

Bicep Class #2

This week we will be discussing Aspects of Aroma, Flavor and Mouthfeel, Overview of the Brewing Process. Equipment, Cleaning and Sanitizing, Acetic, Lactic, Sulfitic Off-Flavors and Beer Categories 3, 4 & 5 - Amber, Dark & Strong Lagers.

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: Aroma, Flavor and Mouthfeel

Something that often isn’t clearly explained to new judges is how the senses of smell, taste and touch actually interplay when judging beer. If you’re doing your job right, you’re using ALL of your senses when you judge. You use your sense of sight to assess the beer’s appearance, your sense of hearing to judge the beer’s carbonation level as you open the bottle and your other senses to evaluate aroma, flavor and mouthfeel.

Obviously, you mostly judge aroma using your sense of smell, but aroma is also affected by your sense of taste and touch. For example, you feel the burning sensation of higher alcohols in your nose at the same time you smell the solventy aroma, or your perceptions of malt sweetness in aroma are reinforced by actual sweetness in taste once you take a sip and then smell the beer again.

Likewise, while you mostly judge flavor using your mouth, your perceptions of flavor are heavily influenced by your sense of smell - which is why food seems “tasteless” when you have a head cold and your nasal passages are blocked.

Finally, while mouthfeel is mostly judged using your sense of touch, it too is influenced by smell and taste.

Aroma: *The human sense of smell is actually pretty bad when compared to most animals. We have 900 or so genes which code for olfactory receptors (compared to about a thousand for your average mammal) and most people only have about 350 functional genes - the rest are non-functional “pseudo-genes.” We also have a much smaller olfactory receptor area within our noses than most other land mammals. Even so, humans can detect about 10,000 different chemical compounds and the human sense of smell is still superior to machines for many purposes. Training your sense of smell allows you to better identify, recall and describe certain chemical compounds.*

Physically, the sense of smell works when volatile airborne chemical compounds (called odorants) are inhaled into the sinuses through the nostrils and the retronasal passages (at the back of the mouth) and contacts olfactory receptors within the olfactory mucosa (a dime-sized area at the top of the sinuses). Biologically, our detection and perception of those odorants occurs due to a neurological reaction when the odorant bonds

with receptors on the olfactory epithelium. But, after a few minutes, the brain starts to ignore signals from the receptors for a particular compound, meaning that we gradually become insensitive to odors which are pervasive in our environment.

Memory of aromas and flavor is stored in the brain’s limbic system, which is also the part of the brain which governs our emotions. This means that our memories of smell and scent can seem much more “visceral” than other memories. On the good side, this means that a particular aroma might evoke memories of happy times long ago, or positive memories of loved ones (e.g., the scent of baking gingerbread at Christmas when you were a kid, or the scent of your long-dead grandmother’s lilac perfume). On the bad side, certain scents (e.g., the smell of gunpowder or rotting flesh) can be “triggers” for fear, anxiety or terrible memories in people who suffer from Post Traumatic Stress Disorder.

Effectively, that means that everyone’s sense of smell is a bit different, meaning everyone brings slightly different perceptions to the judging table. When judging, remember that a scent (or flavor) that is distinct and attractive to you might not be detectable or attractive to the other judges!

While training and experience can help you detect and identify obvious faults, you must also become aware of your personal sensitivities and weaknesses. For example, some people are genetically more or less sensitive to diacetyl. I’ve also met judges who were insensitive to alcoholic or solventy notes (due to long-term occupational exposure to industrial solvents) and judges who interpret the aroma of Citra hops as “cat pee.”

Practically, at the judging table, if another judge detects an aroma or flavor which they swear is there, but which you don’t detect, just “agree to disagree” or get another person’s opinion. If you know that you’re particularly sensitive insensitive to a particular aroma or flavor, tell your judging partners about it up front if you think it is likely to be a problem. If you know that you’re insensitive to a particular aroma or flavor, defer to the other judges’ opinions if they detect it.

How to Smell Beer: To aid your feeble human sense of smell, try to get as many odor compounds into your nasal passages as you can.

* Serve the beer at the proper serving temperature or even on the warm side. Higher temperatures mean that the beer can hold less carbon dioxide, so the head will be bigger and carbon dioxide will escape faster - “scrubbing” volatile aroma compounds from solution as it goes. Higher temperatures also help volatile aromatic compounds evaporate more quickly on their own.

* Smell the beer immediately when you get the glass - many subtle aroma compounds escape quickly.

* Inhale the beer deeply, using both your mouth and nose. I like to hold the cup so that it is halfway into my mouth and under my nose, but upright while cupping my other hand over the cup and my nose, and then inhale deeply through my mouth and my nose, pulling air into my nose and sinuses.

* Cup your hand over the glass or place a coaster on top of it to help trap aromatic compounds before sniffing them.

* Swirl the beer in the glass to help carbon dioxide and aromatic compounds escape.

* Smell the beer several times as you taste it - some aroma compounds aren't as volatile and take time to build up to detectable levels. In particular, compounds such as diacetyl or acetaldehyde sometimes take a bit of time to become detectable.

* To refresh your sense of smell something other than beer - such as the back of your hand or your sleeve.

* Don't confuse your sense of smell. Don't wear strong scents or use strongly scented soaps, shampoos or similar products. Thoroughly wash the soap off your hands when you wash them - many commercial bathroom soaps are quite strongly scented.

Flavor: There are a number of myths surrounding the sense of taste. The biggest myth is that there are only four basic flavors that we can detect. Actually, there are five (possibly six) basic flavors: sweet, sour, salty, bitter, "umami" (meatiness) and maybe fat. Not surprisingly, all of these basic flavors indicate things which are either good to eat and hard to find in nature (sweet, salty, umami and fat) or things which are potentially lethal (sour and bitter). Our visceral negative reaction to most bitter compounds comes from the fact that most naturally-occurring poisons are quite bitter. Our visceral negative reaction to strongly sour flavors comes from the fact that most acids (and unripe fruits) are quite sour.

