mineral deficiency. Poor yeast health. Low dissolved oxygen in wort. Incorrect fermentation temperature for strain (too high or low - especially too high). Dehydration of yeast. Lack of Free Amino Nitrogen (FAN). Insufficient amino acids. Excessive aeration of wort (i.e., above 10 mg/l). * High gravity wort (above 13 °P, 1.052 O.G.). * Excessively high levels of amino acids in wort. * High ethanol concentration (>9%).* Wild yeast infection. * Movement of green beer (i.e., stirring or pumping, repeatedly topping up fermenting wort).

To Avoid or Control: * Proper fermentation temperature. * Cooler pitching and/or fermentation temperature. * Proper yeast health. Correct pitching rates for wort gravity and style. * Avoid oxygenating fermenting wort or green beer. * Proper sanitation to avoid wild yeast infection. * Avoid CO_2 buildup in fermentor. * Avoid over-modification during mashing, to avoid excessive levels of amino acids in wort. * Longer conditioning time - fusel alcohols break down over time, producing a "smoother" flavor. (This is the reason that makers of distilled beverages age their products, and why aged spirits are premium products.)

When Are Fusel Alcohol Notes Appropriate?: Detectable levels of higher alcohols are always a fault. They are likely to appear in strong beers, especially beers fermented at high temperatures (e.g., Belgian strong ales), but can also appear in poorly-made or inadequately aged eisbocks or strong ales.

Phenolic

Detected In: Appearance, Aroma, flavor, mouthfeel.

Described As: Bitter, fruit skins, fruit pits, grape seeds, grape skins, husky, oaky, roasted, tannic, tea-like, vanilla or woody. Some have an astringent, drying, numbing, prickly, puckering or rough mouthfeel, sometimes detectable only in the aftertaste. Some spicy phenols can also be detected as a prickliness, warming, pepperiness or pain in the nasal passages. Polyphenols can combine with proteins in beer to form chill (protein) haze.

Typical Origins: Yeast, microbial contamination, process faults.

Typical Concentrations in Beer: 0.05-0.55 mg/l.

Perception Threshold: Variable depending on exact chemical; usually about 0.2 mg/l.

Beer Flavor Wheel Number: 0500.

Discussion: Phenols are an enormous family of aromatic alcohols consisting of a benzene ring plus a hydroxyl group and side chains. Technically, they are alcohols.

Unlike esters or fusel alcohols, phenols are largely non-volatile and don't get converted into other compounds. This means that once they're in a beer, they tend to remain in it.

There is genetic variation in the ability to detect certain phenolic compounds and some people are completely insensitive to them.

Common phenols found in beer are given below, along with their specific sensory characteristics and biochemical origins. Also see Bromophenol, Chlorophenol, Iodoform, Smoky, Spicy and Vanilla.

*** Flavanoids (AKA Bioflavanoids, Flavanols):** This is a huge family of phenols with ketone-containing compounds which are naturally found in many plants. They have often little aroma, although they can be precursors to aroma compounds.

They produce flavors ranging from mildly to intensely bitter. Specific flavanoids relevant to brewing have aromas flavors reminiscent of chocolate, cocoa, coffee, earth, nuts and/or roasted or toasted foods. Some have an astringent, drying mouthfeel or aftertaste.

Flavanoids are present in grain husks, and the process of roasting or toasting malt oxidizes or pyrolyzes these compounds during Maillard reactions to produce the distinct flavors of biscuits, bread crusts, burnt grain bitterness, chocolate coffee, roasted grain or toast.

Flavanols are also present in many fruits, especially cherries, citrus and grapes.

* **Polyphenols (AKA Tannins):** These are phenols composed of two or more benzene rings. They have bitter, husky, oaky or vanilla-like aromas and flavors, also sometimes described as tasting like grape skins or grape seeds. Most also have an astringent, drying or puckering mouthfeel. They commonly occur in woody or husky plant materials.

Polyphenols in beer are mainly extracted from grain husks due to improper grain milling, mashing or sparging technique, but they can also be extracted from water left to stand in contact with decaying plant material, or from hops. Herbs, spices and fruits can also impart polyphenols.

Beer aged in contact with wood will also pick distinct oaky or woody notes from polyphenols. With time, these compounds will react with alcohol to produce vanillin, imparting the flavor and aroma of Vanilla (q.v.).

Beer left on the yeast cake for excessive amounts of time might also pick up polyphenols liberated during yeast autolysis.

Polyphenols can bind with suspended proteins in beer to form protein/chill haze.

They can also form oxidized fusel alcohols due to a reaction with aldehydes, if oxidized by hot-side aeration or poor storage conditions.

Over-attenuation and low dextrin levels (i.e., thin-body) can increase the perception of astringency.

To Avoid or Control: Methods of controlling phenols depend on the exact family of compounds:

*** Flavanoids (AKA Toasty, Roasty, Bitter):** *Causes:* Toasted or roasted malt additions. Fruit, spice or herb additions. *To reduce or avoid:* Reduce or eliminate toasted or roasted malt additions. Reduce or eliminate fruit, spice or herb additions. Avoid scorching grains or wort.

* **Polyphenols (AKA Astringency)**: Also see Cloudiness (Protein Haze). *Causes:* Malt, hops, fruit skins or seeds. *To reduce or avoid:*

- *Don't over-crush grain.*

- *Proper Mash/Sparge technique:* Avoid excessive sparging (stop runoff before it gets below 0.008 S.G.). Avoid collecting alkaline sparge (pH >5.8) liquor. Don't use highly alkaline or sulfated water. Don't let mash-out or sparge liquor temperature exceed ~168 °F.

- *Boil wort with a rolling boil for at least 1 hour* to promote hot break.

