BICEP #10

This session covers Recipe Design, Packaging, Aging, Oak and Barrel Aging and working with Spices, Herbs and Vegetables. Off flavors covered are Cardboard and Sherry. Beer styles covered are Categories 20-23 - Fruit, Spice/Herb/Vegetable, Smoke & Wood-Aged & Specialty Beers.

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: Recipe Design*‡

Since many beers are free of off-flavors, but fall short due to problems with ingredients or the brewing process understanding recipe design is critical to being a good brewer and a good judge.

Ideally, you will know what every ingredient used in beer tastes like in the finished beer, allowing you to imagine how the beer you're tasting was "put together." Understanding recipe design also allows you to imagine how a hypothetical beer recipe might taste in the glass.

On the BJCP Written Proficiency Exam, you will ALWAYS get this question:

Technical Question T14. "All Grain Recipe"

Provide a complete ALL-GRAIN recipe for <STYLE>*, listing ingredients and their quantities, procedure, and carbonation. Give volume, as well as original and final gravities. Explain how the recipe fits the style's characteristics for aroma, flavor, appearance, mouthfeel, and other significant aspects of the style.

* Styles may include: American IPA, Belgian Tripel, Bohemian Pilsner, Classic American Pilsner, Doppelbock, Dry Stout, English Pale Ale, German Pilsner, Oktoberfest, Robust Porter, Weizen.

10%	Target statistics (starting specific gravity, final specific gravity, and bitterness in IBUs or HBUs) and color (as SRM or a textual description of the color).
20%	Batch size, ingredients (grist, hops, water, and yeast) and their quantities.
35%	Mashing, boil, fermentation, packaging, and other relevant brewing procedures.
35%	Explain how the recipe fits the style's characteristics for aroma, appearance, flavor, mouthfeel, and other significant aspects of the style; and describe how the ingredients and processes used impact this style.

You must answer this question as a recipe form, and its best if you can create a recipe for each style and memorize it in advance.

In your answer, **focus on the underlined portions of the question, with emphasis on process and stylistic aspects,** since they're worth the most points. **Don't Sweat the Vital Statistics;** you don't need to memorize ranges of vital statistics. Instead, just memorize a few key numbers. Even then, they're only worth one point!

How to Design Your Recipes for the Exam

* **Keep target statistics within the midpoint** of the style descriptions.

* **Assume 5 gallon batches** (or whatever size you're most comfortable with) and calculate all quantities based on that target.

* **Keep recipes simple.** You're not trying to win a medal.

* **Use, or at least mention, proper ingredients for the style** (e.g., "Bohemian Pilsner was traditionally made using undermodified continental Pilsner malt").

* **Use, or at least mention, traditional techniques for brewing the style** (e.g., "Bohemian Pilsner was traditionally made using a triple decoction mash.")

*** Understand, and mention, why each ingredient is used in a particular beer.** (e.g., "Burton-style water, with its high sulfate levels, increases alpha acid extraction rates from hops, increasing hop bitterness.")

* **Understand, and mention, what each ingredient contributes to the finished beer** (e.g., "Pilsner malt produces a light-colored beer with bready, cracker-like aromas and flavors and possibly hints of DMS or hydrogen sulfide.")

* **Describe each ingredient** - grain, hops, water, yeast, adjuncts.

- At least describe quantities and basic ingredient type (e.g., "7.5 lbs. pale malt").

- Better yet, give as much detail as possible about the ingredient as possible (e.g., "7.5 lbs. of 5 °Lovibond Thomas Fawcett™ Maris Otter English pale malt" or "7.25 gallons of mash water, adjusted to have at least 350 mg/l Ca++ and 150 mg/l SO_4-, heated to a strike temperature of 175 °F.")

- Mention specific brands of ingredients if appropriate. E.g., Wyeast 1056 American Ale Yeast, Lyle's Golden Syrup.

* **Understand, mention and describe each step of the brewing process, why each step is done and how it should be controlled.**

- The steps in the brewing process are: Milling, Mashing, Sparging/lautering, Boiling, Cooling, Fermenting, Conditioning/lagering, Packaging.

- At minimum, describe the process. E.g., "After wort boil ends, crash cool wort."

Calculating Final Gravity

Final gravity is based on fermentability of the wort, but primarily yeast attenuation. Since most yeast strains attenuate to about 75%, a rough formula for F.G. is:

((OG -1) - ((OG - 1) x A) +1) = FG

The recipe discussion assumes 1.050, so ((1.050 – 1) - ((1.050 - 1) x .75) +1) = 1.0125, which is rounded down to 1.010. Beers with less attenuable worts and/or lower attenuating yeast strains use 1.016 instead.

- Better yet, describe exact techniques and purposes for each step. E.g., "After wort boil ends, crash cool wort using a counterflow chiller or heat exchanger to precipitate cold break, which keeps unwanted proteins and fatty acids from getting into your wort. Crash cooling also limits exposure to airborne pathogens before yeast is pitched."

* **Mention formulas if appropriate** (e.g., W x A x U x 7489 / V x C = hop utilization formula)

* **Mention common potential brewing or technique faults.** (e.g., "High levels of esters are wrong for this style, avoid by fermenting at cool end of the yeast's temperature range.")

* **Mention potential overlap with other styles** (e.g., "Similar to a German pilsner, but darker in color, sweeter, not as hoppy, and with a hint of DMS in the aroma.")

Basic Recipe Design

This section discusses the basics of recipe design for the test. It is based on Al Boyce's BJCP for Dummies exam prep guide, which was a very common preparation guide for the "legacy" BJCP exam. For this reason, most graders are very familiar with "Boyce method" recipes and are somewhat prejudiced against it. If used properly, this recipe design section will give you a score in the 70-85% range, but no higher. **Use it only if you don't have the time or resources to design your own recipes.**

If you do have time, work with your favorite basic brewing text and supplemental books such as ***Brewing Classic Styles*** and ***Designing Great Beers***. It's also helpful to play with various brewing software programs, since you can instantly see how changing ingredient types and quantities will change your recipe.

1) Vital Statistics

Use the following information to set up the vital statistics for your recipe:

O.G.: Original Gravity is 1.050 for "table strength" beers, 1.075 for strong beers - American IPA, Belgian Tripel and Doppelbock. **Memorize "1.075" and "1.050."**

F.G.: Finishing Gravity is 1.010 for beers with medium to medium-light body, 1.016 for sweeter beers with medium-full to full body - Bohemian Pilsner, Oktoberfest, Robust Porter and Doppelbock. **Memorize "1.010" and "1.016."**

IBU: Bitterness (International Bitterness Units) is 40 for beers with medium to medium-high hop bitterness, 25 for beers with medium-low hop bitterness and 10 for beer with very low hop bitterness (i.e., Weizen). **Memorize "40-25-10."**

SRM: Color (Standard Reference Measurement) is 6 for dark gold beers, 25 for dark brown beers. The outliers are 5 (Gold) for German Pilsner and 7 (Amber) for Oktoberfest. Memorize "6-25" "7 Oktoberfest," "5 German Pilsner" (**Mnemonic: At 6:25, you ordered 7 Oktoberfests and 5 German Pilsners**).

Calculating Original Gravity

To find the potential original gravity for a beer recipe, you must know the diastatic power of the grains in your mash, the extract efficiency of your brewing setup and the weight of grains in your grist.

As a rule of thumb, however, pure sugars yield 46 "gravity points" per pound, pale malt yields about 33 gravity points per pound and amber and toasted malts yield about 20 points per pound. Roasted or brown malts and non-malted grains don't yield any gravity points on their own. Expressed as a formula:

OG = ((G x P)/V) x E

Where:

OG = Original gravity.
G = grains (in pounds)
P = gravity points for the grain type.
V = final wort volume.
E = Extract efficiency.

***Grain Blends:** If you use more than one type of malt in the grist, you must calculate the OG of each type of malt separately and sum the total.*

The Basic Recipe Discussion assumes 10 pounds of grain which yield 330 gravity points, 5 gallons of wort, and 75% extract efficiency. So: ((10 x 33)/5) x 0.75 = 1.050.

Vital Statistics Table

This table lists numbers to use for each of the beers mentioned in the question. Outliers are in bold italic type.

STYLE	OG	FG	IBU	SRM
American IPA	1.075	1.010	40	6
Belgian Tripel	1.075	1.010	25	6
Bohemian Pilsner	1.050	1.016	40	6
Classic American Pilsner (CAP)	1.050	1.010	40	6
Doppelbock	1.075	1.016	25	6
Dry Stout	1.050	1.010	40	25
English Pale Ale (EPA)	1.050	1.010	40	6
German Pilsner	1.050	1.010	40	**5**
Oktoberfest	1.050	1.016	25	**7**
Robust Porter	1.050	1.016	40	25
Weizen	1.050	1.010	**10**	6

2) Batch Size

Choose 5 gallons. Mention that actual batch size might be a bit bigger (5.5 gallons) to allow for equipment losses.

Note: The rest of the Basic Recipe Design section assumes 5 gallon batches.

3) Grain Bill (AKA Grist)

Use the following information to describe the grist for your recipe. Note that if you have time and know what you're doing, you can specify specific products (e.g., 15 °L Weyermann CaraMunich malt, Munton's Maris Otter English Pale Malt).

Points per Gallon

Realistically, malts, sugars and grains vary in their extract efficiency.

Malt	*FGDB%*	*Max PPG*	*Typ. PPG (75%)*	*PPG Steep*
2-row lager	*80*	*37*	*28*	*0*
2-row pale ale	*81*	*38*	*29*	*0*
6-row pale	*76*	*35*	*26*	*0*
Barley, roast	*55*	*25*	*19*	*21*
Biscuit	*75*	*35*	*26*	*0*
Brown	*70*	*32*	*24*	*8**
CaraPils	*70*	*32*	*24*	*4**
Chocolate	*60*	*28*	*21*	*15*
Crystal 10-15 °L	*75*	*35*	*26*	*14**
Crystal 120 °L	*72*	*33*	*25*	*16*
Crystal 15-40 °L	*74*	*34*	*25.5*	*18*
Crystal 60-75 °L	*74*	*34*	*25.5*	*18*
Flaked barley	*70*	*32*	*24*	*0*
Flaked Rice	*82*	*38*	*38.5*	*0*
Flaked wheat	*77*	*36*	*27*	*0*
Flaked, Oats	*70*	*32*	*24*	*0*
Munich	*75*	*35*	*26*	*0*
Patent	*55*	*25*	*19*	*21*
Rostmalz	*70*	*32*	*24*	*21*
Rye malt	*63*	*29*	*22*	*0*
Special B	*68*	*31*	*23*	*16*
Sugar, cane	*100*	*46*	*46*	*46*
Sugar, corn	*92*	*42*	*42*	*42*
Sugar, dextrin	*100*	*40*	*40*	*40*
Victory	*75*	*35*	*26*	*0*
Wheat malt	*79*	*37*	*28*	*0*

** Low extraction rates due to unconverted starches.*

*Data taken from **How to Brew**, p. 193.*

Extract Efficiency: Mention 75% for grains, 100% for adjunct sugars. It's easy to remember and allows you to use 10 or 15 lbs. of grain to design a 5 gallon recipe. Note: Actual extract efficiency can vary.

Malt Amounts: Use 10 lbs. for all beers except for IPA, Tripel and Doppelbock, which use **15 pounds.** Multiply by the percentages given below to get the exact grain bill:

Malt Types: Use malts from the appropriate country for the style (e.g., German Pilsner malt). Remember that some form of pale malt ("base malt") forms the largest portion of the grist for virtually all beer styles. You should list your base malt first.

Malts Percentages: Use the following malt percentages for the various styles:

American IPA: 80% American 2-row pale ale malt, 15% 20 °L crystal malt, 5% 60 °L crystal malt. Alternately, just 100% American 2-row pale. **Memorize: 80-15-5.**

Belgian Tripel: 80% Pilsner malt, 20% light candi sugar. **Memorize: 80-20.**

Bohemian Pilsner: 100% Moravian Pilsner malt.