The second big myth about flavor is the "tongue map." This is a leftover from 19th century science and has been thoroughly discredited by scientific researchers, although it still appears in some books. While there are some areas of the tongue which are slightly more sensitive to certain flavors than others, the flavor receptors for all five (or six) basic flavors can be found on any part of the tongue.

Our full perception of flavor is also heavily dependent on aroma, meaning that we can only fully perceive flavor when we exhale after having taken a sip of beer. When we exhale, some aroma compounds are liberated into our sinuses (through the retronasal passages) and the combined sensations of basic flavor plus aroma give us the full perception of taste.

People differ in their sensitivities to basic tastes, and some people are completely insensitive to certain chemical compounds. So-called "supertasters" have a higher density of taste receptors and are much more sensitive to bitter flavors, heat from capsaicin (chili peppers) and alcohol flavor. So-called "non-tasters" have a lower density of taste receptors and are more sensitive to sweet flavors. A quick test to determine if you are a supertaster is to apply a drop of blue food dye to your tongue, then stick out your tongue and place a piece of paper

with a hole punched in it (using a paper punch) over it. Have someone count the number of taste buds visible through the hole using a magnifying glass. If you have more than 35 visible taste buds, you are a supertaster. If you have fewer than 15, you're a non-taster. If you have between 15 and 35, you're somewhere in the middle.

Not surprisingly, people involved in the brewing and food trades tend to be supertasters.

The practical lesson is that, like our sense of smell, everyone's sense of taste is different, too. Be aware of your personal sensitivity to the basic flavors and respect the fact that someone else's perceptions, literally, might not be to your taste.

How to Taste Beer: Sense the beer's aroma first. Then take a quick sip which just coats the tip of your tongue and the sides of your mouth. This will let you detect the Initial flavor sensations. Exhale through your nose to pull aroma compounds into your sinuses. Take a larger sip and hold it in your mouth for a few seconds before swallowing. This will help you pick out flavors in the "middle" of the flavor profile and get an overall sense of the beer. Swirl the beer around in your mouth a bit to coat your mouth and then swallow. This will help you pick up elements of the beer's Finish and Aftertaste. Finally, take another sip and hold it in your mouth for 10-15 seconds before swallowing. Since enzymes in human saliva convert starchy compounds into simple sugars, this will help your perception of the beer's malt profile. After your last sip, notice how the flavor of the remaining beer in your mouth develops over time in the aftertaste.

Flavor Profile: Any food or beverage will have a "flavor profile" - some flavors will be instantly detectable in the Initial flavor, most take a fraction of a second to develop in the "Middle" of the flavor profile and some take a few seconds to develop and are only detectable in the Finish and Aftertaste. Finish and Aftertaste are typically in terms of basic flavors and duration, using terms such as bitter or sweet and lingering, short or non-existent. In beer, it is also important to describe the Balance between malt, hops and other elements in the beer (e.g., alcohol, sourness and/or spices).

Many beers will also have some degree of "Complexity" - interplay of aromas and flavors which "tease" the senses, drawing your attention to the beer as you drink it. "Simple" beers are much less "interesting" in flavor and aroma. Even if well made, they don't demand the same level of attention as you drink them. Generally, the most highly rated beers will have lots of complexity while poorly-rated, but well-made beers will be less complex.

Mouthfeel: Mouthfeel is the physical sensation of food or drink in our mouths. Aspects of mouthfeel aren't dependent on smell or taste, but on touch. Physiologically, aspects of mouthfeel are perceived via sensory receptors in our mouth, teeth and tongue which are sent to the brain via the trigeminal nerve. Physical sensations include body (perception of fullness), texture (crispness or creaminess, sometimes also oily, slick or powdery), physical or chemical burning (usually from alcohol or

higher alcohols), astringency (due to drying and coagulation of mucus in the mouth from tannins) and other sensations such as the presence of actual particles of material in the beer.

FOR THE EXAM IT IS VERY IMPORTANT THAT YOU DO NOT CONFUSE ELEMENTS OF MOUTHFEEL AND FLAVOR.

Part 2 - Overview of the Brewing Process

This section is necessarily short, since we will be covering most aspects of the brewing process in more detail in later classes. Very roughly, beer is made as follows.

Malt (usually sprouted and dried barley) and possibly other grains are crushed. They are then steeped in hot water for a certain amount of time allowing enzymes within the malt to hydrate and react with starches in the malt and grain. This converts the starches to simple sugars that yeast can metabolize.

After the malt has been steeped for a sufficient amount of time, more warm water is added and the liquid is run off into a kettle where it is boiled for a certain amount of time. This sanitizes the liquid (called wort), darkens it in color, concentrates and develops flavors, clarifies it, and drives off unwanted aroma and flavor compounds. In some styles of beer, adjunct sugars are also added to the boil. In most cases, the brewer also adds hops to the beer to add aroma, flavor and bittering to the beer, as well as “kettle finings” to help clarify it.

When the wort has been boiled for a sufficient length of time, it is quickly cooled and transferred to a fermentation vessel. There, yeast and oxygen are added (sometimes yeast nutrient is added as well) and the beer ferments at a controlled temperature. In some cases, once fermentation has mostly finished, the beer is transferred to another vessels to be conditioned or lagered for a period of time. During this time, it might have other ingredients added to it and/or finings might be added to clarify the beer. In some cases the beer will also be filtered. The beer is then packaged in bottles or kegs.

Commercial brewers have specialized equipment for each step of the process. Homebrewers typically use a stainless steel pot (sometimes converted from a beer keg) or a converted cooler as a mash tun, collecting run-off via a screen, mesh bag or manifold made from pipes. Wort is collected and boiled in a large stock pot or converted keg, either on a stove or using a propane cooker or an immersion heater. Wort is fermented in plastic buckets or glass or plastic carboys.

Kit brewers and extract brewers skip the mashing step and make their beer using commercially-prepared malt extract. Malt extract is boiled wort which has been vacuum distilled into syrup (liquid malt extract) or powder (dry malt extract). Both are quite handy to use, but need to be treated with care to get the best flavor.