- *Get proper hot & cold break separation.*

- *Avoid excessive amounts of hops.* To get high IBU levels use a smaller amount of high alpha acid hops rather than a large quantity of low alpha acid hops. As a rule of thumb, use no more than 8 oz. of hops per 5 gallons of wort. Avoid excessively long boil times (>2 hours) when making beer with a large amount of hops.

- *Avoid Polyphenol Extraction:* Don't heat fruit or grains in water above ~168 °F. Limit time that beer spends in contact with dry hops, fruit (especially fruit stems and husks), herbs and spices (time can range from weeks to months depending on the exact material). For wood-aged beers, reduce exposure to wood and/or increase aging time. Don't leave beer on yeast cake for long periods of time (1 month or more) to avoid yeast autolysis.

- *Reduce Sulfate mineral additions.* Sulfate increases tannin extraction and accentuates polyphenol harshness and bitterness.

When Are Phenolic Notes Appropriate?: Whether phenolic notes are appropriate in a beer depends on the type of phenol:

*** Flavanoids:** Flavanoids which give bready, biscuity, crusty and/or toasty notes are expected in very low to high concentrations in almost all styles of amber or brown beer. Compounds which give burnt grain, chocolate, cocoa, coffee, roasted notes are expected in medium to high concentrations in most styles of dark beer, particularly porters and stouts.

*** Polyphenols:** Balanced low to strong polyphenol (woody, vanilla, oaky) character is expected in wood-aged beers. Subtle peat character is acceptable in Scotch Ale. Harsh or astringent notes are a fault in other styles of beer.

Solvent-like

Detected In: Aroma, flavor
Described As: RE chemical solvents
Typical Origins:
Typical Concentrations in Beer: ? mg/l.
Perception Threshold: ? mg/l.
Beer Flavor Wheel Number: 0120
Described As: See Fusel Alcohol and Solventy Esters.

Solventy Esters

Detected In: Aroma, flavor, mouthfeel.

Described As: At lower levels, ethyl acetate can smell flowery, floral or like Juicy Fruit™ gum. At higher levels, it smells like acetone, estery, harsh, lacquer, model [airplane] glue, model paint, nail polish, nail polish remover, paint thinner or turpentine. At high levels, mouthfeel is described as burning, "hot," harsh, "peppery" or "prickly." Aroma might be irritating to the eyes, giving an "eye watering" sensation.

Typical Origins: Yeast.

Typical Concentrations in Beer: ?

Perception Threshold: 8-42 mg/l.

Beer Flavor Wheel Number: 0120 (Solvent-like), 1033 (Ethyl Acetate).

Discussion: Solventy esters occur when alcohols are reduced by oxygen. As such, they naturally occur in all beers. The most common solventy ester is ethyl acetate, which occurs when ethanol undergoes esterification. As with other esters (see Esters) ester production is increased when fermentation is vigorous (e.g., higher temperature fermentation) or when the yeast is stressed (e.g., insufficient yeast cell count or oxygen levels). Some strains of wild yeast can also produce high levels of solventy esters. Also see Esters, Fusel Alcohol, and Oxidation.

Increased by: Yeast strain. Wild yeast infection. Insufficient or excessive yeast growth. FAN/Amino Acid deficiency. Mineral (Zinc, Calcium, etc.) deficiency. Underpitching yeast. Low dissolved oxygen - low oxygen levels limits rate of yeast reproduction due to limited sterol in cells. Incorrect fermentation temperature for strain, especially high temperature fermentation. Aeration of green beer during growth phase of fermentation. High gravity wort (above 15 °P) - going from 10 °P to 20 °P results in fourfold ester production. High ethanol concentration (>9%). Dehydration of yeast. Excessive trub.

Decreased by: Overpitching yeast. High dissolved oxygen. Adequate oxygen levels for wort strength. Incorrect fermentation temperature for strain (e.g., high or low fermentation temperature). Increased lipids in wort - carrying over more cold break into fermenter. CO_2 buildup in fermenter. Aging - esters are degraded by esterases produced by yeast; they are also volatile and will evaporate or degrade into other compounds over time.

To Avoid or Control: Choose appropriate yeast strain. Pitch correct amount of yeast (less for higher fusel levels, which translates into higher esters levels) at 0.5 to 1 quarts of yeast slurry per 5 gallons. Maintain proper fermentation temperature for strain (higher temperature means more fusel alcohols, meaning more esters). Match starter to wort gravity & temperature.

Adequately oxygenate wort after pitching yeast (O_2 is used by yeast to make unsaturated fatty acids, using up aCoA and increasing thickness of cell membranes, thus preventing ester formation). Don't aerate wort once fermentation starts. Proper separation of trub from wort. High-pressure fermentation decreases yeast growth, hence fusel precursors - it is used by some large lager breweries. Aging will decrease or eliminate esters (over the course of 1+ year).

When Are Solventy Notes Appropriate? Never. Although very low levels might occur in otherwise well-made strong ales, such beers should be conditioned until the solventy notes recede. See notes for Esters for styles where lower levels of solventy esters, which give floral fruity notes, are appropriate.

Part 3: BJCP Category 12 - Porters

History: *Porter is both the oldest "industrial" beer and an artificial, "reconstructed" style. The traditional story is that in early 18th century London, there were three types of beer available, and that the drink of choice was a beer cocktail called "the three threads" which consisted of a portion of each of the three types.*

Allegedly, drawing the three threads required the publican to tap three separate barrels, which took an excessive amount of time. In response, a brewer named Ralph Harwood, proprietor of the Bell Brewhouse in Shoreditch (East London), came up with a beer which had all the characteristics of the "three

threads" but which was brewed "entire" (as a single beer). This beer, called "Mr. Harwood's Entire" or "Entire Butt[2]" was first sold at a pub called the Blue Last in Shoreditch. This beer soon became a favorite with manual laborers who carried loads through the streets and loaded and unloaded cargo. In honor of his customers, the publican called the new beer "porter" and the name stuck.