CAP: 75% American 6-row lager malt, 25% flaked maize. **Memorize: 75-25.**

Doppelbock: 100% Munich Malt.

Dry Stout: 65% English pale ale malt, 25% flaked barley (unmalted), 10% 500 °L black roasted barley (unmalted). Alternately: 3% °L 400 chocolate malt, 3% 500 °L patent malt, and 3% 400 °L unmalted roasted barley. **Memorize: 65-25-10.**

English Pale Ale: 90% English pale malt, 10% 60 °L crystal malt or 10% Lyle's Golden Syrup™. **Memorize: 90-10%.**

German Pilsner: 100% Pilsner malt.

Oktoberfest: 100% Munich malt. Alternately: 50% Munich malt, 45% pilsner malt, 5% 15 °L crystal malt. **Memorize: 50-45-5.**

Robust Porter: 80% English pale ale malt, 10% 40 °L Crystal, 5% 350 °L chocolate malt, 5% 525 °L black patent malt. **Memorize: 80-10-5-5.**

Weizen: 70% German wheat malt, 30% pilsner malt. **Memorize: 70-30.**

4) Hop Additions

Use the following information to describe the hops used for your recipe.

Alpha Acid (AA): A quick "cheat" is to always use 5%, regardless of hop type. It is better, however, to memorize a few simple hops which are appropriate to all the beer styles and make them 4% or 5% AA for flavor and aroma hops and 8 or 10% for bittering hops.

Hop Additions: Only use bittering, flavor and aroma additions for the exam. **Mention other techniques where appropriate** (e.g., first wort for Bohemian Pils, dry hopping when for English Pale Ale or American IPA).

Boil Time: Use 60 minutes for bittering hops, 15 minutes for flavor hops and 0 minutes ("at knockout") for aroma hops.

Utilization Rates: Mention 25% or 28% for bittering, 5% or 8% for flavor, 0% for aroma.

Hop Amounts: Choose 2 ounces of bittering hops for 40 IBU, 1 ounce for 25 IBU or ½ ounce for 10 IBU. If a beer is supposed to have hop aroma or flavor, **use ½ to 1 ounce of flavor and/or aroma hops.** Effectively, they're "free" in terms of utilization.

Hop Types: Choose hop varieties appropriate for the beer's country of origin or style. Where multiple types are possible, mention multiple varieties.

Belgium: Styrian Goldings or Strisselspalt.

England: East Kent Goldings, Fuggles.

Czech Republic: Mention "Czech-grown noble hops" or just say Saaz.

Germany: Mention "German-grown noble hops" or name one: Hallertauer Mittelfrüh, Spalt or Tettnang.

USA: Choose one of the "C Hops:" Cascade, Centennial, Chinook or Columbus. If you want to get fancy, mention one of the modern, "dual use," proprietary types, such as Amarillo, Citra or Warrior.

Suggested Hop Additions

This table lists suggested hop amounts and types for each beer listed in the question. Note that "East Kent Goldings is listed as "EKG," Hallertauer Mittelfrüh is listed as "HM" and Styrian Goldings is listed as "SG."

Style	Bitter	Flavor	Aroma
American IPA	2 oz. Centennial	1 oz. Chinook	1 oz. Cascade
Belgian Tripel	1 oz. SG	1 oz. SG	None
Bohemian Pilsner	2 oz. Saaz	1 oz. Saaz	1 oz. Saaz

CAP	2 oz. Cluster	1 oz. U.S. grown HM	1 oz. U.S.-grown Tettnang
Doppelbock	1 oz. Spalter	0.5 oz. Tettnang	None
Dry Stout	2 oz. EKG	None	None
EPA	2 oz. EKG	1 oz. Fuggles	1 oz. Fuggles
German Pilsner	2 oz. HM	1 oz. Tettnang	1 oz. Spalt
Oktoberfest	1 oz. HM	1 oz. HM	None
Robust Porter	2 oz. EKG	1 oz. Fuggles	None
Weizen	0.5 oz. HM	None	None

5) Water

Water Treatment: Water should be dechlorinated using filtration and adjusted to match the historical city (or a historic city) for the style. Mention levels of particular mineral ions if they are particularly high, low or important to the style (e.g., very low ion water for Plzen, high sulfate water for Burton-on-Trent).

Total Volume: 9 gallons of total water for all styles except IPA, Tripel or Doppelbock, where water is increased by 50% to 13.5 gallons.

Strike Water: 3.5 gallons of strike water (increased by 50% to 5.25 gallons for IPA, Tripel or Doppelbock) at 163 °F for a mash temperature of 150 °F.

Sparge Water: 5.5 gallons of sparge water (increased by 50% to 8.25 gallons for IPA, Tripel or Doppelbock) at 168 °F.

Water pH: All water should be adjusted to pH 5.2 using phosphoric or lactic acid. Use 3 tsp for most beers, increased by 50% to 4.5 tsp for IPA, Tripel or Doppelbock. Mention that more acid (or buffer) might be needed when brewing with highly alkaline water (e.g., Burton, Dublin, London).

Water Treatment Type

Style	City	Mineral Ion Ranges
American IPA	San Francisco	Medium low CO_3, Low Ca, Cl, SO_4, Mg, Na.
Belgian Tripel	Brussels	Medium Ca & CO_3, medium-low SO_4, low Cl, Mg, Na
Bohemian Pilsner	Plzen	Very low overall ion levels. Use distilled or reverse osmosis water, cut 50/50 or 75/25 with medium hardness dechlorinated tap water.
CAP	St. Louis	Medium CO_3, med-low Cl, SO_4, low Ca, Mg, Na.
Doppelbock	Munich	High CO_3, medium-low Ca, low Cl, Mg, Na, SO_4.
Dry Stout	Dublin	High Ca, CO_3, medium-low SO_4, low Cl, Mg, Na.
EPA	Burton-on-Trent	Very high Ca, CO_3 & SO_4, medium-low Cl, Mg, Na.
German Pilsner	Munich	High CO_3, medium-low Ca, low Cl, Mg, Na, SO_4.
Oktoberfest	Munich	High CO_3, medium-low Ca, low Cl, Mg, Na, SO_4.
Robust Porter	London	High CO_3, medium Ca, Cl, Na, SO_4, low Mg.
Weizen	Munich	High CO_3, medium-low Ca, low Cl, Mg, Na, SO_4.

6) Yeast

Yeast Type: Choose ale or lager. Mention country of origin (e.g., German lager yeast, English ale yeast). If possible, or appropriate to the style, **mention specific yeast strain or brand** (e.g., Wyeast 3068 Weihenstephan Weizen yeast).

Starter Culture: Create 1.5 quarts of starter for ales, 4 quarts for strong ales, 3 quarts of starter for lagers and 7 quarts for strong lagers. Cell counts for ales should be about 175 million/liter for ales, 275 million/liter for strong ales, 300 million/liter for lagers and 500 million/liter for strong lager. If you want to be clever, and have the time to explain yourself, suggest underpitching yeast for weizen.

Aeration: Write **"Use food-grade oxygen and a sintered airstone for 1 minute to deliver 10 ppm dissolved oxygen to the cooled wort."**

Fermentation Temperature: Choose 55 °F for lagers, 65 °F for ales and 70 °F for Belgian Tripel. If you want to be

Calculating Hop Amounts

A simplified formula for figuring the weight of hops needed is:

Weight= IBU x V/ (A x U x 7490)

Where:

Weight = weight of hops in ounces.
IBU = target IBU level for your beer.
V = wort volume in gallons
A = Alpha Acid percentage of the hops.
U = Utilization efficiency.
7490 = This is a conversion factor from metric to English units.

The calculation for IBU (Rager method) is

*IBU = ((W x A x U x 7462) / (V * (1+GA))*

If wort gravity > 1.050 GA = (Boil Gravity - 1.050)

Utilization Efficiency: *Utilization efficiency depends on a number of factors, mostly boil time, but also wort pH, mineral levels in the wort and sugar concentration. Utilization of bittering hops ranges from 25-33%, 2-10% for flavor hops and 0-2% for aroma hops.*

Hop Blends: *If you add a blend of hops, you must determine the average level of alpha acids. If you add different types of hops at different times during the boil, you must determine their total contribution to alpha acid levels separately and sum the total.*

The sample recipe section assumes IBU targets of 40, 25 or 10, 5 gallons of wort, 5% alpha acid level, a utilization of 25% for bittering hops and utilization levels of 0% for flavor and bittering hops. Calculations are then rounded to the nearest whole ounce.

For example, for a beer with 40 IBU: 40 x 5 / (.05 x .25 x 7490) = 2.13 oz (rounded to 2 oz.)

clever, and have the time to explain yourself, suggest fermenting weizen at 62 °F and gradually letting the temperature rise to 70 °F.

Yeast Information Table

Suggested brands are based on Wyeast, no insult intended to other yeast producers! Outliers are in bold italic text.

Style	Brand	Cell count (mill/l)	Starter	Temp.
American IPA	American Ale	**275**	**4 qt.**	65 °F
Belgian Tripel	**Abbey Ale**	**275**	**4 qt.**	**70 °F**
Bohemian Pilsner	Budjevoice Lager	300	3 qt.	55 °F
CAP	American Lager	300	3 qt.	55 °F
Doppelbock	Munich Lager	**500**	**7 qt.**	55 °F
Dry Stout	Irish Ale	175	1.5 qt.	65 °F
EPA	London Ale	175	1.5 qt.	65 °F
German Pilsner	Munich Lager	300	3 qt.	55 °F
Oktoberfest	Munich Lager	300	3 qt.	55 °F
Robust Porter	London Ale III	175	1.5 qt.	65 °F
Weizen	Weihenstephan weizen	175	1.5 qt.	65 °F

7) Mashing

Mash Type: Choose the proper mash type for the style you wish to brew.

If you can't remember the details for the appropriate mash type, choose Single Infusion, but mention and describe the appropriate traditional (or modern commercial) method of producing the beer and give justification for your choice. For example: "X is the classic mash technique for this style, but due to the highly modified malts available today, this recipe uses a single infusion mash."

Rests: Unless you specified a Single Infusion Mash, mention types of rests and rest temperatures associated with the traditional forms of mashing.

Acid Rest: 95-120 °F for 60-120 minutes.

Protein/Beta-Glucanase Rest: 122 °F for 20 minutes.

Saccharification Rest - Beta Amylase: 130-150 °F for 30-90 minutes. Mash at this temperature for thinner-bodied, drier beers, e.g., EPA, Pilsners, American IPA.

Saccharification Rest - Alpha Amylase: 149-158 °F for 30-90 minutes. Mash at this temperature for fuller-bodied beers, e.g., Doppelbock, Oktoberfest.

Mash Out: 168 °F for 15 minutes.

Strike Water Temperature & Volume: Discussed under Water.

Mash Water Acid and Mineral Adjustments: Discussed under water (should be 3.5 or 5.25 gallons). Mash pH should be 5.2. **Regardless of style, mash water should have 50 mg/l of calcium for optimal mash efficiency.**

Special Ingredients: Tripel uses Candi Sugar, which is added to the boil, not the mash. **CAP made using a cereal mash would use ground corn or rice, rather than flaked corn.**

Recirculation (AKA Vorlauf): You should **recirculate the mash runoff** back through the mash bed in order to clarify the runoff for **30 minutes. Avoid splashing or spraying the runoff to avoid hot side aeration.**

Sparging (Lautering): You mentioned sparge water volume back in the water section (5.5 or 8.25 gallons). Sparge water temperature should be **168 °F** and should last **for 45 minutes**. To avoid extracting tannins from your grist, **stop collecting runoff if the mash pH goes above 5.8 or the specific gravity of the runoff goes below 1.008.**

Calculating Strike Temperature

Strike Temperature Formula: *When using an infusion mash, you must know the "strike temperature" for your water to achieve a particular target temperature before you add it to the mash. The formula is:*

(0.2 ÷ R) X (T2 – T1) + T2 = Tw

Where:

Tw = actual temperature of infusion water
R = Ratio of water to grain in quarts per pound.
T1 = Initial mash (or dry grain) temperature.
T2 = Target mash temperature.