Additionally, two systemic problems that brewers face are oxygen pick-up and infection.

Care and Handling of Extract Beers: Many beers encountered in judging are “kit beers” (i.e., made from malt extract - often with hops added, along with other ingredients

supplied by the manufacturer) or “partial grain” beers (i.e., made from malt extract with some grains which are steeped to provide color and flavor). Typically, these beers are made by inexperienced brewers and have a lot of flaws.

Old extract can have oxidative faults (covered in the first class) with darker color and dull flavors. Old hopped extracts can have cheesy flavors from stale hops. Since the brewer has no control over the wort composition, extract-only beers often lack some of the malt complexity and body of all-grain or partial-grain beers.

Since malt extracts are already boiled, boiling them again after they are reconstituted can further darken color, caramelize the wort and reduce head- and body-forming compounds. If not carefully dissolved, sometimes extract can scorch on the bottom of the kettle.

Most manufacturers recommend adding malt extracts only in the last 10-30 minutes of the boil - just long enough to sanitize it. Liquid malt extract should be carefully warmed before being added to the kettle, so they will pour and dissolve more easily. Dry malt extract should be added carefully so that the sticky malt particles don't get all over your stove and so that the wort doesn't boil over. Both sorts of extract must be stirred thoroughly to dissolve them and to prevent them from scorching on the bottom of the kettle.

Care and Handling of Partial-Grain and All-Grain Beers: Steeping or mashing grains adds an additional level of complexity to homebrewing. Two common problems with partial-grain or all-grain beers are oxidation from mishandled mashing or steeping process and astringency or grainy notes from poorly crushed, mashed or steeped grains. Poor grain crushing or mashing equipment, or poor equipment design, can result in lower extract yields, which can result in beers which aren't as strong as expected, or which don't have the proper malt character.

Brewing Equipment: Rarely, homebrewers will use non-food grade equipment, which can introduce phenolic or metallic faults to the beer. All brewing equipment should be made from aluminum, glass, enameled metal or stainless steel, although copper vessels can be used for wort boil. Storage and fermentation vessels must be made from glass, glass-lined metal or stainless steel to avoid oxidation or off-flavors. Although wood vessels can be used, they will impart distinct flavors to the beer. Plastic containers are oxygen permeable, but food-grade plastic containers can be used for short term storage or fermentation. Quite often, homebrewers ferment in plastic buckets, but condition in glass carboys.

Brass fittings can be used for brewery equipment, but they must be properly passivated (i.e., a layer of oxidation built up on the surface) lest they introduce metallic flavors to the beer. Brass and copper fittings shouldn't be used for fermentation and storage vessels, since the acidic nature of beer and prolonged contact will both corrode the fittings and introduce metallic flavors.

Sometimes, improper welds or brazing in brewery equipment can also introduce metallic notes into beer. Welds are also a potential hiding place for bacteria. Avoid these problems by using no-weld fittings and choosing proper brazing or welding materials. Food-grade stainless steel welding is quite tricky, especially on thin metal, so it might be worth hiring a professional, qualified food-grade stainless steel welder to make important joins if you are designing a stainless steel homebrew system.

To avoid mold contamination and musty aromas and flavors, brewery equipment must be stored dry and storage vessels must be kept from direct contact with wet surfaces (e.g., wet floors or damp basements). A quick solution if you have a damp basement is to put your fermenters on shipping pallets.

John Palmer's book, *How to Brew*, has a long appendix which discusses how to passivate brass fittings used in the brewhouse.

Part 3 - Sanitizers and Cleaners

Oddly, the BJCP exams don't test on cleaning and sanitizing in the brewhouse, but this information is important to know since these steps are critical in brewing and can result in serious problems if done incorrectly.

Beer production depends on producing wort from malt. Since this is a nutrient rich, sugary solution, it is the perfect media for just about every microorganism on the planet. To make sure that the yeast strain you want gets to eat that wort - as opposed to unwanted bacteria or wild yeast - brewers have to be meticulous about cleaning and sanitizing their equipment and their brewery.

Cleaning means that you physically remove unwanted materials from your equipment without cleaning or scratching the material - since scratches provide places where germs can hide. Sanitizing means reducing the number of unwanted microbes to a minimum, so that your chosen strain of yeast can out-compete them. Cleaning must precede sanitizing. You can't sanitize dirt!

Note: Sanitizing is different from sterilizing. Sterilizing kills all microbes, including their spores. Sanitizing just gets rid of most live bacteria and other microorganisms, but not bacterial spores.

When cleaning brewery equipment use soft rags, cellulose sponges or the softest variety of plastic scouring pad. You must be careful to not scratch the equipment!

Cleansers include things like soap, oxygen cleaners (e.g., Oxyclean™) and bleach, as well as specialized brewery and beer line cleaners. Sanitizers include bleach, 70% isopropyl alcohol solution (AKA rubbing alcohol), 1% hydrogen peroxide solution, Iodophor™, Star-San™, and other specialized brewery sanitizers. None of the BJCP exams get into the importance of cleaning and sanitizing, but improper sanitizing or cleaning can cause serious problems for homebrewers.

Typically, homebrewers are quite good about sanitizing, but not so good about cleaning. Gaskets, bad welds, hairline

cracks in carboys or other equipment can all harbor bacteria. If troubleshooting a persistent sanitation problem on your brewing system, you need to take apart every fitting and clean and sterilize it (if possible) and look carefully at every piece of equipment for pits and cracks. It is cheap insurance to replace inexpensive items like hoses, gaskets or airlocks rather than ruining a batch of beer.

Another common problem in homebrewed beer is overuse of cleaners and sanitizers. Excess use of chlorine-based cleaners or sanitizers can introduce unpleasant and distinct chlorophenol notes to the finished beer. Overuse of iodine-based sanitizers can introduce similar phenolic notes. Overuse of alkaline cleansers and sanitizers can result in unpleasant harsh bitter or soapy notes. Brewers must rinse cleansers thoroughly and use them at manufacturer-recommended concentrations. More is not better when it comes to cleansers and sanitizers!