The problem with this story is that it comes from a single book, written over 100 years after the fact, and none of the details can be corroborated from historical sources. So, in reality the origin of porter, and its name, remains a mystery. Likewise, we can only guess at what an authentic 18th century porter might have tasted like. The best guess, based on early 19th century sources, is that porter was a strong (O.G. 1.071+), highly-hopped (IBU 60+), fairly-well attenuated (F.G. 1.018), brown beer of approximately 6-7% ABV, brewed with London water.

What is known is that porter brewers were the first "industrial" brewers. From the late Middle Ages on, large professional brewers dominated the beer trade. These operations had a brewing capacity approximately equal to that of a modern microbrewery, but no European city had the population or the infrastructure to support an actual industrial brewery. By the end of the 17th century, the greater London area had the population (over a million people) and the infrastructure (canals to cheaply and quickly transport bulk goods, cheap energy from coal, early steam engines) for "artisan brewers" to make the jump to becoming "industrial brewers." Porter, which could be brewed cheaply using brown malt and hops from the nearby Kentish countryside, and which stored well, was the product that took the biggest brewers to the next level.

Since beer prices were controlled by statute rather than the law of supply and demand, porter brewers also had another advantage in that they brewed their beer "entire" – mixing all the runnings from the mash into a single batch of beer - rather than using the old "parti-gyle" system where the first runnings of the mash were drawn off to make a strong beer, then sparged and run off to make a second beer and finally sparged again to make a weak "small beer." Brewing "entire" allowed porter brewers to make more strong beer from the same quantity of malt, putting them at a competitive advantage.

These factors led to a shakeout in the industry over the course of the 18th century, which has continued to this day. In 1700 there were 194 breweries in London, and in 2007 there were just two (Fuller's and Meantime)! Only the wealthiest brewers were able to brew porter, because capital investment in equipment was so high. In particular, industrial porter breweries required massive wooden storage vats. Porter brewers competed to create the largest vats, both for competitive advantage and as a point of pride. By 1790, one brewer built a vat so massive that 200 people were able to dine inside it at its inauguration! In 1814, a gigantic vat at the Meux Tottenham Court Road brewery burst. The resulting flood of beer knocked of the brewery walls and flooded into the street, demolishing nearby buildings and killing 8 people!

For those who could make the investment, the rewards of owning a porter brewery could be spectacular. In 1871, Dr. Samuel Johnson remarked on the sale of one brewery, "Sir, we are not here to sell a parcel of boilers and vats, but the potentiality of growing rich beyond the dreams of avarice." Not surprisingly, many of the great British breweries (e.g., Barclay's, Whitbread, Courage) started out as London porter breweries.

Sadly, like every other old style of British beer, porter's star faded over the course of the 19th and 20th centuries. Initially, porter faced competition from cheap gin, which was considered the scourge of London in the middle of the 18th century. Beer, although more expensive than gin, was seen as a healthy, patriotic drink (since much gin was imported). Subsequently, porter lost out to progressively lighter-colored beers, such as IPA and pale ale on the one hand, and Stout (originally described as a "Stout Porter") on the other. By the end of the 19th century, porter only accounted for 25-35% of sales for London breweries.

Likewise, as with every other style of British beer, temperance movements, changing public tastes and restrictive tax laws conspired to make porter progressively weaker throughout the 19th century. By 1900, most examples of porter

Stout vs. Porter

Historically, porter and stout were virtually identical styles, the only distinction being that "stout" beers were brewed to a higher ABV. In the 18th and early 19th centuries the term "stout" was used in the same way that modern brewers might use the terms "double," "extra", "imperial," "special" or "strong." In the 18th century, it wasn't an oxymoron to call a beer a "Stout Pale Ale!"

The beer style we now know as Stout originally was called "Stout Porter," and, until modern times, the ingredients and techniques used to brew porter and stout were identical. In the 19th and early 20th century, most British and Irish breweries would have different strengths of stout, with the term porter being applied to the weakest (and possibly most cheaply made) dark beers in the brewery's portfolio.

The modern distinction between Porter and Stout came about in the 1970s and 1980s, because revived porter recipes were sometimes based on reconstructions of 18th and early 19th century recipes, which didn't use black "patent" malt (it wasn't invented until 1817) and which could use a much higher proportion of "brown" (i.e., lightly kilned, toasted or torrified) malt than later recipes.

By contrast, since stout survived as a commercial style, it reflected changes to stout and porter recipes which had occurred during the 19th and early 20th centuries - notably use of black malt, greatly reduced amounts of brown malt, and additions of adjunct grains and sugars.

While brewing historians might gnash their teeth in frustration, in modern beer parlance, the distinction between porter and stout seems to be here to stay.

[2] Although the term "Mr. Harwood's Entire Butt" is guaranteed to make small children snicker, it wasn't intended to be scatological. At the time, the term "butt" was synonymous with the terms cask or barrel, and "butt beer" referred to beer intended to be served from a cask (as opposed to a bottle). The term "entire" referred to any beer brewed as a single batch, rather than being "vatted" (blended from different batches). Entire also had overtones of being a "young," relatively sweet beer, as opposed to "stale" (aged) beer which was likely to have lactic sourness and Brettanomyces funkiness. If he were alive today, the hypothetical Mr. Harwood would have probably named his beer something like "Harwood's complete, fresh cask ale."

were just 4-5% ABV, and some breweries' porter was weaker than their Mild brown ale!

By the middle of the 20th century, porter was almost extinct. Regulations on beer strength and restrictions on ingredients imposed by two brutal World Wars made porter even weaker and forced brewers to use ever cheaper ingredients. By 1950, porter was all but extinct in England, and by 1972 it died out in Ireland.