The sample recipe discussion assumes 1.25 quarts/lb. of mash, a mash temperature of 70 °F, a target temperature of 150 °F. So (0.2 ÷ 1.25) x (150 – 70) + 150 °F = 162.8 °F (rounded to 163 °F)

Calculating Water Volume

To find the volume of water needed for mashing and sparging you must know the mass of grain to be mashed and the target volume of the wort to be collected.

Mash Water Formula: *The formula for mash water volume is:*

Mass weight (lbs.) x 1.25 quarts = Wort volume (gallons).

Total Water Volume Formula: *The formula to find the total volume of water needed for mashing, sparging and wort boiling is:*

(Batch Volume + Trub Volume)/ (1 - ((Wort Shrinkage Percent/100)/ 1 - (Boil Time x (Boil-off Percentage/100)) + Equipment Loss Volume + Grain Volume) x Absorption Rate) = Total Water Volume.

The sample recipe section assumes a 5 gallon batch, with .5 gallons of trub, 4% wort shrinkage, 1 hour boil time, 10% boil-off, 1 gallon of equipment loss volume, 10 lbs. of grain and an absorption rate of = .13.

Sparge Water Volume Formula: *The formula to find the amount of sparge water needed is:*

Total Water needed – Mash Water = Sparge Water Volume

Mash Type Table

Style	Mash Type	Rests
American IPA	Step	Beta Amylase > Alpha Amylase > Mash Out.
Belgian Tripel	Step	Saccharification > Mash Out
Bohemian	Triple	Acid Rest > Saccharification >

Pilsner	Decoction	Mash Out.
CAP	Cereal Mash	Protein > Saccharification > Mash Out
Doppelbock	Double Decoction	Protein > Saccharification > Mash Out.
Dry Stout	Single Infusion	Saccharification
EPA	Step	Saccharification > Mash Out
German Pilsner	Double Decoction	Protein > Saccharification > Mash Out.
Oktoberfest	Double Decoction	Protein > Saccharification > Mash Out.
Robust Porter	Single Infusion	Saccharification
Weizen	Triple Decoction	Protein/Beta-Glucanase > Saccharification > Mash Out

8) Wort Boiling, Cooling and Transfer

Boil Time: A 60 minute, full, rolling boil in an open kettle to facilitate hot break., except for beers where extensive hop extraction or color development is desired (American IPA, Doppelbock, Oktoberfest), in which case specify a 90 minute boil. For styles which use Pils malt or corn, mention that this process drives off DMS.

Hop Additions: Bittering hops added at the beginning of the boil. Flavor hops added at 30 minutes before the end of the boil. Aroma hops added at the end of the boil.

Finings: For all but weizen, **1 tbsp of Irish moss (or similar kettle finings) added 5-15 minutes before the end of boil in order to help precipitate the hot break.**

For weizen: "No finings added due to desired cloudiness in finished beer."

Chilling: Crash cool the wort using a counterflow wort chiller or heat exchanger in order to precipitate the cold break. Wort should be cooled to approximately 5 °F below desired fermentation temperature.

Wort Transfer: Wort should be whirlpooled, filtered or siphoned to avoid transferring trub (hot and cold break, hop residue) to the fermentor. Some cold break is acceptable in the wort since it is necessary for optimum yeast health.

Fermentation

Yeast Strain, Volume, Temperature, etc: See Yeast, above.

Primary Fermentation Time: Ales: 3-5 days. **Strong Ales:** 7-14 days. **Lagers:** 2-4 weeks. **Strong Lagers:** 3-6 weeks.

Secondary Fermentation Time: Ales: None (for cask-conditioned English ales), otherwise 1-3 weeks. Strong Ales: 2-4 weeks. Lagers: Diacetyl Rest at 65 °F for 2-3 days. Conditioning for 2-4 weeks (6-8+ weeks for strong lagers).

8) Packaging

Bottle Conditioning: A quick and simple "boilerplate" answer to this part of the question is to just write, "**Add ¾ cup of corn sugar at bottling or force carbonate to achieve 2.5 volumes of CO_2.**"

A better approach is to adjust bottle conditioning methods to the exact style, as listed below.

Style	Vol. CO_2	Carbonation method
American IPA	2.5	115 g (4 oz.) corn sugar
Bohemian Pilsner	2.5	115 g (4 oz.) corn sugar*
CAP	2.5	115 g (4 oz.) corn sugar
Doppelbock	2.5	115 g (4 oz.) corn sugar*
German Pilsner	2.5	115 g (4 oz.) corn sugar*
Oktoberfest	2.5	115 g (4 oz.) corn sugar*
Belgian Tripel	3.0	150 g (5.5 oz.) corn sugar
Weizen	3.0	150 g (5.5 oz.) corn sugar*
Dry Stout	2.0	75 g (2.6 oz.) corn sugar
EPA	2.0	75 g (2.6 oz.) corn sugar
Robust Porter	2.0	75 g (2.6 oz.) corn sugar

* Use of speise (wort at high kräusen from another, similar batch of beer) is traditional.

Color Calculations (Mosher, Daniels Formulae)

A rough and ready method of calculating beer color is as follows:

MCU = sum of (°Lovibond rating x pounds)/gallons

Once you've gotten MCU, you then need to correct the formula:

MCU < 10.5 SRM, the MCU rating is reasonably accurate.

MCU => 10.5- =>37 use Ray Daniels' formula to get actual SRM 10.5 to 15.8

MCU >37 MCU, use Randy Mosher's formula to get SRM 15.8 and higher.

***Ray Daniels' formula:** SRM = (MCU x 0.2) + 8.4 (Use this for Doppelbock on exam).*

***Randy Mosher's formula:** SRM = (MCU x 0.3) + 4.7(Use this for Stout and Robust Porter on the exam)*

***Example: Tripel,** 15 lbs 1.8 L Pilsner malt, (15 x 1.8) / 5 = 5.4 MCU = 5.4 MCU = 5.4 SRM.*

***Example: Doppelbock (**8 lbs 10 L Munich malt, 8 lb 4 L Vienna Malt, Color = (8 x 10) + (8 x 4) / 5 = 22.4 MCU, 22 > 10.5 and < 37. Use Daniels 22.4 x .2 + 8.4 = 12.88 SRM.*

***Example: Dry Stout** 8 lbs 2 L 2 row malt, 1 lb 400 L Roasted Barley, 1 lb 1 L Flaked Barley SRM = ((8x2)+(1x400) + (1x1))/5 x = 83.4 MCU. Use Mosher 83.4 x.3 + 4.7 = 29.72 SRM.*

***Example: Robust Porter** 8 lb English pale 2 row malt 2L 1 lb crystal malt 60L 0.75 lb chocolate malt 350L 0.25 lb black patent malt 400L SRM = ((8x2) + (1x60)+(.75x350) +(.25x400))/5 = 87.7 MCU, Use Mosher 87.7x.3 + 4.7 = 31.01 SRM*

9) Explaining How the Recipe Fits the Style

*** Mention the most important attributes first. (e.g., hop character for the American IPA).**

* **Aroma:** Comment on malt, hop and yeast aroma (e.g., esters, phenols, diacetyl, DMS, sulfury notes, acetaldehyde), as well as other aromatics.

* **Appearance:** Comment on color, clarity and effervescence (e.g., sparkling, still), as well as head size, retention, color and texture. If appropriate, mention viscosity or alcohol "legs."

* **Flavor:** Comment on malt flavor, sweetness or dryness, hop bitterness, hop flavor, yeast character (e.g., esters, phenols, diacetyl, DMS, sulfury notes, acetaldehyde), balance (sweetness vs. hop bitterness) and finish/aftertaste.

* **Mouthfeel:** Comment on body, carbonation level, alcohol character (e.g., warming, prickly, burning), texture (e.g., creaminess), astringency, and other palate sensations.

- If a beer doesn't have a particular characteristic, say so! (e.g., "Alcohol warmth is inappropriate for this style").

10) Describe How ingredients & Process Affect Style

* If you're running out of time, a quick cop-out is to just write, **"The malt, hops, and yeast used in this recipe work together to produce the aroma, appearance, flavor and mouthfeel representative of an X style beer**." But, if you use this boilerplate text expect the graders to recognize it for the B.S. it is, and grade accordingly.

* A better way to answer is to briefly describe what each ingredient adds to the final beer, hitting the most import aspects first. For example for a German Pils, a good answer might be, "IBU levels, and Noble German hops (Tettnang and Spalt), used for flavor and aroma, give the beer firm bitterness, and the moderate to high elegant floral, spicy notes expected for this style."

* If you've got extra time at the end of the test come back to this part and elaborate, if you know it.

Question T14 Sample Recipe Sheet

This is a sample recipe sheet for question T14. You should practice using it to design sample recipes. Before the exam begins, if the exam organizer allows you to do so, write out as much of the form as you can remember and then fill in the blanks once you know what style you're being tested on.

Style:	**Category:**	**Subcategory:**		
Batch Size: 5 Gallons				
Vital Statistics				
OG:	IBU:	FG:	SRM:	
Grist (@ 75% efficiency)	**Amount**			
Base Malt:	_____Lbs.			
Other Malt: _____ °L	_____Lbs.			
Other Malt: _____ °L	_____Lbs.			
Other Malt: _____ °L	_____Lbs.			
Other fermentables:	_____Lbs.			
Hops (all @ 5% AA)	**Amount**	**Utilization**	**Boil**	
Bittering:	_____Oz.	25%	60 min.	
Flavor:	_____Oz.	5%	30 min.	
Aroma:	_____Oz.	0%	at flame-out	
Mash hopping? Y/N				
Dry hopping? Y/N				
Water	**Volume**			
Total Volume:	_____gal.			
Mash Volume	_____gal.			
Sparge volume:	_____gal.			
Acid:	_____tsp.			
Water adjusted to: (City name)				
Important ion adds: Cl, CO_3, Ca, Mg, Na, SO_4				
Yeast				
Variety:	Starter volume:	1.5, 3, 4 or 7 qt.		
Aeration: 2 min. w/ food-grade O2 & sintered airstone to get 10 ppm dissolved O_2				
Fermentation Temp.				
_____ºF				
Mash				
Mash Type: Infusion.				
Traditional Mash Type: Step, Decoction, Cereal.				
Strike Water Temp.	_____ºF			
Traditional Rests	Mash temp.	Time	Purpose	
1.	_____ºF	_____ min.		
2.	_____ºF	_____ min.		
3.	_____ºF	_____ min.		
Mash Out Y/N	168 °F	15 min.		
Recirculate/Vorlauf:	168 °F	30 min.		
Sparge/Lauter:	168 ºF	45-90 min.		
Boil: Boil 90 min. Full rolling boil to facilitate hot break, add hops according to schedule above.				
Finings: 1 tsp Irish moss added 15 minutes before flame-out to precipitate hot break.				
Chill: 1. Use counterflow chiller to crash cool wort to facilitate cold break. 2. Cool to 5 °F below fermentation temp. before pitching yeast. 3. Siphon, whirlpool or filter to separate wort from most of the cold break.				
Fermentation:	**Temp.**	**Time**		
Primary:	_____ºF	___days/weeks.		
Diacetyl Rest:	_____ºF	___days/weeks.		
Secondary:	_____ºF	___days/weeks.		
Packaging: Bottle condition with ¾ cup corn sugar for priming				
Aroma:				
Appearance:				
Flavor:				
Mouthfeel:				
Impact of ingredients & procedures on style?				

Part 2: Packaging

Packaging refers to the process of preparing the beer for dispense. Of necessity, this section will be short, since there are entire books on the minutiae of kegging and draft dispense.

While it is possible to drink your beer directly from the conditioning vessel, it is desirable to package the beer in a different container for storage and consumption. The beer can also be carbonated or have final ingredients added to it during this process.

Typical methods of packaging are bottling, kegging and cask-conditioning. These notes will just discuss bottling, since bottled beers are the only style of beer allowed in most competitions.