If necessary, brewers must also let sanitizers air dry before adding beer or wort to a sanitized vessel, lest the finished beer pick up unpleasant phenolic or chlorophenolic notes.

Finally, be aware of how sanitizers or cleaners interact with various materials. Acidic sanitizers like Star-San or bleach can pit stainless steel if left in contact with them for long period of time. Strongly acidic cleansers can even pit glass over time.

Part 4 - Infections

Infections can be divided into two categories "wort spoilers" and "beer spoilers." Wort spoiling bacteria typically don't do well in alcoholic or acidic environments. But, if they get a head start on the yeast, they can produce extremely ugly flavors and aromas, notably sulfur compounds and dimethyl sulfide (DMS). To prevent wort spoiling bacteria, not only must you practice good sanitizing and cleaning in the brewhouse, you must make sure that your yeast is healthy and gets off to a good start. Once the yeast starts fermenting, the pH of the fermenting wort goes down and the alcohol level goes up, and wort spoiling bacteria die off.

Beer-spoiling bacteria take more time to get started. They survive better in higher-alcohol, low oxygen and lower-pH environments. Typical beer spoilers are the various species of *Lactobacillus*, *Pediococcus*, *Acetobacter*, *Pectinatus* and *Brettanomyces*.

Lactobacillus: Anaerobic. Produces a distinct lactic sourness and haze. This "infection" is extremely common in beer. Homebrewers frequently infect their beer with *Lactobacillus* by starting siphon hoses with their mouths, since the human mouth is filled with *Lactobacillus* bacteria. *Lactobacillus* is sometimes deliberately used to sour beer. It is particularly important to the flavor of Berlinerweisse.

Pediococcus: Can grow with or without oxygen. Produces diacetyl and lactic sourness. Fairly rare in beer, but part of the microflora used to produce lambics.

Acetobacter: Requires lots of oxygen. Produces a distinct vinegary taste and smell, as well as haze and possible slimy or "ropy" appearance or mouth texture. This infection is extremely

rare in beer, since brewers need to be extremely careless about both sanitation and oxidation for it to get started. Some acetobacter notes are acceptable in Flanders Red, Flanders Brown and the Belgian Lambics. Otherwise, it is a serious fault in beer.

Pectinatus: Requires oxygen. Produces haze, hydrogen sulfide (i.e., rotten eggs) aroma and a foul taste. Rare in beer and never appropriate.

Brettanomyces: This is a genus of wild yeasts. Requires some oxygen and slow to start. Produces haze and distinctive “horse blanket,” leathery, “barnyard,” smoky, bacon-like, clove-like, cheesy, or sweaty aromas and flavors, as well as acetic acid. Desirable in some varieties of beer, notably some American sour beers and the Belgian Lambic beers.

Part 5 - Acetic, Lactic and Sulfitic*†‡

These are common faults associated with infected beer. **You should know the difference between acetic and lactic sour for the exams.**

Acetic (Sour)

Detected In: Aroma, flavor.

Described As: Acidic, cidery, lingering sourness, sharp sourness, sour, tangy, tart, vinegary.

Typical Origins: Microbial contamination.

Typical Concentrations in Beer: 30-200 mg/l.

Perception Threshold: 130 mg/l.

Beer Flavor Wheel Number: 0910.

Discussion: Acetic acid is one of the more common sour (q.v.) tastes found in beer. It naturally occurs at low levels in all beers as a result of yeast activity during fermentation, although detectable levels are considered to be a defect in most beer styles.

* Acetic acid is volatile and has a relatively low perception threshold, so it can easily be detected in a beer’s aroma as well as in its flavor.

* High levels of acetic acid are caused by oxidation of ethanol by bacteria; most commonly *Acetobacter* species which produce a white pellicle or film on top of the beer in the conditioning vessel. *Acetomonas* bacterial infection also produces high levels of acetic acid. These infections produce a slimy, ropy film on top of the beer. Both of these infections take time to develop and can only proceed in the presence of oxygen. *Zymomonas* bacteria (typically *Zymomonas mobilis*) also produce acetic acid, along with esters, acetaldehyde and sulfur dioxide. Yeasts of the *Kloeckera* and *Brettanomyces* families can also produce acetic acid, in conjunction with other distinctive off-flavors (e.g., leathery, sweaty). Infections by these organisms can occur in anaerobic conditions, usually at ale fermentation temperatures or higher.

Increased By: * Inoculation with bacteria or wild yeast. * Exposing green or packaged beer to air.

To Avoid or Control: * Proper yeast management: Choose appropriate yeast strain. Reduce percentage of adjunct sugars in

the beer. Pitch correct amount of yeast (0.5 - 1.5 qt per 5 gallons) for optimum yeast health and to minimize lag time. * Practice proper sanitation. Thoroughly clean all cold-side equipment before sanitizing it. Don’t use cold side equipment which can’t be sanitized (e.g., wooden or scratched plastic utensils/containers). * Don’t use the same equipment for regular and standard beers unless it can be completely sanitized; especially avoid using soft plastic items for both. * Don’t expose green or packaged beer to air.

When Is Acetic Sourness Appropriate?: Low levels of acetic sourness are expected in Belgian sour ales (Flanders Red, Flanders Brown, Lambics).

Lactic (Sour)

Detected in: Aroma (but only at extreme concentrations), flavor.

Described As: Citric, crisp sourness, lactic, lemony, refreshing, sour, sour milk, tangy, tart, yoghurt.

Typical Origins: Microbial contamination.

Typical Concentrations in Beer: 0.2 - 1.5 mg/l.

Perception Threshold: 0.04 mg/l.

Beer Flavor Wheel Number: 0920.

Discussion: Caused by infection by various forms of Gram-positive bacteria, most commonly *Lactobacillus*, but also *Pediococcus* (although lactic sourness is only obvious after diacetyl has been reduced), both of which are present in dust and saliva. Acidulated malt can also introduce lactic sourness without the need for bacterial infection. Likewise, lactic acid, normally used to reduce mash pH can be used to sour beer. Lactic acid is mostly non-volatile so it is odorless except in high concentrations. It has a crisp, clean, tart sourness reminiscent of yogurt.