Overseas, porter just barely survived. Porter was widely exported and American ale brewers in the 18th and 19th century often included a porter in their product line. In particular, porter survived well in Pennsylvania and other Northeastern states. Except when interrupted by Prohibition, the Yeungling Brewery of Pottsville, Pennsylvania has been brewing their porter since 1829!

The English revival of porter came in the 1960s and 1970s, with the resurgent interest in craft brewing led by the Campaign for Real Ale (CAMRA) in Great Britain. In 1979, porter was revived by the Penrhose and Timothy Taylor Breweries. In the U.S., homebrewers and microbrewers led the revival of the style. But, because there were so few commercial examples, and because interpretations of the revived style vary so much, modern porter is essentially a "reconstructed" historical style, like Classic American Pilsner or medieval-style gruit beer.

Brewing Porter: The BJCP guidelines divide porter into "Brown Porter" and "Robust Porter" when in actuality the two styles represent different ends of a continuum. Brown Porter tends towards lower alcohol and hop levels, is slightly lighter in color and tends to be a bit sweeter and grainier than robust porter. Robust porter is stronger, more highly hopped, slightly darker and is a bit drier and bitterer. Perhaps by accident, the commercial examples for Brown Porter are all English, while most of the commercial examples for Robust Porter are be American. Some commercial examples of American robust porter have a citrus hop aroma and flavor that make them seem like toned-down versions of American Stout.

Porter should be a drinkable, balanced dark ale, with relatively low hop aroma and flavor, moderate body and moderate malt complexity. The malt flavor shouldn't be too sweet, too bitter or too "big," but should have some complexity to hold the drinker's interest. High alcohol levels turn the style into an "Imperial porter" or "strong porter," which should be entered in competition as a specialty beer. Strong toasted or roasted malt notes (especially strong coffee or chocolate notes), and higher levels of dark malt and hop bitterness turn a porter into a stout. Lighter coloration, lack of roasted notes and a bit more hop flavor turns it into brown ale.

Grains: English or American pale ale malt makes up the majority of the grist in most commercial and award-winning homebrewed brown and robust porters. Commercial porters often use crystal malt, along with some mixture of brown, chocolate, black and wheat malts, plus roast barley and sugar to make up the remainder of grist. Homebrewed examples often use a mixture of crystal, chocolate and black malts to make of the rest of the grist, although some brewers include some Munich or wheat malt and/or roasted barley.

Hops: Any English or American hop can be used. For commercial porter examples, Goldings is most popular hop variety, followed by Challenger, Fuggles, Northdown, Target and Progress. Commercial IBU levels range from 20-60, averaging 31 IBU. Some commercial examples are aroma hopped. Award-winning homebrew examples tend to use Goldings, Northern Brewer and Willamette. With some using Chinook or Eroica for bittering, and/or Cascade, Fuggles, Mt. Hood or Tettnanger as flavor and aroma additions. Very few commercial or homebrewed examples are dry hopped. Hopping levels are much lower for brown porter than for robust porter (39 IBU vs. 53 IBU on average).

Water and Yeast: Water should conform at least somewhat to London standards, with high hardness and bicarbonate levels. London water has 160 ppm carbonate, 100 ppm sodium, 60 ppm chloride. Yeast should be some variety of English ale yeast, since American yeasts tend to produce too neutral a flavor profile.

Baltic Porter: While nominally classified with brown and robust porter, Baltic porter has evolved sufficiently that it must be discussed in its own section.

History: *Baltic porter is a leftover from porter's heyday. From the 18th century on, England exported beer to all parts of the world, and for a time porter and stout had the same worldwide popularity as light lager does today. As with their other export beers, British brewers made their export porter stronger so that it would keep better on the long sea voyage. Export beers also tended to be stronger, if more attenuated, since they cask conditioned during their journey and since the constant rocking of the ship kept the yeast in suspension. Porter exported to the Baltic was also effectively cold-conditioned, since the beer was kept in a cool ship's hold which was surrounded by the cold (30-55 °F) waters of the North and Baltic Seas.*

Over the course of the 19th century, due to wars, tariffs and developing national infrastructure, the countries which bordered the Baltic Sea all developed their own brewing industries. While the no longer imported shiploads of porter from England, they still appreciated the strong English export porter and started to brew their own versions of it. Likewise, the cities which once composed the Hanseatic League had been brewing strong dark beer for export since the Middle Ages, so while porter brewing on an industrial scale might have been beyond local breweries, they had no problem emulating the techniques of brewing porter. While Baltic porter was originally brewed as an ale, when

Keeping vs. Mild Ale

In the 18th and early 19th century, another distinction between beer styles would have been between "keeping" and "running" beers. "Keeping" beers were aged to pick up a bit of sourness and Brettanomyces character, and reduce the residual smokiness from the malting process, while "running" or "mild" beers were served fresh.

Originally, the industrial brewers got their start because they could afford to "start" (i.e., age) casks of "keeping beer." Later, they learned to age beer in huge vats, which was then blended with "running" beer just before it was released to the public. Hence the trend towards ever larger storage vats in the late 18th and early 19th centuries.

In the middle of the 19th century, perhaps due to increased public concern about adulteration of food and incipient understanding of germ theory, the trade in "keeping" beers - especially "keeping porter" - collapsed as public tastes changed to fresh or "mild" beer. The term "Mild Ale," while now applied to a nearly extinct variety of low alcohol British brown beer, in the 18th and 19th centuries, could be used to describe any variety of freshly made ale.

Continental breweries converted to lager production in the late 19th century, they adapted their porter recipe to use lager yeast.

Other than the name, Baltic porter has little in common with other types of porter. Instead, it is something like a combination between a Russian imperial stout and a doppelbock. Unlike other forms of porter, Baltic porter never got weaker, always remaining somewhere near original porter strength. Because Baltic porter uses German malt, it has a much fuller body and a sweeter, more complex aroma and flavor profile. Because it uses debittered black malt and low alpha acid continental hops (often Polish Lublin hops), it has a smooth bitterness which is never harsh. And, because it is fermented at lager temperatures, it has a much smoother, crisper flavor.