***Bottling:** This is the simplest and cheapest, but most time-consuming method of packaging beer (at least for homebrewers). Improper bottling can result in biological contamination, excessive oxidation or improper carbonation levels.*

In homebrew competitions, improper carbonation levels can directly or indirectly make the difference between a winning beer and one which doesn't place.

Low carbonation level is a serious fault, it impairs not just head formation and retention, but also reduces perceptions of aromas and make the beer seem fuller-bodied and more cloying than it actually is.

Excessively high carbonation levels result in gushing or excessively high head. The former can mix remaining yeast trub into the beer; either problem can result in very quick loss of

delicate aromas and contribute to perceptions that the beer is thinner, lighter bodied and more astringent than it actually is.

The easy way to get the proper level of carbonation is to "cheat" – by force carbonating your finished beer when you bottle or keg it. If you bottle-condition your beer, however, you must coax the yeast cells back to life, forcing them to produce just a bit more ethanol (with CO_2 as the desired byproduct), which might be difficult if you are brewing a strong beer or one which has conditioned or lagered for long periods of time.

Bottle Conditioning: *While it is possible to force-carbonate bottled beer, bottle-conditioning is desirable for some styles of beer. The smaller mass of yeast and larger relative headspace in the bottle produces more oxidation and a different ester profile.*

For some styles of beer, such as strong Belgian ales, these flavors are essential and can't be reproduced by kegging or forced carbonation. But, premature bottling can result in off flavors, since the yeast must ferment and condition both the priming sugar as well as reabsorbing products of the main fermentation.

The formula for how much sugar to add to bottle condition beer is:

$$Vol.\ CO_2 = C + (0.5 * F * M)/V$$

Where:

Vol. CO_2 is the desired carbonation level in volumes of carbon dioxide (g/ml), C = current carbonation level (in volumes), F = Fermentability of the sugar used, M = mass of sugar used (g) and V = volume of beer (liters).

The 0.5 conversion factor is due to the fact that only 50% of the mass of sugar is converted to CO_2, the rest becomes alcohol (and other stuff).

Fermentability of Various Priming Sugars

Sugar	***Fermentability***
Corn Sugar	*0.91*
Sucrose	*1.0*
Dry malt extract	*Apparent Attenuation (usually 0.8) x 0.82*
Speise or wort	*Apparent Attenuation x 0.82*

Speise is wort taken from a previous batch of beer; either sterilized canned wort or freshly pitched kräusen from a similar beer.

Bottle Conditioning Strong Beers: *It is difficult to bottle-condition strong beers, even under the best circumstances. To start the process, however, it is often necessary to add fresh yeast (one capable of surviving in a high-alcohol environment) and some yeast nutrient to your priming sugar solution. Even so, your beer will carbonate very slowly over a period of months.*

Caps: *Caps or seals for bottles should be tight. Oxygen-barrier bottle caps are desirable for malty beers which are intended to be aged for long periods of time. They are not recommended for beers with lots of late hop character, since the same chemicals which scavenge oxygen also scavenge hop aroma and flavor compounds!*

Carbonation Levels: *Different beer styles require different carbonation levels. As a rule of thumb, anything below 2.0 volumes of CO_2 is "low" carbonation, 2.0-2.5 is "moderate," 2.5-3.0 is "high" and anything above 3.0 is "very high." Some authors suggest carbonation levels to higher or lower ranges.*

Beer Style	***Volumes of CO_2 Ranges***
American Ales & Lagers	*2.2-3.0*
Belgian Ales	*1.9-4.5*
British Ale	*1.5-2.2*
European Lagers	*2.2-2.7*
Fruit Lambic	*3.0-4.5*
German Wheat Beers	*2.8-5.1*
Gueuze	*2.4-2.8*
Porters & Stouts	*1.7-2.3*

Kegging and Counterpressure Bottling: *Kegging is a specialized subject which is beyond the scope of these notes. Keep in mind, however, that the amount of carbonation the beer can hold, and the rate at which carbonation dissolves in the beer depends on the temperature of the beer. This is important if you are trying to get proper carbonation levels in kegged beer prior to dispensing it to bottles using a counterpressure bottling wand.*

Many counterpressure bottle fillers fill almost to the lip of the bottle, and some brewers think that this minimizes oxidation by limiting headspace. This isn't true, however. Any headspace gets filled by carbon dioxide.

Part 3: Aging

Aging is the process of letting beer condition in its final package (bottle or keg) at cellar temperatures for extended periods of time. This mostly has undesirable effects, but there are exceptions.

Oxidation: Most features of aging are due to oxidation, which can be slowed by using compounds such as ascorbic acid. The effects of oxidization are as follows:

- Hop oils degrade, reducing the intensity of hop aroma and bitterness. Oxidation also causes a "raspberry leaf" or "catty" aroma.
- Malt products degrade to produce cloying sweet, toffee-like or caramel notes.
- Dark malts degrade to produce "dark fruit," "black currant," or "raisin," notes.
- The color of the beer lightens slightly as melanoidins degrade.
- Volatile ester and fusel alcohol compounds degrade to become less noticeable.
- Staling of other compounds produces "inky" flavors and aromas.
- As oxidization progresses, lipid compounds break down to produce papery, cardboard or leathery aromas and flavors.
- Extremely oxidized dark malts react with oxygen to produce sherry or vinegar aromas and flavors.

Other Aging Effects: Other effects of aging include:

- Wild yeasts or other infectious bacteria can gradually take hold, causing off flavors, especially in barrel-aged beers. This is desirable in lambics and other "wild fermented" beers.
- Prolonged contact with a metal bottle cap can cause rusty or metallic flavors and aromas if the beer is aged on its side.
- Wood-aged beers can take on vanilla aromas and flavors as lignins in the wood convert to vanillin in the presence of alcohol.

Desirable Aging: For strong beers, especially highly-hopped, dark strong beers, such as Russian Imperial Stout, Old

Ale or Barleywine, aging is desirable, as long as oxidation is kept in check. Extended aging breaks down fusel alcohols and esters making the beer's flavor more complex, while melanoidins react with alcohol and oxygen to produce "dark fruit" aromas and flavors reminiscent of black currants, black cherries, figs, dates, plums, prunes or raisins, as well as flavors and aromas reminiscent of sherry. Aging also reduces hop bitterness, making the beer taste smoother. As a rule of thumb, if a beer is above 7% ABV, it will usually cellar well, at least for a year or so. Beers above 9-10% can be stored for years, if not decades.

Aging and Preserving: *While some degree of oxidation is desirable in strong ales and a few other styles of beer, excessive oxidation will ruin even the finest beer. If you intend to cellar a high-gravity beer for more than a few years, protect your beer from oxidation by using the following techniques.*

- *Make sure your containers are filled to the proper level.*
- *If you have a CO_2 tank, use it to purge air from your bottles or kegs before you fill them. Carbon dioxide is heavier than air, so unless it is disturbed, it will stay in the containers until they are filled.*
- *Use special anti-oxidant bottle caps.*
- *Add a small amount of vitamin C (ascorbic acid - a natural antioxidant compound) to your beer.*
- *If you cork your bottles, store them on their sides so that the liquid remains in contact with the cork so that it doesn't dry out and shrink. If you cap your bottles, store them upright so that the liquid doesn't touch the cap, and so that carbon dioxide outgassed during carbonation forms a vapor barrier between the outside air and the beer.*
- *Protect the cork or bottle cap by dipping the seal and bottleneck in wax or similar material. Not only does the wax help keep air out of the bottle, but it makes it look fancy!*

Part 4: Off-Flavors

Almond (Oxidation, Malt)

Detected in: Aroma, flavor.

Described As: Benzaldehyde, bitter almond, marzipan, nutty. Also described as Brazil nuts, hazelnuts or other types of tree nuts. In some cases it can be reminiscent of Playdough™, plastic or cherries.

Typical Origins: Aging, specialty grains, yeast strain.

Typical Concentrations in Beer: 1-10 µg/l.

Perception Threshold: 1 mg/l.

Beer Flavor Wheel Number: 0224.

Discussion: An occasional off-flavor in beer which arises due to aging. Similar smelling and tasting compounds might arise due to use of brown or toasted malt. Nutty oxidative notes occur when melanoidins, alcohol and oxygen interact reducing volatile molecules such as esters and hop compounds. They often occur with other oxidative notes such as dark fruit or sherry-like aromas and flavors. These compounds might be reduced back into their original form by oxidizing alcohols into aldehydes. Almond aroma is mostly caused by benzaldehyde.

Some strains of yeast produce aldehydes other than acetaldehyde during the initial phases of fermentation, which can result in aromas which are reminiscent of nuts, Playdough™ or plastic.

Also see Catty, Leathery, Oxidation, Papery and Sherry-like.

Increased By: High oxygen levels during mashing and boiling (i.e., Hot Side Aeration - HSA). Carrying hot or cold break into fermenting beer; increasing the amount of fatty acids present in finished beer. Exposing green beer to air during transfer and/or packaging. Excessive air inside storage containers. Non-airtight storage containers. High temperature storage conditions (above ~ 55 °F).

To Avoid or Control: Avoid hot side aeration (don't splash or spray hot mash liquor or wort). Get good hot and cold break. Separate hot and cold break from wort. Don't aerate beer after fermentation starts. Avoid splashing beer during transfer and packaging. Purge conditioning and storage vessels with carbon dioxide before filling them. Don't underfill bottles or kegs. Minimize headspace in bottles (no more than 1-2" below the crown). Get a good seal on bottles and keg. Use anti-oxidant bottle caps and/or wax over caps. Avoid high temperature (90+ °F) storage conditions. Keep beer cool (32-50 °F) for long-term storage. Don't age beer unless it can stand up to long-term storage.

When Are Almond (Nutty) Notes Appropriate?: Low levels of nutty notes are acceptable, even welcome, in malt-focused dark beers such as Munich dunkels, English milds, brown ales, and brown porters and American brown ales, as well as dunkelweizens, weizenbocks and old ales.

Oxidation

Detected In: Aroma, flavor, mouthfeel.

Described As: Dull, stale. At low levels oxidation can be taste or smell "like ball-point pen," honey, inky, metallic, musty or nutty and might have a slight harsh, metallic, peppery mouthfeel. See discussion for further sensory characteristics associated with oxidation.

Typical Origins: Aging, process faults.

Typical Concentrations in Beer: Variable depending on exact chemical.

Perception Threshold: Variable depending on exact chemical.

Beer Flavor Wheel Number: Variable.

Discussion: Oxidation is the interaction of dissolved oxygen with other chemical compounds in beer, usually formy carboxyl compounds. It is the major source of flavor instability during beer storage. Oxidation is increased by introducing air to wort or beer after fermentation has begun and by storing beer at high temperatures in non-airtight containers. There are many pathways which cause flavor instability in beer, some of which are discussed elsewhere; also see Almond, Catty, Leathery, Papery and Sherry-like.

Flavor instability is noted as a progressive drop in hop bitterness (the remaining bitterness can become harsher), hop flavor, hop aroma, and Esters. Changes in flavor or aroma due to flavor instability are more perceptible in blander beers than more full-flavored ones.

In early- to mid-stage oxidation, beer might develop "ribes" (blackcurrant leaf or tomcat urine) and/or Leathery notes which fade with time. As the beer ages, it might also develop honey, bready or toffee-like flavors and a sweet or honey-like aroma. With time, the beer might develop distinct Papery or "tomato juice" (see Papery), and/or Almond, Isovaleric or Sherry-like notes (q.q.v.). The latter can sometimes be perceived as vinous or woody. Likewise, harsh or solventy higher alcohols might degrade to more pleasant Esters or Aldehydes, and the beer might develop Earthy, Metallic, straw-like (see Grassy)

notes. Beer aged at 77 °F (25 °C) tends to develop caramel notes while at 86-99 °F (30-37 °C) it develops more papery notes.

Changes in flavor or aroma due to flavor instability are more perceptible in blander beers than more full-flavored ones.

The main factors in oxidation are levels of dissolved oxygen in the beer and temperature. Oxygen can be introduced into the beer at any stage during the brewing process, from mashing to conditioning. Except when aerating the wort to improve yeast performance (the yeast takes up the dissolved oxygen within a few hours), brewers should take every step possible to avoid aerating their brewing liquor, mash, wort or beer.