Increased By: * To induce lactobacillus infection, brewers sometimes use a sour mash, where mash inoculated with *Lactobacillus Debruckii* is held in an anaerobic state at ~115 °F for 2-3 days. Lactobacilli are also sometimes added to beer during secondary fermentation. * Avoid oxygenation of mash during sour mashing. Don’t let mash temp. fall below ~115 °F when sour mashing. * Cold-side storage containers and utensils used to produce sour beers must be kept separate from those used to produce regular beers if they can’t be sterilized.

To Avoid: * Proper yeast management. Choose appropriate yeast strain. Reduce percentage of adjunct sugars in the beer. Pitch correct amount of yeast (0.5 - 1.5 qt per 5 gallons) for optimum yeast health and to minimize lag time. * Practice proper sanitation. Thoroughly clean all cold-side equipment before sanitizing it. Don’t use cold side equipment which can’t be sanitized (e.g., wooden or scratched plastic utensils/containers). Don’t start a siphon by sucking it (lactobacillus is present in the human mouth). * Avoid oxygenation of green beer. * Perform mash out and sparge at ~168 °F, laut at above 160 °F. * Limit or eliminate acidulated malt, sour mash or lactic acid additions.

When Is Lactic Sourness Appropriate?: Very low levels of lactic sourness are acceptable in dry stout. Medium to high levels of lactic sourness are expected in Berlinerweisse. Medium to high levels of lactic sourness and low levels of acetic sourness are expected in Belgian sour ales.

Sulfitic (Sulfur Dioxide)

Detected in: Aroma, flavor.

Described As: Biting, burning matches, burnt rubber, choking, mothballs, sodium sulfite, sharp, striking match, sulfur dioxide, sulfurous.

Typical Origins: Yeast, process faults.

Typical Concentrations in Beer: <10 mg/l.

Perception Threshold: 7-20 mg/l.

Beer Flavor Wheel Number: 0710.

Discussion: Normally, yeast produces small levels (10 mg/l or less) of sulfur dioxide (SO₂) during fermentation. Higher levels are associated with added sulfites (e.g., potassium metabisulfite) used as anti-microbial, anti-oxidant and preservative.

Sulfites block staling in beer by interacting with acetaldehydes and carbonyl compounds, temporarily masking their distinctive flavors and aromas. As beer ages, however, sulfites form sulfur dioxide, adding distinctive “off”-characteristics to the beer along with the usual staling compounds.

High levels of sulfites (>10 mg/l) are toxic to yeast and bacteria. Levels of more than ~200-250 mg/l are toxic to people, but, fortunately, at that level, sulfite character is so strong as to be unpalatable. People with asthma are sometimes hypersensitive to sulfites, so U.S. and European law requires alcoholic beverages with more than 10 ppm of sulfites to be labeled with the warning: “Contains Sulfites.”

Note: When spiking beer samples with sulfite, make sure than none of your tasters are sensitive to sulfites and that they have no history of asthma.

To Avoid: * Avoid excessive sulfite (e.g., potassium metabisulfite) additions. * Choose proper yeast strain for style - some strains produce more SO₂ than others. * Avoid aerating mash, wort or beer, except when aerating wort prior to pitching yeast. This makes sulfite additions unnecessary. * Get a vigorous fermentation to scrub SO₂ out of beer. Ales seldom have SO₂ problems because their fermentation is more vigorous than lagers. * Condition beer for a sufficiently long time to get SO₂ out of green beer.

When Are Sulfite Notes Appropriate?: Never.

Part 6 - European Amber Lagers (BJCP Category 3) *†‡

The European Amber Lager category covers Vienna Lager and Oktoberfest, which covers German Traditional Oktoberfest/Märzen beers and some American adaptations of that style.

All beers in this category are medium-strength, malty beers which can range in color from dark golden to light brown, tending towards copper or amber. Hop bitterness is present but does not dominate the aroma and flavor profile. Vienna lagers are a bit darker than Oktoberfest and have a different, sweeter malt profile. Oktoberfests tend to be a bit “roastier” and usually have a copper color.

Originally “Märzen” was a German term for any strong, keeping beer, brewed in March, just before the end of the brewing season, and intended to be stored through the summer months. In its modern sense, however, Märzen is synonymous with Oktoberfest-style lager beers.

History of Vienna Lagers: Vienna lagers and Oktoberfests are the second and third products, respectively, of the “lager revolution” (of which Pilsner beer was the first) which swept the German-speaking world in the early part of the 19th century.

They are also the products of a remarkably productive friendship between Anton Dreher, an Austrian brewer studying at various breweries in Munich, and Gabriel Sedlmayer, a fellow brewer and Munich native. Their collaboration revolutionized brewing throughout the world. Together, Dreher and Sedlmayer, inspired by industrial breweries in Britain, created the first modern, industrial-style breweries in the German-speaking world, forcing their competitors to modernize as well, thus changing the face of brewing on the European continent. They were also the first to recognize that there was a difference between ale and lager yeast (although they had no idea that yeast was a living organism or exactly what the difference between ale and lager yeast strains was), the first to brew Pilsner-style beer on a large scale and the first to incorporate refrigeration technology on a large scale into German brewing (using ice, industrial refrigeration wasn’t invented until 1871 by Carl Linde).

Over the course of his career, Dreher and his followers founded lager breweries throughout Germany and Austria, producing both pilsners, but also darker amber beers. The first amber lager was designed by Anton Dreher in the 1830s, and was intended to combine the crispness and clean finish of a lager with the color of an English pale ale. Dreher called this new style “Schwechater Lagerbier, after the Vienna suburb home of his brewery, and it quickly became very popular. At first, the style might have been called “Weiner Typ” (Vienna style) after Dreher’s malting process, which produced reddish, caramelized crystal malt. Later, it was referred to as Märzen, in reference to the traditional German “keeping beers” brewed in March and lagered through the summer for consumption in autumn.