Baltic porters can be big, and even somewhat syrupy, as long as the alcohol and sweetness isn't overpowering and helps to accentuate dark malt, chocolate, roasted, dark fruit and licorice notes and is balanced by a pleasant bitterness.

Grains: Munich or Vienna malt is used as a base, with debittered black malt brown and Rostmalz added for flavor, aroma and coloring. Historically, brown and amber malts were added. Crystal malts and adjuncts such as sugar can be used as well, although Baltic brewers influenced by German Reinheitsgebot laws would have avoided adjuncts. Homebrewers sometimes add roasted barley, licorice, candi sugar or molasses.

Hops: Polish Lublin hops are traditional for many varieties of Baltic porter, but any variety of English or Continental hops will do. Some recipes use English bittering hops (e.g., Northern Brewer) and German noble hops for flavor. There are no aroma hop additions.

Water and Yeast: Water profile can vary widely. As long as the water is suitable for brewing a dark lager it should be fine. German or Scandinavian lager yeast is probably the most common commercially used yeast for Baltic porters, although some brewers use English Ale yeast which can stand lower fermentation temperatures.

Part 4: BJCP Category 13 - Stouts

History: *Although Europeans have been drinking dark, heavy-bodied beers since antiquity, stout only developed in England in the late 18th century as a stronger "stout" porter. Soon the term "stout porter" was abbreviated to "stout" and stouts began to develop their own character even as the popularity of porter declined.*

Stouts were ideally adapted for water available in the major brewing centers of the expanding British Empire; London, Burton, Edinburgh and Dublin all had hard, alkaline water that accentuated hop bitterness and balanced the acidic roasted malts needed to make stout. Furthermore, stouts were ideally suited to make use of both traditional ingredients and new brewing materials imported from distant parts of the British Empire.

From the start (even before it was legal to do so), as a cost-cutting measure, brewers brewed stouts (as well as their other beers) using adjuncts or substitutes for barley malt and hops. Corn (maize) and sugar produced lighter-bodied beers, molasses and caramelized sugar syrup (treacle) added licorice and caramel notes, while whey added body and sour notes. Oats added body, but also caused bitterness in large quantities, while roasted barley added toasted and slightly drying astringent notes. Since stouts used hops mostly for bittering, they could use non-hop bittering agents such a Quassia (an intensely bitter South American tree bark) as well as older or imported hops which had lost most of their aromatic compounds.

Stouts were also ideally suited as an export beer. By brewing to higher alcohol levels and sometimes using higher hopping rates, stouts could withstand long sea voyages or long storage in the same way as the later India Pale Ales could. Furthermore, long aging mellowed stouts, reducing hop and roast grain bitterness and adding complexity to the beer as it aged. Both Russian Imperial Stouts and Foreign Extra Stouts are reminders of these strong 18th and 19th century brews.

As with other British beers, tax laws, pressure from temperance movements and changing consumer tastes, forced brewers to produce lower alcohol beers over the course of the 19th and 20th centuries. By the 1880s, alcohol levels in typical stouts were sufficiently low that brewers could advertise the benefits of stout on the health of invalids and nursing mothers.

While stout declined in popularity throughout the 20th century it never died out, partially due to the lingering popular belief that stout was a health food. This notion persisted until after World War 2 and was exploited by Guinness during its famous "Guinness Is Good For You" advertising campaign of the 1940s and 50s.[3]

Paradoxically, stout even benefited from the privations of the World Wars, which destroyed the character of so many other historic British ales. Due to the need to keep Ireland from revolting during World War I, the British authorities mostly allowed Irish brewers to do as they pleased, even as the government imposed high taxes and severe restrictions on beer made in other parts of Britain.

Likewise, when World War II broke out, Ireland was an independent, neutral country, immune to the legal restrictions and many of the economic stresses which afflicted British brewers during and after the war. This was a benefit to such famous stout brewers as Guinness and Murphy's.

Even so, the number of brewers producing stout, and the varieties of stout, declined in the late 20th century. Oatmeal stout, a popular late Victorian stout style died out after World War I, until it was revived in 1980 by Samuel Smith's. Russian Imperial Stout nearly went extinct as well. As with all other British specialty beers, CAMRA (Campaign for Real Ale) was crucial in reviving the style in Britain in the 1960s and 1970s.

Stouts were historically brewed using high alkaline, London or Dublin water. The acidity of the roasted grains helped to overcome the buffering effects and alkalinity of the mash and sparge water. When brewing with soft or medium hardness waters, calcium carbonate should be added to the mash (not to the water) to bring pH up to the optimal 5.2-5.4 range. High sulfate water must be diluted using distilled or reverse osmosis, since excessive sulfate levels give unpleasant hop bitterness inappropriate in a stout.

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[3] There is some truth to the notion that beer is a health food. The yeast in unfiltered beer is a valuable source of B vitamins and, to a lesser extent, trace elements such as copper and zinc. (The "brewers yeast" from health food stores is actually pressed, dried yeast trub from commercial breweries, although the yeast cells are long dead). Dark beers also have trace amounts of iron and the anti-oxidant resveratrol (similar to the amounts of resveratrol found in red wine or grape juice). Dry stout is also a surprisingly lean and low-alcohol beverage for all its flavor, with approximately 4-5% ABV and just 12 calories per ounce.

Calcium chloride is often used, especially for sweet stouts, since the calcium buffers mash pH while the chloride can enhance perceptions of sweetness.