Commercial breweries take great pains to prevent oxygenation at all phases of production. During mashing, mash is "doughed in" in an oxygen free environment and, ideally, mash is pumped into the mash tun from below to minimize oxidation of the mash. Sparge liquor is deoxygenated and is pumped into the lauter tun under oxygen free conditions. Pumps and other equipment are checked to make sure that oxygen doesn't get into the mash or wort during transfer. Wort boil, fermentation and conditioning also takes place in oxygen free environments. Modern packaging equipment means that modern commercial bottled beer has less than 0.1 ppm dissolved oxygen.

-Aeration of the sparge liquor during recirculation (AKA "hot side aeration") is a major factor in oxidation of homebrewed beer. Splashing or aerating mash liquor, sparge liquor, wort or beer during transfer or packaging are other sources of oxidation in homebrew.

Regardless of oxygen levels, rate of flavor change depends on temperature. Beer stored at 32-39 °F (0-4 °C) shows no oxidation even after many months of storage, while beer packaged under low oxygen conditions might show signs of aging after about 100 days at 68 °F (20 °C). Storage at higher temperatures results in a 2-3 fold increase in aging rate; beer might show signs of oxidation at 30 days if held at 86 °F (30 °C), while beer held at 140 °F (60 °C) will show signs of oxidation after just 1 day!

Pathways involved in synthesis of staling substances include:

* ***Melanoidin-Catalyzed Oxidation of Higher Alcohols:*** Alcohols in beer can be converted to their equivalent aldehydes through the catalysis of melanoidins.

**** Oxidation of Iso-alpha-acids:*** Might be involved in staling of beer. Hop fractions less prone to staling.

**** Strecker Degradation of Amino Acids:*** Reactions between amino acid and an alpha-dicarbonyl compound, such as the intermediates in browning reactions. The amino acid is converted into an aldehyde. Polyphenols may have a catalytic role.

*** Aldol Condensations:** Reactions between separate aldehydes or ketones is route through which (E)-2-nonenol might be produced by a reaction between an acetaldehyde and heptanal. Diverse other carbonyls might be generated in this way, with the amino acid proline as a catalyst.

* ***Oxygenation of Unsaturated Fatty Acids:*** Oxidative breakdown of lipids can cause sulfury or rancid notes in beer.

Antioxidants naturally found in beer, which block oxidation, include:

* *Polyphenols:* These compounds scavenge oxygen free radicals, superoxide and hydroxyl, inhibit lipoxygenase and act as chelating agents - sequestering metal ions such as iron and copper. Unfortunately, they also cause astringency and chill haze.

* *Melanoidins:* The compounds scavenge superoxide, peroxide & hydroxyl, but also promote formation of higher alcohols.

* *Sulfur dioxide:* SO_2 scavenges free radicals, but carbonyls bind with SO_2 in brewing process and SO_2 are lost in beer through unknown means (half is lost in 27 days at 104 °F - 40 °C - , 3 years at 32 °F - 0 °C). As SO_2 is lost carbonyl compounds are freed, resulting in flavor instability.

* *Yeast:* Yeast produces SO_2 and reduces carbonyl compounds to fusel alcohols.

* *Chelation:* Various chemicals in beer, such as amino acids, phytic acid and melanoidins, chelate metallic ions, preventing them from accelerating flavor instability.

* Sulfites (e.g., Potassium metabisulfite) added to beer immediately reduces carbonyl compounds, eliminating many "stale" characteristics. The problem is that sulfites contribute unwelcome sulfury notes to beer and are toxic to yeast, making it impossible to use them in cask or bottle-conditioned beer. In some cases, their use is also restricted or prohibited by law, making commercial brewers hesitant to use them.

To Avoid: * Avoid hot side aeration (don't splash or spray hot mash liquor or wort). * Avoid splashing or spraying mashing in liquor, sparge liquor, wort or beer at all stages of the production process. * Get good hot and cold break to avoid carrying excess fatty acids into wort. Separate hot and cold break from wort. * Don't aerate beer after fermentation starts. * Purge brewing, conditioning and storage vessels with carbon dioxide before filling them. * Proper packaging: Don't underfill bottles or kegs. Minimize headspace in bottles (no more than 1-2" below the crown). "Cap on foam" by immediately capping the bottle once it is filled. Get a good seal on bottles and kegs. Use anti-oxidant bottle caps and/or wax over caps. * Proper storage conditions: Avoid high temperature (90+ °F) storage conditions. Keep beer cool (32-50 °F) for long-term storage - the cooler the better. * Don't age beer unless it can stand up to long-term storage.

When Is Oxidation Appropriate?: Whether oxidation is appropriate depends on the beer style and the flavors and aroma produced by oxidation: Dull, cardboard-like, inky, papery or rotten notes are never appropriate. Low to medium sherry-like notes are acceptable in weizenbock, Flanders brown ale, old ale and English barleywine. Aged examples of eisbock, Scotch ale, Baltic porter, foreign extra stout, Russian imperial stout, Dubbel, Belgian dark strong ale and American barleywine might also have slight dark fruit and vinous notes. Musty notes are acceptable in some cellared beer styles such as bière de garde.

Papery (Oxidation)

Detected In: Aroma, flavor.

Described As: Cardboard, dull, papery, shoe box, stale, wet cardboard. At low levels papery character can be taste or smell "like ball-point pen," inky, musty, peppery or prickly. Less commonly, it is perceived as smelling like cucumbers, fat, honey, "library," "old people," orris root, soy sauce or stale bread crumbs. In dark beers it might be detected as "tomato juice" notes.

Typical Origins: Aging, process faults.

Typical Concentrations in Beer: <50 ng/l in fresh beer, >0.2 µg/l in aged beer.

Perception Threshold: 50 - 100 ng/l.

Beer Flavor Wheel Number: 0820.

Discussion: Cardboard and papery notes are caused by long-chain aliphatic (non-aromatic) aldehydes (e.g., 2-nonenal). These are produced when lipid compounds naturally found in malt, which are liberated during mashing and wort boil, but initially bound to other molecules, undergo auto-oxidation.

The most notorious compound, 2-nonenal, is detectable at levels above 0.1 µg/l in water. It is responsible for cardboard or papery notes. Some people describe it as smelling like "library" (decaying paper) or "old people." The latter sensation might be because 2-nonenol is present in human sweat and the human body produces more 2-nonenal as we age!

Obvious papery notes develop in the mid to late stages of aging, especially in light-colored, light-flavored, relatively weak (i.e., below 6% ABV) beers. At low levels, papery notes might be mistaken for one or more of the sensory descriptors listed above. As described for Oxidation, the time needed to develop papery notes depends mostly on how much oxygen is present in the beer and the temperature at which it is stored. Also see Almond, Leathery, Oxidation and Sherry-like.

To Avoid: As for Oxidation (see above).

When Are Papery Notes Appropriate?: Never.

Sherry-Like (Oxidation)

Detected in: Aroma, flavor.

Described As: Dark fruit (e.g., fig, grape, plum, prune, raisin), dry sherry, honey, inky, nuts (e.g., almonds, hazelnuts, walnuts), musty, port wine, red wine, rotten fruit, sherry, vinous, wine, woody. The combination of dark malt, dark fruit, sherry and alcohol is sometimes perceived as being like a Christmas or plum pudding.

Typical Origins: Aging.

Typical Concentrations in Beer: ?.

Perception Threshold: ?.

Beer Flavor Wheel Number: n/a.

Discussion: Sherry notes emerge when melanoidins, alcohol and oxygen interact, reducing volatile molecules such as esters and hop compounds. They only form in strong (6+% ABV) dark-colored (20+ SRM) beers and often accompany a darkening of the beer. These compounds sometimes develop from compounds which are responsible for less pleasant flavors earlier in the oxidation process (e.g., inky, musty, rotten fruit) and are reminiscent of aged red wine, dark fruit (e.g., dates, figs, prunes, plums, raisins), dry sherry, honey, nuts (e.g., almonds, hazelnuts, walnuts) and/or port wine. These compounds might be reduced back into their original form by oxidizing alcohols into aldehydes. Also see Almond, Leathery, Oxidation and Papery.

To Avoid: * Avoid hot side aeration (don't splash or spray hot mash liquor or wort). * Get good hot and cold break to avoid carrying excess fatty acids into wort. Separate hot and cold break from wort. * Don't aerate beer after fermentation starts. Avoid splashing beer during transfer and packaging. Purge conditioning and storage vessels with carbon dioxide before filling them. Don't underfill bottles or kegs. Minimize headspace in bottles (no more than 1-2" below the crown). Get a good seal on bottles and keg. Use anti-oxidant bottle caps and/or wax over caps. * Avoid high temperature (90+° F) storage conditions. Keep beer cool (32-50 °F) for long-term storage - the cooler the better. * Don't age beer unless it can stand up to long-term storage.

When Are Sherry-Like Notes Appropriate?: Low to medium sherry-like notes are acceptable in weizenbock, Flanders brown ale, old ale and English barleywine. Aged examples of eisbock, Scotch ale, Baltic porter, foreign extra stout, Russian imperial stout, dubbel, Belgian dark strong ale and American barleywine might also have slight dark fruit and vinous notes.

Sherry-like notes can arise in other strong, amber to dark beers, such as bock, doppelbock, robust porter, American stout or double IPA, but are considered to be a fault in those styles.

Smoky (Phenol)

Detected in: Aroma, flavor, mouthfeel.

Described As: Bacon, barbeque, barbeque sauce, bitter, burnt, campfire, charred, lox (smoked dried salmon) scorched, smoked, smoked bacon, smoked ham, smoked herring (kippers), smoked salmon, wood smoke.

Typical Origins: Malt, process faults, contamination.

Typical Concentrations in Beer: 10 - 400 µg/l.

Perception Threshold: 15 µg/l.

Beer Flavor Wheel Number: 0423.

Discussion: Smoky notes arise due to monophenols; simple phenols with a hydrocarbon side chain. In brewing they occur as minor compounds during pyrolysis (heating material in the absence of oxygen), such as scorching wort/mash or smoking malt. These compounds are then extracted during mashing and wort boiling. They can also be deliberately introduced into beer by using smoked malt or by adding smoked, or smoke-flavored ingredients (e.g., smoke flavor). Occasionally, wild yeast infections will also produce smoky notes, but these are generally subtler than those produced by scorched wort or smoked malt. Very rarely, smoky notes might get into beer when brewing equipment has been exposed to smoke or has scorched material on the inside, and isn't properly cleaned out before being use. Also see Bromophenol, Chlorophenol, Phenol, Spicy and Vanilla.

To Avoid: * *Avoid Scorching Mash or Wort:* Avoid excess heat during mashing/wort boil. Use a "flame tamer" under direct-fired brewing equipment or used indirectly-heated equipment. Add malt extract at lower temperatures and make sure it is thoroughly dissolved before bringing the wort kettle to a boil. Stir vigorously after adding extract to wort kettle to avoid scorching. Avoid excessively long boil times. Use proper technique when decoction/step mashing. * *Proper sanitation* to avoid microbial contamination by wild yeast. * *Proper yeast health.* Pitch yeast at sufficient levels and at correct temperature for style. Oxygenate wort to proper level for wort gravity. * *Reduce or eliminate smoked malt or smoke flavoring.* Especially with smoke flavor, a little goes a very long way. * *Clean equipment thoroughly.* Make sure that scorched material is completely removed.

When are Smoky Notes Appropriate?: Unpleasant burnt or scorched notes are a fault in any style of beer. Balanced, roasted, smoky aromas and flavors, typically imparted by judicious use of smoked malt, are appropriate in smoked beer. Subtle smoky notes from restrained use of peat smoked malt are acceptable in Scotch Ale. Smoky notes are a fault in other styles of beer.

Vanilla (Phenol)

Detected in: Aroma, flavor.

Described As: Cream soda, custard-like, custard powder, ice cream, vanilla.