Sadly, the popularity of the Vienna style faded after just a few generations, and it went extinct in Europe following World War I. Fortunately for the style, for various reasons in the mid-to late 19th century a large number of people, including brewers in the Dreher tradition, were emigrating from the Austro-Hungarian empire.

A large number of these brewers emigrated to the Americas, but because German immigrant brewers were already established in the American North and Midwest, ambitious immigrant brewers found better prospects in the Southwestern U.S. and in Central and South America. Commercial refrigeration, steamships and railroads allowed breweries to exist in climates where they couldn't previously exist, and there was a ready market for cold, crisp-tasting beer in the tropics and sub-tropics.

Austro-Hungarian emigration to Mexico was particularly strong in the later part of the century. In 1861, Mexico defaulted on its debts to French, English and Spanish banks. This provoked Spanish troops to invade the country in same year, and allowed Napoleon III of France to install a puppet king, Maximilian I, an Austrian prince, as emperor of Mexico in 1863. Although Maximilian's rule was short and ill-fated, and European troops were driven out after just a few years, familiarity with Mexico inspired a number of immigrants to later move there.

While Vienna lager soon vanished in its home country, it flourished in Texas and Mexico. Although Prohibition killed the Texas Vienna lager tradition, the style flourished south of the border, and eventually became a "traditional" part of Mexican culture, as evidenced by beers such as Negra Modelo and Noche Buena. Recently, there has been a revival of interest in the style, particularly among American craft brewers.

Oktoberfest: The first Oktoberfest was held on October 12, 1810, in honor of the marriage of Crown Prince Ludwig (later King Ludwig I) and Princess Therese of Saxe-Hildburghausen. The festival in honor of the royal couple was held on the 12th of the month and a grand horse race in their honor was held on the 17th. The event was repeated the next year, but was called off the year after, since Bavaria had been swept up in the Napoleonic Wars. Once peace returned, in 1816, the festival was restarted. In 1819, the Munich city fathers took over the festival and declared that it should be an annual event. Later, the festival was lengthened and its dates pushed forward to take advantage of typically better weather at the beginning of October. With the rise of the railroads in the middle of the 19th century, and with the emergence of a larger, more prosperous middle class, Oktoberfest became popular throughout Bavaria and then throughout Germany.

Except for cancellation due to a cholera epidemics in 1854 and 1873, due runaway inflation and economic collapse in 1923-24, and due to wars in 1866, 1870, 1914-1918 and 1939-1945 Oktoberfest has been held ever since 1810. In 1919-20 and 1946-48, however, when German was (partially or fully) under control of the Allies, Oktoberfest was replaced by a less nationalistic "Fall Festival." To add to the indignity, during the 1946-48 festivals, the American military government only allowed beer under 2% ABV to be served.

The traditional blue and white repeating diamond pattern associated with Oktoberfest decorations is actually taken from the arms of the ruler of Bavaria. In German the only Oktoberfest

beer allowed to use the blue and white diamond design is the Hofbräu Brewery, which was once owned by the ruler and is now controlled by the Bavarian Ministry of Finance. Except when the Nazis were in control during years the Oktoberfest was held, from 1933-1938, the blue and white diamond pattern has been used every year the Oktoberfest has been held.

Today, Oktoberfest lasts for more than two weeks, attracts tens of thousands of visitors from all around the world, and is by far the best-known beer festival on the planet. Its success has sparked thousands of imitators, but - at least in the European Union - only Munich's celebration can call itself just "Oktoberfest."

Oktoberfestbier: While traditional märzen was doubtless served at early Oktoberfests (although there was no beer served at the original one in 1810), the style of beer now associated with Oktoberfest was only created in 1871 by Josef Sedlmayer. Although his older brother Gabriel had produced lager-style märzen beers since the 1840s, in 1871, lager beers in Munich were still dark, so Sedlmayer decided to make a paler, reddish beer in the Vienna style. He called it märzenbier because it was brewed in March, but lagered through the summer before it was sold in September.

Whether or not he intended it for Oktoberfest, the new märzen was sold at the festival and proved extremely popular, at a time when Oktoberfest itself was becoming increasingly popular as a tourist destination. Other breweries imitated the style and the new märzen soon became the dominant beer style at Oktoberfest. In time, the name of the beer style and the festival became synonymous.

Technically, only beer brewed by Munich breweries can be called Oktoberfestbier. Products by other breweries are designated "Oktoberfest-style" beer or Märzen. Over time, the original Oktoberfest beer style has evolved from Sedlmayer's original märzen. American brewers developed hoppier, versions of the style, with a lower or different malt profile, while Austrians developed lighter versions of the style, which are more akin to Munich Helles beers. The BJCP only recognizes the traditional Oktoberfest/Märzen style.

In recent years, German brewers have been producing lighter, less malty "Oktoberfestbier®" or "Festbier" designed to appeal to an audience more familiar with light lagers, which are similar to Austrian varieties. Most German Oktoberfest beers available in the U.S. are stylistically Märzen rather than Oktoberfestbier, but you should be aware of the difference. Traditional style Oktoberfest beers are often described as being "Traditional Oktoberfest," "Dunkel Oktoberfest" or Märzen. The few Oktoberfest-style beers are released in spring are sold as Märzen.

German Oktoberfest is classified as a "Vollbier" ("Full Beer") for taxation purposes, and must, by law, have a minimum Original Gravity of 13°Plato (S.G. 1.052), while Oktoberfestbier must have a minimum Original Gravity of 13.5 °Plato (S.G. 1.054).

Brewing Vienna, Märzen & Oktoberfest: Originally, Vienna Lagers were produced using Moravian malt and decoction mashing, which was the secret to its full, malty flavor. Oktoberfest beers originally included some proportion of Munich malt, which contributed to their flavor profile. Prize-winning Vienna lagers, Oktoberfests and Märzens use some form of two-row (usually continental) pale malt as a base, with Munich, Vienna, melanoidin and/or crystal malts to provide color and flavor. Noble continental hops are used for flavor and aroma. Munich- or Vienna-style water profile is appropriate, depending on the style.