Historical Stouts: *In the 18th and early 19th centuries, stouts were usually aged "stock ales," with secondary fermentation from Brettanomyces, Pediococcus and Lactobacillus infections. Single stouts were brewed to SG 1.065-1.073, double stouts to SG 1.073-1.080, imperial stout to 1.080-1.100, and Russian export stouts to an SG of 1.100 or more.*

Frequently, weaker (SG 1.049-1.053) young stout would be blended with strong (SG 1.080+) aged stout to achieve the proper flavor, in a process called "vatting." Until recently, Guinness used a variant of vatting to give their stouts a unique, slightly sour taste.

As mentioned above, stouts could be made using a number of adjuncts, of which molasses, sugar, unmalted grains, milk sugar (lactose), licorice and quassia were the most common. It was illegal for commercial brewers to use these materials, however, until the Free Mash Tun Act of 1880. Even so, private brewers would sometimes add adjuncts when it was illegal to do so, as would unscrupulous brewers and publicans.

Stouts vs. Porters: *Historically, porter and stout were identical. In the 1730s when industrial brewing developed in England, brewers produced variants of the same recipe brewed to different strengths, and the stronger beers in the brewery's line-up were referred to as being "Stout" (i.e., strong) beers. In the 18th century, it wasn't an oxymoron to call a beer a "Stout Pale Ale" or a "Stout Porter."*

Modern stouts descended from strong porters. Until the 1950s or 60s, many English and Irish breweries produced both a porter and a stout (porter). But, due to the drop in alcoholic strength of English beers from about 1880 to 1950, porter became a very weak beverage which didn't keep well. Furthermore, because it consumed by poor, undiscriminating drinkers, porter was sometimes adulterated, both to make it seem stronger and to hide spoilage. These factors helped drive porter into extinction; its place taken over first by mild and bitter, then by lager.

As porter became weaker, the strength of stout fell as well, until typical English and Irish stouts reached ABV of about 2-4%, although some versions of stout, notably Guinness Extra Stout and Courage Russian Imperial Stout, were higher in ABV.

Likewise, the recipe for porters and stouts changed over the years. Early 18th century stouts were, by law, all malt beers, made predominantly or entirely using brown malt. This probably made them much more like strong modern porters when fresh. The fashion was also for them to be aged for several months, so that any smoke from the malt dissipated, and the beer soured. (The term for fresh beer was "Mild," regardless of strength.)

By 1770, brewers had discovered that it was more cost effective to use mostly pale malt and a smaller amount of brown malt or colorant to darken the beer. This changed the flavor of the fresh beer, making it sweeter and not as roasty. Brewers struggled to find a legal means of getting the expected dark color and roasted flavors. Many resorted to illegal expedients such as adding licorice or concentrated licorice solution (so-called "Spanish Juice") and burned or heavily caramelized brown sugar.

The solution came in 1817 when Daniel Wheeler invented a drum roaster for malt, allowing maltsters to produce extremely dark roasted malts. This "patent malt" allowed brewers to darken their beer legally, and this changed the recipe again. The resulting beer probably had much more of the characteristic dark roast character we expect of modern stouts.

At the same time, there was also a shift in public tastes towards "mild" (i.e., fresh) beer and the huge wooden aging vessels which characterized 18th century English breweries were gradually replaced.

The last major change occurred in 1880, when the British parliament passed the Free Mash Tun Act, which repealed the tax on malt and allowed brewers to use any wholesome ingredient in the brewing process. Brewers responded by replacing some of their malt with adjunct grains such as roasted or flaked barley and sugars and syrups. Late 19th and early 20th century stout and porter recipes could vary widely in ingredients used. Cheaper products had simpler grist bills, with mostly pale malt, some sugar, possibly a bit of wheat, oats or barley for body and head retention, and a bit of patent malt for color. Better quality products retained some brown malt. Most modern-style stouts date to this period.

As mentioned previously, stouts and porters used similar recipes and varied only in alcoholic strength. But, as beer strength declined from about 1880 to 1950 porter went extinct while stout survived in weaker form.

With the revival of craft brewing in the 1960s, brewers tried their hands at recreating 18th and 19th century "stout porter" recipes and the split between modern-style stouts and porters was created. **Modern porter styles are expected to be slightly lighter in color than stouts, with more toasted malt notes, and roast character dominated by chocolate and no dark malt or roast grain astringency.**

By contrast, stouts are expected to be very dark in color, not so toasty, with dominant coffee, espresso or mocha dark roast notes, instead of chocolate.

Irish Dry Stouts: *In 1759 Arthur Guinness signed deal to pay £40 per year rent for a brewhouse for a period of 9,000 years. After an early struggle to make a profit, he found commercial success in the 1760s brewing not just stout, but a variety of beers which might now be recognized as porters, dark milds and brown ales.*

Eventually other brewers, such as William Beamish and William Crawford, in 1792, and James, William, Jerome and Francis Murphy, in 1856, followed his lead, making Dublin one of the two great centers of stout production (London being the other).

Despite its seeming simplicity, dry stout is a surprisingly difficult style to brew, if only because the style parameters and expected flavor characteristics are so narrow. Just as Anchor Steam sets the standard for California Common beer, for many people Guinness Draught[4] Stout sets the standard for Dry Stout, possibly to the detriment of equally ancient, authentically Irish breweries such as Beamish and Murphy's, and brewers outside of Ireland who produce equally valid interpretations of the style.

Guinness Draught is particularly difficult to define since ABV and character vary depending on where it is brewed and whether it is bottled or dispensed on draft.[5] In all cases,

[4] Draught is just the old British spelling for "Draft" in the same way that "gaol" is the British spelling of "jail." "England and America are countries divided by a common language" - O. Wilde

[5] Draft Guinness is frequently "nitro pulled" - meaning that it is dispensed at low pressure using a mixture of nitrogen and carbon dioxide, which promotes a lacy, creamy head and smooth body.

however, Guinness Draught Stout is brewed using a small quantity of unmalted deeply roasted barley to give a coffee-like character to the brew, about 10% raw, unmalted barley (cooked or flaked to gelatinize the starch) to give the beer a distinct "Irish" palate. Historically, a tiny bit (about 1%) of strong, soured stout, added during "vatting," gave a dry finish, although this might not be done anymore. Pale malt composes the rest of the grist; no caramel or crystal malts are used. Irish Ale[6] yeast is used to ferment the wort.