Typical Origins: Malt, aging, adjuncts, microbial contamination.

Typical Concentrations in Beer: 10-80 µg/l.

Perception Threshold: 40 µg/l.

Beer Flavor Wheel Number: 1003.

Discussion: Vanillin, the active ingredient in vanilla, is formed by the breakdown of lignins, naturally found in plant cell walls, when exposed to alcohol and oxygen. It is formed in some beers, particularly those high in phenols (e.g., tannins) during aging.

Vanilla is also produced during fermentation by strains of yeast ((POF+ strains) which produce phenolic off-flavors, from its precursor, ferulic acid. In such cases, it is usually accompanied by a similar molecule 4-vinyl guaiacol (see Spicy).

In a few cases, vanilla notes might occur as part of a wild yeast infection. Some wild yeasts produce phenolic flavor compounds which are degraded to form vanillin.

To Control or Avoid: * Avoid getting tannins and spicy phenols into beer. Practice good milling and mashing practice to avoid tannin extraction from malt. See Phenols for more suggestions. * Practice good sanitation to avoid wild yeast infection. * Limit contact with wood (both amount of wood used and time spent in contact) when wood-aging beer. * Proper choice of yeast strain - some yeasts produce vanilla-like notes.

When Are Vanilla Notes Appropriate?: Typically beer has trivial amounts of vanillins, so it is considered a fault in most beer styles. Some degree of vanilla character is welcome in wood-aged beers and German wheat and rye beers. Vanilla flavor and aroma might occur in spiced specialty beers.

Part 5: BJCP Categories 20-21 - Fruit Beers and Spice/Herb/Vegetable Beers

This section is a summary of received wisdom from Randy Mosher's Radical Brewing and Homebrew Companion, Charlie Papazian's Complete Guide to Homebrewing and Homebrewer's Companion, as well as other online sources (mostly Brew Your Own Magazine archives).

The Four Basic Rules of Using Flavor Adjuncts

1. Use a good base beer that stands on its own. *Adjuncts should complement the beer flavor and aroma rather than replace it. Most judges like to know "there is a beer in there" when sampling adjunct-flavored beers.*

A. Beers with strong, complex flavors of their own (e.g., hoppy, phenolic) generally don't make a good base unless the adjunct carefully complements the beer flavor.

B. Light-colored, delicately-flavored beers work best for subtle flavors, especially if you want to show off the color of an adjunct. Stronger flavors can stand up to roasty, hoppy beers. For example, cherry, raspberry or chili can work in porters, stouts or barleywines.

C. Use a yeast strain that will complement, or at least not interfere, with the adjunct's flavor. Consider ale yeasts that produce fruity esters or yeasts that give a "neutral" or "clean" flavor.

2. Fruit beers should really emphasize the fruit presence and complexity.

A. Don't be afraid to add fruit at different brewing stages or to use different types of fruit flavor/aroma (e.g., fresh fruit, plus concentrate, plus two types of fruit flavoring).

B. Since people expect fruit to be sweet and sour, adding fruit to extremely bitter beers confuses the palate, so highly-hopped fruit beers generally don't work.

C. Fruit beer must be sour enough to bring out the fruit flavor. Insufficient sourness in wine is called "flabbiness," and it also a defect in fruit beer. Add malic acid or citric acid during secondary or before bottling to adjust acid levels. If necessary, add a bit of tannic acid to adjust fruit bitterness. Talk with your friendly local ciderers or winemakers to learn more.

D. The easiest fruits to use are raspberries and cherries, since they have strong flavors that easily survive the brewing process and can stand up to the other flavors in the finished beer. Subtly-flavored fruits, such as peach, watermelon or strawberry, are usually disappointing.

3. ***Spice, herb and vegetable beers must be much more understated,*** *even to the extent that the adjunct flavor is only detectable in the finish. In some cases, excessive SHV flavor can ruin the beer (e.g., too much heat from a chili beer).*

A. If you are designing a SHV beer to bring out the flavor of a particular delicately flavored adjunct (e.g., mushrooms, orange blossom) use a delicately-flavored beer (e.g., Cream Ale, Blonde Ale, American Wheat/Rye, Kölsch) to emphasize the SHV flavor and aroma. Stronger flavors can stand up to bitter, toasty-flavored beers (e.g., Coffee Stout).

B. Be careful not to overdo it. Don't layer on the SHV flavor unless you know exactly what you want. Leave the "11 herbs and spices" to KFC.

C. Know your ingredients. Some SHV adjuncts impart a stronger flavor the longer they remain in contact with the beer, and some traditional herbal adjuncts can be poisonous.

4. ***Experiment!*** *Most flavor adjuncts can be added just before bottling or directly to a glass of finished beer. If you have a beer that you think might benefit from a flavor adjunct, it is easy to make part of the batch into a Fruit or SHV beer.*

Making Fruit and Vegetable Beers

Depending on the type of fruit and the level of flavor desired, you can add anywhere from 1-15 pounds of fruit to a 5 gallon batch. Best to make a small test batch and then scale the amount of fruit needed up or down to suit your taste.

Sanitizing Fresh Fruit: *Most fruits are naturally covered with wild yeast, often visible as a white "dust" on the skin of tree fruits. This poses an infection risk. There are five ways to deal with this problem:*

1. Add it to Secondary: *By the time the beer goes into the secondary fermenter, its acidity, alcohol content and lack of oxygen or fermentable sugars make it inhospitable to microbes. Very clean fruit can be added, unpasteurized, to secondary, especially if the beer has an ABV of 5% or more. This method can introduce wild yeast or unwanted bacteria to the beer, especially if fruit skins are included.*

2. Pasteurize it: *Soak the fruit in hot (180° F, not boiling) water for 20 minutes or at 160° F for 30-40 minutes. Alternately, you can steam your fruit or pasteurize it in your brew kettle at the end of the boil while keeping the temperature at the desired temperature.*

To pasteurize concentrates, pulp or frozen fruit, add enough water to the mix so that it can be easily stirred, put it in a pot, and carefully bring the temperature to 180° F, stirring

frequently. Once the temperature reaches 180° F cover and let rest for 20 minutes. Cool it and add to your fermenter.

3. Blanch it: *Soak the fruit in hot water or steam it until the skins come loose (usually just a few seconds), then squeeze the fruit out of the skins. The flesh underneath is almost sterile. If you don't want fruit skins to color your beer, this is the best way to get rid of them. The heating and peeling also breaks down cell walls, allowing more juice to get into your beer. The drawback is that this trick only works for relatively large, smooth fruits with thin skins (e.g., apples, peaches).*

4. Sanitize it. *Sanitize the fruit in a potassium or sodium metabisulfite or chlorine solution, and then thoroughly rinse it. This technique works better for some fruits than others and doesn't work very well at all for berries.*

5. Sulfate it. *You can add Camden tablets (sodium or potassium metabisulfite) to fruit added to the secondary fermenter, but this will kill any yeast left over from fermentation and will also add sulfites to your brew. To bottle condition your beer, you will need to add a live yeast culture at bottling.*

Pectin Haze: *Pectin is a naturally-occurring fruit carbohydrate. Boiling "sets" the pectins so that they can't easily break down increasing the risk of haze. Due to the large size of pectin molecules, they can form haze in fruit beers (also wines, ciders and meads). Due to the fact that they form gels (pectins are what make jams and jellies hold together) they can interfering with filtering.*

If haze is a problem, don't use fruit during the mash or boil, or brew a base beer where cloudiness is acceptable (Wit, Hefeweizen).To prevent clogged filters, or to break up or prevent pectin haze, use pectinase enzyme (available at wine-making shops). Fining can also remove pectin haze. Both methods typically take a week or two to work.

To check for the presence of pectin, add one part wort, beer or wine to one part 70% ethanol or iso-propanol. If pectin is present it will gel, making the sample cloudy as the pectin begins to precipitate.

Using Citrus Fruits: *The fresh flavor of citrus fruits is easily lost during fermentation as essential citrus oils evaporate. The most common citrus oils (lemon, lime, orange, grapefruit) are mostly composed of a monoterpene called d-limonene. Similar compounds produce pine and bergamot aromas, as well as piney, citrusy hop aromas. To boost citrus aroma, use zested citrus peel (just the colored part, not the bitter white part) in the same way you would aroma hops. Add them late in the boil and/or during primary or secondary fermentation.*

The taste of citrus fruit is dominated by sugar and acid. Since citrus juice has an O.G. of ~1.048, its sugar will be converted to alcohol and CO^2 during fermentation. Likewise, the acidity of the citrus is diluted by the beer. To improve citrus flavor, add fresh juice just before bottling while increasing acidity using a mixture of citric and phosphoric acid. The juice of 10 lemons or limes is needed to give an assertive flavor in a 5 gallon batch. To stabilize the beer, you would need to filter or pasteurize it to remove the yeast and citrus pectin, or add sulfite to kill the yeast, and then force carbonate it.

Other Tricks: *Put your fruit in a large closed muslin or polyester bag to make it easier to get the fruit into or out of your beer. A large bag allows more wort/beer to circulate around the fruit. If you sanitize your fruit in the cooling wort, you can pull the bag out and put it into the primary fermenter.*

After sanitizing their fruit, some brewers freeze it in sanitized containers to further rupture the cell walls, letting more juice out. Some also mash or puree the fruit before freezing it, although this might be excessive.

A mixture of malic acid, lactic acid, acetic acid mixed with high quality fruit juice can impart a "pseudo-lambic" flavor to a light wheat beer. Other acid blends can be used to enhance the flavor of fruit beers.

Using Vegetables: *Most of the comments regarding fruit also apply to fresh vegetables, except that starchy vegetables such as potatoes or pumpkins should be added to the mash with plenty of rice hulls to prevent a stuck mash. Typically, these vegetables are prepared separately and then mashed to a pulp before being added.*

Using Pumpkins: *Pumpkins are optional when brewing pumpkin ale; many excellent pumpkin ales contain no pumpkin. Pumpkin pulp contributes little flavor to a pumpkin ale, and the "pumpkin" flavor and aroma we perceive is actually pumpkin pie spice. Brewers who still wish to use pumpkin when brewing pumpkin ale often use canned pumpkin pulp. Purists use the following recipe to make pumpkin pulp from scratch:*

Buy a small (12" in diameter) pumpkin intended for cooking, as opposed to a giant jack-o-lantern pumpkin. Wash it, cut it in half and remove the seeds. Place the halves cut side down on a baking sheet and cook at 350° F for approximately 30 minutes, or until the pulp becomes soft and the pumpkin shell begins to collapse. The edges and inside of the pumpkin should be slightly caramelized. Let the pumpkin cool and scoop out the pulp. Use a potato masher or food processor to grind into a chunky puree and add it to your mash or mash it separately and add the liquor to your main wort boil.

Making Spice Beers

The simplest way to add spices is to just throw loose spices into the boiling wort or the primary or secondary fermenter. Controlled use of spices requires a bit more finesse. At the very least, use a closed bag so that you can get all (or most) of the spices out of your wort or beer.

Important Note: *Many herbs and spices add drying, astringent notes, which change taste perceptions of the underlying beer. For this reason, herbal or spiced beers often require extra malt sweetness and body to balance the drier flavor and mouthfeel.*

Common methods of adding herb or spice flavor are listed on the table below, but several popular ingredients bear special mention.

Using Chili & Peppers: *When working with extremely peppery spices, less is more. Your beer should emphasize the flavor of the spice first, with the heat of the spice only becoming obvious in the finish. Even then, the finish shouldn't be too spicy. Alcohol easily absorbs capsicum (the active ingredient in chili) and similar flavor compounds, so your beer will be hotter than you expect. Choose small peppers with a good balance of sweetness to fire. For dramatic effect, you can even stuff a small, mild chili pepper into each finished bottle of beer.*

Chili and pepper can be carefully added at any time during the wort boil. This imparts spiciness, but little aroma or chili flavor. Be aware that the longer peppers are boiled, the more intense the spiciness.

You can add peppers to the primary or secondary fermenter, after sanitizing them as you would fresh or dried fruit. This preserves more of the vegetable or sweet chili character. Again, the longer the spice is kept in contact with the raw beer, the more intense the spicing will be.