Part 7 - Dark Lagers (BJCP Category 4)

History: *German Dark lagers are descended from two old brewing traditions. The first tradition is that of pre-modern brewing, when all malt was brown malt and all beer was brown or dark brown. The second tradition is that of British Porter brewing. In the late 18th century, Continental brewers began brewing lager versions of English porters and stouts. While these beers never became particularly popular, and most died out by the middle of the 19th century, some survived.*

Schwarzbier (Black Beer) is a Regional specialty from southern Thuringen in northern Franconia (part of the principality of Bavaria), particularly around the towns of Kulmbach and Bamberg. This style of beer is related to the brown and black smoked beers (rauchbiers) for which the region is famous, as well as more obscure styles of beer such as Kellerbier and Zoiglebiere (both cloudy, brown farmhouse ales). A beer similar to Schwarzbier is found in Bad Köstritz near Leipzig. It has a mellower malt profile than Franconian Schwarzbier, since it uses de-bittered roast malt, like that used to produce Baltic Porters.

Munich Dunkel is possibly a remnant of medieval and Renaissance Munich brewing traditions, a surviving form of continental porter, or both. It is slightly stronger than Schwarzbier, but slightly less hoppy and has a different flavor profile. Rather than being black, Munich Dunkels are a mahogany brown.

American Dark Lager is a simplified version of German dark lager, adapted to American (or industrial brewing) ingredients and tastes. They are less complex in both hop and malt flavor than their German counterparts making them easier to drink quickly. Some examples of this style are merely light or amber lagers with caramel coloring added. The only "historical" example of this style is Shiner Bock, which represents German brewing techniques adapted to the American market. Dixie Blackened Voodoo Lager is a craft-brewed example of the style, while all of the rest are essentially "industrial lagers" dressed in black.

Brewing Dark Lagers: German dark lagers are brewed using Vienna or Munich malt as a base. Munich Dunkels add a bit of Chocolate and crystal malt, while Schwarzbiers add a bit of Pilsner and Carafo malts. Both styles are decoction mashed, are hopped with noble hops and fermented using Munich lager

yeast. American dark lagers are brewed much like American Light Lagers, except that a small amount of caramel or chocolate malt is used to darken the color. They use small amounts of noble or noble-derived hops and are fermented using American lager yeast.

A useful, but simple way to think of the differences between the dark lager styles is to think of Munich Dunkel as tasting and smelling like "liquid bread" while Schwarzbier smells and tastes like "liquid toast" and Dark American Lager can taste like a Standard or Premium Light Lager, or an American Amber Lager (not covered by the BJCP guidelines) with some level of toast or roast character.

Part 8 - Strong Lagers (BJCP Category 5)

Bock beers are strong, malty, lightly-hopped German (specifically Munich, Bavaria) beers, traditionally associated with the spring and fall. Typically, they were brewed in the fall and then lagered until early spring, when they were served.

History: *Bock beers are a modern Bavarian adaptation of a late medieval style of strong wheat and barley ale once brewed in the Northern German city of Einbeck. They are said to have been first brewed in Munich in 1590 when Wilhelm V, Duke of Bavaria, noticed how much he and his subjects were spending on imported Einbeck beer. To save money he had an Einbeck-like, strong, brown to red beer brewed in his own brewhouse in Landshut (50 miles northeast of Munich).*

In 1591, he built another brewhouse in Munich on the current site of the Hofbräuhaus brewery. Initially, the new beer was reserved for the Duke and his court, but in 1610 it was sold to the general public, making a profit for the state. In 1612, Wilhelm's successor, Maximilian I, hired an Einbeck brewmaster, Elias Pichler, to brew beer in Munich. Under Meister Pichler's supervision, the first true strong Bavarian lagers emerged. Beers brewed "the Einbeck way" were first sold in 1614. In the local Bavarian dialect, Einbeck was pronounced "Ayn Bock" which punned nicely with the local word for a billygoat ("ein bock"). Because of the pun, soon Bavarians started referring to any strong, malty beer brewed according to the Einbeck tradition as "Bock." To this day, many bock beers make use of a goat in their label or advertising.

Bock beer gained its reputation as a spring or holiday beer due to the religious observances of medieval monks, who were required to fast on a regular basis. During these times, they could eat little or no solid food, so less devoted monks skirted the regulations by consuming plenty of fortifying liquids such as strong beer. Since the longest period of fasting was during Lent (the 46 days from Ash Wednesday to Easter Sunday), the monks made sure they had a plentiful supply of strong beer on for the late winter or early Spring Lenten fast. Following the monks' lead, lay people did likewise. While Bock beer wasn't the original Lenten fast beer, its high alcohol level (which meant it kept well) and full body meant that it was perfectly suited for that purpose. Later, bock was brewed for other holidays,

especially Christmas. In Austria, bock is a Christmas specialty beer.

Modern Bock Beers: While the original Bocks were dark reddish or brown beers, modern bocks can be dark, amber or pale. For tax purposes, the German government considers them to be Starkbier (literally “strong beer” – the highest of the four tax categories), which includes beers with an extract value greater than 16% (16°+ P, 5.5°+ ABV). The most famous, and arguably best, examples of the various Bocks still come from Bavaria.

Helles or Maibock is a relatively young, lighter-colored and lighter-flavored version of Bock associated with springtime, specifically the month of May. It is traditionally consumed between Easter and the opening of the Munich beer gardens in June. Arguably, Helles bock and Maibock are two different styles, with Maibock being darker and hoppier than Helles bock, but the two styles are similar enough that they effectively count as one. Frühlingsbock is a synonym for Maibock.

Traditional Bock was historically brewed September and October to be ready in time for Advent (roughly December 1) and is consumed from December to March. Traditionally, a bockbier has a minimum alcohol by volume content of about 6.5% and most standard bocks do not exceed 8% ABV.