Dry stouts use generous amounts of hops for bittering and to dry the finish. Hop aroma and flavor are inappropriate to the style, as is lingering or astringent hop bitterness - in all cases the hop finish should be clean, yielding only a slight sourness or roasted maltiness.

Typically, the IBU rates for Guinness products match the last two numbers of the SG (e.g., 50 IBU for a bottled stout with SG 1.052). The dry character of dry stout is much more pronounced on draft. In bottles, the same beer has a sweeter palate, fuller body and a rougher, pricklier mouthfeel (due to the higher level of carbonation). Draft dry stout sometimes also has faint "metallic" or "bloody" notes, as well as slight acetic notes due to poorly maintained dispensing systems.

While dry stout can appear as a black hole of inky darkness, close inspection under good light reveals it to be a transparent mahogany color with deep garnet highlights. Aroma should emphasize roasted, coffee-like malt, with hints of fruity esters and caramel sweetness. Head should be cream-colored or tan, lacy or beady in appearance, stiff and long-standing. Pub-lore has it that a good bartender should be able to entertain the customer with a brief story in the time it takes for the head of a pint of stout to subside.

Sweet Stout: Sweet stouts are another variant of English stout. The quintessential sweet stout, Mackeson's XXX Stout[7] (formerly called Mackeson's Cream Stout) was patented in 1875, but similar beers were made with milk or whey long before then. Made with whey or milk sugar (lactose) these beers were originally developed for invalids and nursing mothers. Like Guinness Draught, however, Mackeson's (now brewed by Whitbread) varies in alcoholic strength and character depending on its intended market. Mackeson's brewed for British consumption has SG 1.038-1.042, while beer brewed for export has SG 1.056, less sweetness and a more assertive dark malt flavor.

Sweet stouts are brewed using a combination of black, chocolate and/or crystal malt, up to 10% flaked maize, and possibly blackstrap molasses or similar sugar syrups. If roasted unmalted barley is added, it is used in tiny amounts. The key sweetening agent, however, is lactose; meaning that people who are highly lactose-intolerant shouldn't consume sweet stouts. Sweet stouts are fermented using English Ale yeast.

Sweet stout should be inky black and opaque in appearance with a tall, long-lasting tan head. Flavor should be sweet, with less roasted malt flavor than dry stout, but with enough hop bitterness and roast malt flavor to avoid being cloying. As with many other English "present use" beers, alcohol levels are very low.

Oatmeal Stout: Oatmeal Stout was another Victorian English stout variant, usually produced as a seasonal specialty. As with many other historic styles, it died out sometime after World War I, only to be revived in 1980 by Samuel Smith's. Influenced by this British revival and Michael Jackson's writings on the subject, as well as the creative homebrewing spirit, American microbrewers soon produced their own interpretations of the style.

Historically, oatmeal stouts might have only contained a trivial amount of oats, perhaps just as an aid to head retention, and couldn't have had much oat flavor or aroma. Modern interpretations of the style are expected to have some degree of oat aroma and flavor, as well as a creamy, slightly oily mouthfeel from oatmeal additions.

Oatmeal stouts are brewed using a malt palate similar to that used for Sweet Stouts, but slightly higher SG, largely due to the use of a small amount of oatmeal. Oats are extremely sticky due to their high levels of beta-glucan gums, hence very hard to work with. Typically, brewers use no more than 5-7% oatmeal in the grist, but some single infusion mash brewers use 5% or less. More than 7% oatmeal requires a beta-glucanase rest.

No cereal mashing is needed when working with oatmeal, since flaked oats are pre-gelatinized, but because oats are so sticky, rice hulls or similar material is needed to prevent a slow or stuck mash. When working with oatmeal, use the most highly-processed variety you can find; ordinary "quick oats" are good, but "instant" oatmeal is better. Steel cut oats must be cooked before they are mashed, as must flaked barley. Starch conversion is problematic when working with oats and must be carefully monitored.

Filtering oatmeal stouts is also tricky; posing problems similar to those presented when filtering wheat beers. Starches can easily clog fine filters and excessive filtration can remove much of the oatmeal character from the finished beer.

In flavor, oatmeal stouts are much like sweet stouts, but the addition of oats gives fuller body, a distinct smooth, "velvety" creamy mouthfeel, and possibly some grainy oat notes in the aroma. Hops are present only in the flavor and only as a bittering agent. They are generally opaque due to the difficulty of filtering the finished beer.

Foreign Extra Stout: These stouts are reminders of Britain's thriving beer export trade during at the height of British Empire. Brewed in London, Dublin, Burton and Edinburgh to be shipped to far-flung colonies, like India Pale Ales, stouts were brewed to higher alcoholic strengths and were sometimes more highly hopped to survive long sea voyages.

Once Britain's overseas colonies developed their own brewing industries, however, colonial brewers began brewing their own interpretations of this style, often using locally available ingredients as part of the grist. Today, most of the classic examples of the style are brewed in former British territories.

Foreign Export Stouts are brewed using the same ingredients as a dry stout or sweet stout, but with a bigger malt bill and higher levels of bittering hops. As a result, they have

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By comparison, bottled Guinness was, and sometimes still is, bottled conditioned. Furthermore, draft Guinness in the U.S. has SG 1.040 versus 1.052 for Guinness in bottles. In the UK and Ireland, the SG of draft Guinness sold in the summer is about SG 1.036 versus SG 1.046 for the bottled product. In winter the SG of both products is slightly higher.