Using Chocolate: *Chocolate flavor can easily be achieved using chocolate malt (0.66-1.0 lb. per 5 gallons) in an otherwise malty beer with balanced hop bitterness. Stouts and porters lend themselves well to chocolate flavors.*

If you wish to use actual chocolate in your brew, add high-quality cocoa powder to your wort at the beginning of the boil, in the last 15 minutes of the boil and/or at knockout.

Cocoa powder is best. It has a strong flavor, a pH similar to that of boiled wort, and little or no fat or oil. Unsweetened baker's chocolate is also acceptable, although it has a bit more oil than dry cocoa powder. Choose the brand with the least amount of fat and cocoa butter. Avoid using eating chocolate, especially cheap chocolate, since it has lots of fats, oils and other ingredients which interfere with head retention. White chocolate is actually cocoa butter. It will give you headless, oily beer. Chocolate flavors are acceptable, but don't have quite the same character as real cocoa. Add them just before packaging if your chocolate beer needs a boost. A few drops will do. Be careful and taste as you go.

To add cocoa or baker's chocolate at packaging, stir cocoa into hot (at least 160° F) water and hold the mixture at that temperature for 15 minutes, while stirring. Quickly cool the mixture and add it to your bottling bucket or keg.

To emphasize sweetness, consider adding a bit of non-fermentable sugar (either an artificial sweetener or lactose), or add a fruit or spice flavor, such as cherry or vanilla, that is reminiscent of chocolaty desserts.

Using Coffee: *Make a pot of your favorite coffee and let it cool. Add it to the raw beer in secondary or just before packaging.*

When to add Fruit, Spices, Herbs or Vegetables?

Stage	*Advantages*	*Disadvantages*	*Notes*
Mash	*Converts carbohydrates to fermentable sugars. Gives deep herb/spice flavor.*	*Possible Off-flavors (cooked, tannic, bitter, vegetal), Likely aroma/flavor loss during mash, boil & primary fermentation, Pectin haze, Stuck mash.*	*Use for Pumpkin, starchy vegetables, Rice hulls prevent stuck mash*
Start of Boil	*Gives deep herb/spice flavor, Some aroma retained.*	*Possible Off-flavors, Likely aroma/flavor loss, Pectin haze, Can clog counterflow chillers*	*Use for cocoa, some herbs/spices*
End of Boil[1]	*Can be used to sanitize adjuncts, Extracts most resins & oils without off-flavors, Give decent herb/spice flavor, some aroma retained*	*Likely aroma/flavor loss during fermentation, Infection risk, Pectin haze, Can clog counterflow chillers*	*Use for most herbs & spices*
Primary Fermentation[2]	*No off-flavors due to heat, Minimal pectin haze, mild fruit flavor/aroma retained, less herb/spice flavor, more aroma retained.*	***Explosion Risk!*** *Aromas lost due to CO^2 out-gassing, Infection risk, Loss of beer due to absorption/extra trub, Can remove fruit color from beer.*	*Gives subtle flavor, milder aroma.*
Secondary Fermentation[3]	*No off-flavors due to heat, Minimal pectin haze, Controlled aging, Hostile environment for microbes, Strong fruit aroma/flavor, Herb/Spice flavor/aroma intensifies with aging.*	*Fermentation can restart (especially with fruit), ABV can change, Infection risk, Loss of beer due to absorption/extra trub, Long aging can leach tannins from fruit skins while reducing fruit flavor. Spice flavor will intensify with aging.*	*Gives more obvious flavor/aroma*
Packaging	*No off-flavors due to heat, Minimal pectin haze, Hostile environment for microbes, Strong fruit aroma/flavor, Herb/Spice flavor/aroma intensifies with aging, Can just flavor part of batch.*	*As above. Can't easily remove adjuncts form packaged beer. Fruit flavor will mellow with age. Spice flavor may intensify.*	*Can produce striking effects (e.g., whole fruit in a bottle)*
Dispense	*Easy to control, Usually quick*	*Can change ABV, body, etc., Can't be done for competition, Time consuming*	*Good way to experiment*

Notes

1. Adding Adjuncts at the End of Wort Boil: *Stir the adjuncts into the pot and then let the wort sit for 5 minutes before you begin to chill. Note that chunky adjuncts (e.g., fruit or vegetables) added to the wort might clog counter-flow chillers unless contained in a bag or strained out using a hop-back. On brewer suggested sanitizing and then freezing fruit inside a sanitized plastic bag. On brewing day, the frozen pulp is removed from the bag and used to chill the wort.*

2. Adding Adjuncts to Primary Fermenter: *For safety, either use an open fermentation in a wide-mouthed vessel or fill your fermenter no more than half full of wort and adjuncts. Narrow-necked fermentation vessels (e.g., carboys) or airlocks can become clogged with blow-off products, turning your fermenter into a bomb.*

Keep in mind that fruit will increase the volume of wort in your fermenter as well as reducing the final volume of beer due to losses associated with removing the fruit. For convenience, put adjuncts into a bag or hop sock. This makes it easier to remove them.

Leave the fruit in the primary for 1-4 weeks, and then transfer the beer to a carboy, leaving the fruit behind. If possible, squeeze out as much liquid from the fruit as you can. Condition in secondary for 2 weeks or more and then proceed as normal.

3. Adding Fruit to Secondary Fermenter: *This is the preferred way to add fruit, since the flavors will be more pronounced. Ferment the beer for 1 week in primary, and then transfer to wide-mouthed vessel (such as a stainless steel milk jug or plastic bucket). Put the fruit in a closed large muslin or polyester bag and add it to the secondary fermenter. If you wish, sanitize, cook, freeze or pulp your fruit before it goes in. If using a fruit pulp or concentrate, you might wish to strain it or add water to it to thin it out. The bigger the bag, the more the wort can circulate around the fruit. Cover the fermenter with a piece of plastic held in place with an elastic band. Ferment for 1-2 weeks. Note that if aging beer for more than 1 month, some fruits (especially those with skins) will leach tannins into the beer, lending a bitter flavor. Transfer to another carboy, leaving the fruit behind, squeezing as much raw beer as you can from the fruit. Ferment for 2 or more weeks. Condition or package normally.*

Ways of Adding Adjuncts to Your Beer

Adjunct Form	*Advantages*	*Disadvantages*	*Notes*
Concentrate, Bottled	*Sanitary, Quick, Imparts intense flavor*	*Limited variety/availability, Expensive (for good stuff, same drawbacks as bottled/canned juice for cheap stuff), Less flavor than fresh juice.*	*As for Canned/Bottled Juices. Health Food brands are best.*
Concentrate, Canned Winemaker's	*Sanitary, Quick*	*Limited flavors, Expensive, Limited availability, Uncertain freshness.*	*Lots of grape flavors! Check freshness before buying.*
Concentrate, Frozen	*Relatively cheap, Sanitary*	*As for Canned/Bottled Juices. Low levels of wild yeast present.*	*As for Canned/Bottled Juices.*
Cordial, Commercial	*Stores well, Gives precise control over flavoring, Sanitary*	*Very expensive, Increases ABV of finished beer, Can modify fruit flavors and add its own flavors, Possibly limited availability.*	*Wide variety. 750mm bottle added to 5 gal. increases ABV by ~1%*
Cordial, Home-made[1]	*As for Commercial Cordials*	*Time-consuming, Expensive, Requires storage space & equipment, Requires skill to produce good product, Increases ABV of finished beer, Can modify fruit flavors and add its own flavors.*	*Much cheaper than commercial cordials, start with a base of good-quality neutral-flavored vodka or brandy.*
Flavor Extracts/Essential Oils	*Sanitary, Quick, Imparts intense flavors, Can easily be added at any part of brewing process, Gives high degree of control.*	*Expensive, Can give "one-dimensional", artificial or overpowering flavor, Limited flavors/availability, Many essential oils not safe for consumption. Essential oils can interfere with head retention.*	*Use sparingly. Try using different brands of same flavor to increase complexity of flavor.*
Fresh Fruit/Vegetable, Chopped/Mashed	*Relatively cheap (in season), Can be sanitized by blanching or pasteurizing. Color from fruit skins retained.*	*Mess, Possible pectin haze/off-flavors if added during mash or boil, Infection risk if added in primary/secondary, Can clog counterflow chillers, airlocks & carboys, Can absorb liquid reducing total volume of finished beer, Oxidation of fruit can impart unwanted colors & flavors.*	*Better juice extraction than whole fruit.*
Fresh Fruit/Vegetable, Frozen	*As above. Freezing kills some microbes*	*As above, but less messy, Must be put in sanitized container when frozen if added to primary/secondary.*	*Best method of juice extraction from whole fruit*
Fresh Fruit/Vegetable, Whole	*As above, Quick, Dramatic effect if whole fruit put into bottles.*	*As for Fresh Fruit, Chopped, but less juice extraction.*	*Buy good-quality unblemished fruit.*
Fruit, Dried[2]	*Quick, Can impart distinctive flavors*	*Expensive, Can impart unwanted flavors, Can restart fermentation in secondary, Can clog counterflow chillers, airlocks & carboys, Can absorb liquid reducing total volume of finished beer, Infection risk if added to primary/secondary.*	*Most dried fruit has preservatives (sulfates, potassium sorbate). Look for dried fruit without preservatives at Health Food stores.*
Fruit/Vegetable, Canned	*Cheap, Quick, Sanitary, Good juice extraction, Stores well.*	*Can impart "cooked" or "canned" flavors, Can restart fermentation in secondary, Can change the character of underlying beer, Can transfer pectin haze to beer, Can clog counterflow chillers, airlocks & carboys, Can absorb liquid reducing total volume of finished beer.*	*Sometimes the only way to cheaply get certain types of fruit/vegetables. Buy water-packed if at all possible. Also check out high-quality pie fillings.*
Fruit/Vegetable, Frozen	*Can be cheaper than fresh fruit, Stores well, Freezing kills some microbes*	*As for Whole Fresh Fruit/Vegetable. No easy method of sanitizing*	*Good juice extraction. Sometimes the only way to get out of season fruit.*
Herb/Spice, Decoction/Infusion[4]	*Stores well, Gives high degree of control, Sanitary. Only way to extract certain compounds.*	*Potentially time-consuming &/or messy, Flavor possibly not as intense as fresh herbs/spices.*	*Extraction methods depend on material used.*
Herb/Spice, Dry	*Quick, Can be inexpensive, Most store well.*	*Can impart bitter, tannic or other off-flavors if added during mash or boil, Flavor possibly not as intense as fresh herbs/spices, Minor infection risk, Can be difficult to remove from wort/beer.*	*Buy whole herbs/spices if possible and grind them yourself. Spices from health food bulk bins usually freshest & cheapest.*
Herb/Spice, Fresh	*Usually gives best herb/spice flavor, Can be inexpensive.*	*As for Dry Herb/Spice, Can impart vegetal flavors.*	*Crush before adding. Buy in season & store in freezer like hops.*
Jam or Marmalade	*Quick, Stores Well, Relatively Inexpensive*	*Can impart "cooked" flavors to beer, Can restart fermentation in secondary, Can change the character of underlying beer, Jam likely to impart pectin haze.*	*Marmalade best available source of "bitter orange" in U.S. If using jam choose jam or preserves, not jelly. They have more flavor, less pectin. Buy*

			jam brands that list fruit rather than corn sugar as primary ingredient.
Juice, Bottled or Canned	*Quick, Sanitary, Lots of flavors, can be cheap*	*As above. Many commercial juices have corn sugar, artificial colors &/or preservatives that can interfere with underlying beer. Can impart pectin haze. Many vegetable juices have too much salt. Less flavor than fresh juice.*	*Do not buy brands with preservatives. Choose brands with less/no added sugar & coloring. Cold-pasteurized health food brands best, but pricy.*
Juice, Fresh-Squeezed	*Relatively cheap (in season), best juice flavor*	*Mess, Time, Special equipment needed (blender, juicer), Pectin haze, possible off flavors if added during mash or boil, Infection risk if added in primary or secondary, Color from fruit skins lost.*	*Buy good-quality unblemished fruit. Blanch or pasteurize before squeezing.*

Notes

1. Cordials: *Cordials are made by adding flavorings to an alcohol base, usually vodka, brandy or rum. A simple cordial recipe is:*

4 cups of crushed fresh or frozen fruit
3 cups vodka or 2 cups vodka & 1 cup brandy
Additional flavoring can be added through the addition of pure extracts, herbs, spices, drops of edible essential oils, etc.