Doppelbock was first brewed by the monks of St. Francis of Paula in Munich as a Lenten fast beer, first in their abbey brewery (which eventually became the Paulaner brewery) and later by secular “contract brewery” (which became the Franziskaner brewery). In honor of the Easter season, the monks christened their beer “Salvator” (Latin for “Savior”). In 1780, Salvator was made available to the public and soon other breweries were selling similar beers under the same name. This ended in 1896, however, when Paulaner trademarked the name, forcing other breweries to give their beers names reminiscent of the original, such as Celebrator, Triumphator, or Maximumator. American craft breweries frequently follow this tradition, giving their doppelbocks whimsical names which end in “-or.”

Alcohol for doppelbocks content ranges from 7% to over 10% ABV. Historic versions were sweeter and less alcoholic. Most versions of doppelbock are dark-colored, but pale versions exist. The traditional Munich season for doppelbock starts around St. Joseph's Day (March 19) and lasts for two weeks thereafter. Fastenbock (literally “Fast Bock”) is largely synonymous with doppelbock, but can refer to the original St. Francis of Paula Lenten beer. Winterbock is a doppelbock brewed for the winter season.

Eisbock is a traditional Kulmbach (a town approximately 20 miles north of Munich) specialty beer made by freeze-distilling doppelbock. After fermentation, the beer is frozen for 11-14 days and between 5 and 7 per cent of its volume is removed as ice. The beer is then lagered for six months. Because freezing removes not only water but also most tannins (from grain husks) and bitter resins (from hops), eisbock is extremely soft, smooth, and malty. Alcohol content ranges from 9% to more than 14% ABV. The beer is released to the public in a festival which takes

place in the Kulmbach town hall on the last Saturday in March, with the ceremonial hacking open of an icebound wooden cask.

G'fornes (Franconian vernacular for “a frozen thing”) refers to a type of eisbock. G'fornes was originally made by the Reichelbräu Brewery, which became part of the EKV Brewery in 1996, and has since become part of the Kulmbach AG brewery conglomerate.

Other types of bock beers include Urbock (a bock beer from the city of Einbeck – similar to a Traditional Bock) as well as doppelbock- or eisbock-strength versions of Munich Dunkel, Schwarzbier and Hefeweizen. The BJCP does not consider these types of beers to be bocks, though. They are either treated as specialty beers or are included in different judging categories.

Brewing Bock Beers: There are two schools of thought about homebrewing bock beers, the first holds that bocks should be made largely, if not exclusively from Munich malt, the other holds that lager or pilsner malt should make up the bulk of the grist, with about 30% Munich malt and small additions (less than 15%) of crystal malt (20-28° L for pale bocks and typically 40-47° L for dark ones, but up to 90-120°L can be used). In the latter case, dextrin malt (other than Munich malt) can be used to add body and amber or chocolate malt can be used to darken the beer. Helles bocks are largely made from 2-2.7° L pale lager malt with small amounts of 5-9° L Dunklesmalz making up the rest of the grist.

Note that Dunklesmalz (literally “Dark Malt”), which the Germans refer to as Munich malt, is not the same as Farbesmalz (Roasted Malt) which is commonly referred to as Munich Malt in the U.S.

Double decoction mashing is also traditional, with a protein rest and a high-temperature saccharification rest, although some German breweries forgo the protein rest and just use a high temperature saccharification temperature infusion mash.

Munich-style water (55-65 ppm Ca, 0 Mg, 40-60 Na, 35-55 SO₄ 60-90 Cl, 60 HCO₃) is required as are continental noble-type hops (Saaz, Hallertau, Tettnanger, Spalter) or hops derived from those strains. The wort is boiled for 90 minutes, chilled to 55° F or less and lager yeast (Wyeast 2124 Bohemian Lager™, 2206 Bavarian Lager, 2308 Munich Lager™, 2206 GF Bavarian Lager™, White Labs WLP800 Pilsner Lager Yeast, WLP820 Oktoberfest/Märzen Lager Yeast, WLP830 German Lager Yeast, WLP833 German Bock Lager Yeast or WLP838 Southern German Lager Yeast) is pitched.

After fermentation is complete, bocks are lagered at 33-38° F for up to 6 months, but usually for only 2 to 6 weeks. Eisbock is either produced by just brewing a stronger version of doppelbock, or, as is traditional, by freeze-distilling a doppelbock.

Freeze Distilling: Were you to practice freeze-distilling, in contravention of U.S. federal law, you would want to lager your doppelbock in a wide-mouth container which will not break should it, or its contents, freeze. You would then chill the surface of your lagering doppelbock to 10° F or a less and then slowly raise the temperature up from there to 32° F or less, so that any

alcohol trapped in the ice has a chance to drain away, leaving pure ice crystals. Alternately, you would chill your beer just to the point at which slush forms on the surface. In either case, you would then remove the ice, skimming off slush using a sanitized sieve or colander. As you did so, you would be careful not to aerate the beer, and to remove just the water and not alcohol trapped in larger pieces of ice. You could also set the ice aside in a separate closed, sanitized container held at freezing temperatures and return the alcohol which drains from the ice to the lagering container.

You would also be aware that removing as little as 5% of the volume of your beer would bring your doppelbock up to eisbock strength, and that the more water you remove from your beer, the more concentrated the remaining alcohol will be, meaning that if you progressively freeze and remove the water, you must chill your beer to progressively lower temperatures to get ice to form.

Keep in mind that ice distilling preferentially removes water, leaving behind alcohol and other compounds collectively known as congeners, which include methanol, higher or fusel alcohols, aldehydes and ketones. In extreme cases, freeze-distillation can produce hazardous concentrations of methanol and fusel oils. In any case, since it is congeners which are largely responsible for hangover symptoms, by freeze distilling you are concentrating all your hangover-producing products along with the alcohol.

By contrast, evaporative distillation removes congeners first, before it drives off the ethanol. For this reason, distillers typically discard the "first runnings" to remove some or all of the congeners from the distilled beverage, sacrificing some of the flavors and aromas contributed by the congeners for smoother flavor and reduced hangover risk.