[6] Most "Irish Ale" yeasts are actually from Guinness.

[7] Changes to British food labeling laws in the 1970s forced the name change, although Mackeson's XXX still retains an image of a butter churn on its label.

higher alcohol levels, greater hop bitterness, fuller body, and hints of fruity esters and diacetyl in the flavor and aroma.

American Stout: Although many 18th and early 19th century American brewers produced stouts and porters, by the middle of the 19th century, ale brewers were supplanted by immigrant German lager brewers, and even the surviving ale brewers found that most consumers demanded lighter-colored, more delicately-flavored beers. Already a marginal style in the U.S., Prohibition killed off stouts in the U.S., as it did so many other traditional brews. Credit for the revival of stout in the U.S., as well as the development of aggressively-hopped "American" and "American Imperial" Stout belongs entirely to American craft- and homebrewers. Specifically, modern American Stout was brewed by America's first microbrewery, New Albion Brewing, around 1978. Soon, other California brewers, such as Anchor and Sierra Nevada began to offer their own interpretations of the style.

Historically, American stouts were very similar to porters, except for higher gravities (SG 1.072-1.076) and hopping rates double those for porter. Modern American stouts have SG 1.044-1.072 and emphasize hop flavor and aroma rather than just using hops as a bittering agent, although dry hopping isn't appropriate for the style. West coast brewers, especially, use distinctively American hops such as Chinook, Centennial and Cascade. Many American stout brewers also use their beer as a basis for flavor adjuncts such as coffee, chocolate, herbs or spices, although these fall into the category of Spice/Herb/Vegetable or Specialty beers.

The problem with producing an aggressively hopped stout is the risks of too-intense hop bitterness and unpleasant lingering hop aftertaste. High alpha-acid hops are needed to balance the intense malt flavors, since delicate "noble" hop aromas and flavors get lost, but "coarse" (high cohumulone) hop varieties can give an unpleasant bitterness. A blend of good, low cohumulone, high alpha-acid bittering hops and traditional flavoring varieties yields the best results. Recommended varieties for stout include Fuggles, Willamette, Cluster, Northern Brewer, and Bullion or Brewer's Gold.

Russian Imperial Stout: *The crown jewel of the British beer export trade, Russian Imperial Stout dates to the "golden age" of English porter brewing in the 18th century, when strong English brown beers were in high demand throughout Europe. The beer gets its name from the fact that it was supplied to the court of Catherine the Great, czar of Russia, who gave contracts to English brewers to supply her court with beer.*

In order to produce beer that would travel and store well, English brewers used their usual trick of boosting alcohol levels and hopping rates. The result was a massively strong brew that kept extremely well, developing complexity as it matured.

Barclay's Russian Imperial Stout, brewed to a gravity of SG 1.104 was the first and finest example of the style. It was capable of lasting 25 years or more[8] in the bottle and had intense, complex flavors similar to those of an English Christmas pudding. Sadly, this great beer is rarely available and is a shadow of its former self. When Barclay's was bought by Courage, it was no longer aged before being released to the public, with the resulting decline in flavor. As a result, sales dropped off and Courage stopped brewing it, except for occasional, rare batches. Fortunately, Young's and Samuel Smith's continue the tradition of English-style Russian Imperial Stouts.

In the early 19th century, the combination of the Napoleonic Wars and high import duties forced brewers to produce Imperial Stout within the borders of the Russian Empire. A leading beer exporter, Alexander De Coq, of Belgium, built a brewery in what is now Estonia, continuing the tradition the English brewers started.[9]

Russian Imperial Stout has intense alcohol warmth, and an complex aroma and flavor profile that includes notes of figs, plums, honey, sherry, tar, fino port, currants, raisins and caramel as well as roasted malt flavors (coffee, chocolate) and intense hop bitterness that mellows with age.

"American Imperial Stouts" are a recent variation on the theme. They are similar to traditional English versions, but continue the American craft brewing love affair with American hops and bold, assertive flavors. Some American versions of the style approach the alcohol levels of the original.

Other Types of Stouts: *In addition to varieties of stout listed above, there are two other types of stouts that deserve mention.*

"English" stouts fall into the gap between sweet stouts and dry stouts. While they have the roast bitterness of a dry stout, they are can have more malt sweetness and will have high levels of fruity esters and possibly very low levels of diacetyl from English ale yeast. Unlike sweet stouts, they can be well attenuated and don't have added sugars. They typically range from 3-4.5%, but some can be stronger.

Oyster stouts are a version of English or Dry Stout, advertised as an accompaniment to oysters or lobsters. In the 18th and 19th century, these were generally just ordinary stouts. No stouts were actually made with oysters, although ground oyster shells were sometimes added to beer, either to counter sourness from spoilage (the calcium carbonate in the shells neutralizes the acetic or lactic acids produced by bacteria) or as a fining agent.

In the 1930s, a few British breweries experimented with actually using oyster puree as a yeast nutrient, but nothing came of it.

Recently, however, some craft breweries have produced oyster stouts made using actual shellfish. Shucked raw oysters are added during wort boil or during primary fermentation. The oysters impart a slightly minerally, fishy, "seawater" note to the beer's flavor and aroma, which is more pleasant to drink that it sounds.

In addition to these variants, there are a number of specialty stouts. Additions of chocolate, coffee, vanilla, bourbon and dark fruits work very well with stouts, making it one of the most popular base beer categories for beers entered in BJCP categories 20-23.

[8] In 1972 divers found a wreck of Prussian merchant ship that sank in 1875 while carrying a load of Russian Imperial Stout. Some of the bottles brought to the surface were still drinkable after 94 years beneath the waves!

[9] Sadly, this brewery, in Tartu, Estonia was nationalized during the Russian Revolution and never recovered. It still produces beer, but not Russian Imperial Stout.