Pour alcohol over the fruit. Place in tightly-sealed glass jar with minimal headspace. Steep 3 months. Strain out fruit residue. Sweeten to taste (use sugar syrup composed of 2 parts sugar/1 part water, boiled until sugar dissolves). Bottle in a tightly-sealed glass container. Age an additional 3 months. If using fruit concentrate, no steeping or straining is needed, halving the time needed to make a finished cordial.

A 12-15 ounce (750 ml) bottle of cordial is enough to flavor a 5 gallon batch of beer, while increasing its ABV by about 1-1.5%. Since cordials have sugar, reduce priming sugar needed for bottling by about ¼ cup.

2. Dried Fruit: *Briefly stewing dried fruit not only sanitizes it, but also softens the fruit allowing its flavors to better blend with the beer. Alternately, you can soften dried fruit by letting soak in hot water which has been brought to a boil. This will partially sanitize it.*

3. Decoction/Infusion: *Pour hot or boiling water over bruised or mashed fresh herbs/spices or freshly-ground dry spices. If necessary, store the mixture in a sealed sanitized container until the proper degree of flavor and aroma has been achieved. Strain out the herb/spice residue and add the liquid to the secondary fermenter. The water temperature, proportion of herb/spice to water, and steeping time depends on the herb/spice you use.*

Part 6: BJCP Category 22 - Smoke and Wood-Aged Beers

A. Smoked Beer

Ever since people have been making malt there have been smoked beers. Historically, malt was dried over wood, straw or peat fires, which imparted some degree of smokiness to the malt. For this reason ancient and medieval malt beers were likely to have been dark-colored and smoky flavored. It was only with widespread use of coked coal and improved malt ovens in the late 18th century that pale beers became feasible. While this lead to the "lager revolution" which saw progressively weaker and paler beer dominating the marketplace, there were backwaters of brewing where the tradition of using smoked malts never died out and was ultimately turned into an art form.

In particular, the town of Bamberg, in the German state of Franconia, is famous for its smoked beers, mostly smoked versions of traditional Bavarian-style beers, such as Märzen and Hefeweizen. Bamberg Rauch (smoke) beer malts are smoked over beechwood fires, and typically rauchbier is entirely made from smoked malt.

Likewise, in the Scottish Highlands, peat-smoked malt has been used to make Scottish whisky for centuries. Although there is no evidence that Scottish brewers ever used peat-smoked malt since the 18th century, modern brewers, especially in the U.S. will sometimes use a bit of peat malt in beer.

Effects of Smoke on Beer: Smoke saturates the malt husks with monophenols and other flavor compounds, which are transferred to the wort during mashing and sparging. Monophenols are particularly important because they are responsible for the distinctive smoky, astringent and medicinal flavors and aromas associated with smoked foods. Not surprisingly, different types of smoke have their own unique character, which reflects the nature of the burned material. Due to the nature of smoked malt, most smoked beers tend to be malt-focused beers which are at least amber in color. Hops or esters and smoke don't tend to blend well together.

Both Papazian's The Homebrew Companion and Mosher's Radical Brewing describe techniques to smoke your own malt at home. Ray Daniels and Geoffrey Larson's book, Smoked Beers goes into the process of making smoked malt in depth. The rules of thumb are:

1) Any water you use must be free of chlorine (and chloramines). Use distilled or reverse osmosis water if possible. If not, use water which has been treated to remove chlorines and chloramines.

2) Only use wood you would use to smoke food.

3) Experiment. Minor changes in technique can produce big variations in flavor.

4) Be safe. Don't hurt yourself, burn down your house or scorch your malt. Use a stead, relatively cool fire - use coals, not flames or electric heating elements. Don't let ash and tar mix with your malt. (Smoking on two layers of 16 x 16 stainless steel or copper mesh works well for this).

5) Dry the malt thoroughly after smoking. Not only does this allow you to store the malt once it's smoked, it also helps drive off unwanted flavors (acetic acid) picked up by the malt during smoking.

6) Sample your malt before you brew with it.

7) Less is more. It's easy to add too much smoked malt to a recipe. Start off cautiously, then add more as you "dial in" subsequent batches.

Methods of Smoking

Typically, homebrewers smoke malt using a barbecue grill, with the malt contained on a fine-mesh screen. Get a good bed of coals, then add wood chips to it, close the lid and let the malt smoke to taste. Cool, moist smoke and moist malt will produce mellower, less intense flavors than hot smoke and/or dry malt.

Smoking will darken the malt considerably, and is likely to kill most of its diastatic power. Pale malt will be toasted to amber or brown.

1) Wet malt, wet chips: *This gives maximum smoke pickup, but is the slowest method. It requires a smoker. 1.75 pounds of wood chips and 3 cups of water. Let the chips fully absorb the water (several hours to overnight). This prevents the chips from flaming. Put the damp chips into the smoker container but don't yet start it. Use one "malt screen" (15-24 copper or stainless steel mesh) as an ash catcher, suspended below the main malt screen, or on the bottom shelf of your smoker. Put a mesh screen at least 3" deep on the top shelf of the smoker. 15 minutes before starting the smoker, evenly pre-moisten 5 pounds of pale malt using 3 cups of distilled or reverse-osmosis water. Fill the top rack, evenly spreading the malt on the top screen. Start the smoker heating element and let the chips smolder for 2 hours. Leave the top off the smoker to let the heat out. After the malt has been smoked, dry it in a 200 °F, slightly open oven. Test the malt to determine that it is dry before storing it.*

2) Dry malt, dry chips: *This method requires a gas heater, like a Cajun cooker, produces less smoke character and risks burning the malt, but is very fast. 10 ounces of chips in bottom tray, just above the gas heater. Place a fine screen above the chips, between the chips and the malt rack. The screen should cover the entire smoke path to keep ash out of the malt. Make a smoke chimney from a metal coffee can which has multiple holes punched in it. Put the perforated can into the middle of the grain screen before filling the try with malt. Place 10-15 pounds of malt, moistened with 2 tsp of chlorine-free water, in the rack. Mix to disperse the water. Burn the chips in a low to medium flame. Put the top on the smoker and wrap a moistened paper towel around the lid to help contain the smoke. After 10 minutes, remove the cover, stir the malt and leave the cover off while continuing to heat. Heat for an additional 5-7 minutes, which will aid in drying the malt. If you hear crackling, the malt it charring - reduce to eliminate the flame! Remove the grain from the smoker, empty it onto a sheet pan and spread evenly. Leave it for at least 20 minutes to dry further.*

3) Quick and Simple: *This method requires a barbecue grill. Build a charcoal fire and let it burn down to about 4 cups of ash-covered coals. Bank the coals steeply to one side of the grill. Moisten 1 pound of wood chips with 2 cups of water, as described for method 1. Place damp chips on the coals, heaping them in the middle of the coals. Put a screen over the grill, covering it entirely, to act as an ash catcher. On the opposite side of the grill, away from the coals, place a basket with a stainless-steel or copper screen sufficient to contain and cover 5 pounds of malt. The basket is used to quickly remove the grain from the grill, and to keep the malt from contacting the grill. Mist the grain light with 2 tsp of chlorine-free water. Cover the grill while still letting enough air in to still allow the wood to char without bursting into flames. Smoke for 10 minutes. Stir the malt and smoke for another 20 minutes, replacing the lid after you've stirred. Remove the grain and spread it flat on a dry place to dry overnight.*

Malt Smoking Woods

Alder	*Sweet, rich woodiness, very neutral, delicate. Traditionally used for smoking fish.*
Apple	*Sweet, spicy, extremely mellow. Few acrid notes*
Beech	*Dry, woody, neutral, with a hint of pungency. Traditional wood used for smoking Bamberg malts.*
Birch	*Spicy, hints of wintergreen.*
Cherry	*A dry, complex, almond fruitiness.*
Corncobs	*Mild, pleasant. Historically used to smoke meat in Northeastern U.S.*
Grapevine	*Intensely dry, herbal and woody.*
Hickory	*Dry, mellow, mild. Traditionally used for smoking ham and bacon in the U.S.*
Juniper	*Spicy, sharp, piney, creosote-like. Use sparingly.*
Maple	*Sweet, spicy, buttery, mild. Commonly used to smoke sausage.*
Mesquite	*Delicate, slightly spicy.*
Oak, European	*Softer than American oaks, allegedly used to produce malt in Poland and Scotland historically*
Oak, Red	*Somewhat sharp, but softer than white oak.*
Oak, White	*Intensely pungent, acidic, musty.*
Peach	*Fruity and delicate.*
Pear	*Slightly sweet and spicy, very mellow.*
Peat	*Phenolic, sharp, oily, creosote-like. Use sparingly! Used to make peat malt for Scottish whisky.*
Pecan	*Massively spicy, pungent, intense!*
Straw	*Almost pure cellulose, produces very little smoke flavor. Historically preferred for drying malt for this reason.*

Other woods which have been used to successfully make smoked malt (or which can be used to smoke food) are aspen, balsam poplar, bamboo, coconut shells, cottonwood, elm, grapefruit, hazel, orange, sassafras, walnut, white ash and willow.

Source: Mosher, Radical Brewing & Daniels and Larson, Smoked Beer.

B. Wood-Aged Beers

Another traditional brewing technique, which only survives as a curiosity today, is wood-Aged beer. Historically, brewers had only two options for storing their beer, clay pots or wooden barrels. Of the two choices, wood is the lighter and more durable material. While clay vessels were used in the ancient Near-East, in Northern Europe vast forests of high quality timber meant that barrels were the storage container of choice. This had important effects on the character of pre-modern beer.

1) Wooden barrels are gas-permeable, allowing water and alcohol vapor to escape from the barrel while allowing oxygen in. Over time, the alcoholic content of barrel-stored beer could increase or decrease, even as the total volume of beer decreased due to evaporation. Historically, this decrease in volume was called "ullage" and had to be corrected by periodically topping off the beer in the barrel.

Diffusion of oxygen into the barrel has the important effects of oxidizing the beer and providing oxygen for spoilage bacteria. As a rule of thumb, the larger the barrel, the thicker the staves and the lower the surface-to-mass ratio, and the lower rate of gas diffusion.

Extreme oxidation can impart "cardboard" or "papery" aromas and flavors to beer, but subtle oxidation mellows hop bitterness and interacts with melanoidins and alcohols to produce sherry and dark-fruit aromas and flavors.

Infection by Brettanomyces and Pediococcus will produce sweaty, goaty, horsy, spicy, fruity and waxy flavors and aromas,

which, if properly controlled, can add complexity to the finished brew.

2) Wooden barrels can't be effectively sanitized[1], meaning that old barrels eventually become infected with spoilage organisms, such as Brettanomyces, Pediococcus, Lactobacillus and wild yeasts. Lambic brewers, in particular, prize old barrels for their high quality bacteria cultures.

3) Wooden barrels can't be adequately cleaned, meaning that an old barrel retains some of the flavor and aroma of whatever material was previously stored in it. While barrels can be reconditioned to remove old flavors, doing so imparts more of the taste of the wood itself (see below) to the any liquid subsequently stored in it.

Lambic brewers prefer to use old wine or beer barrels, while there has recently been a fad among U.S. craft-brewers to brew beer aged in bourbon barrels. Obviously, the flavor of the previously stored material diminishes over time, making previously oppressive flavors more subtle and eliminating subtle flavors. Unfortunately, short of reusing the barrel for wine or spirits, there is no good way to renew the flavors imparted to beer by a newly retired wine or liquor barrel.

4) The wood of the barrel imparts its own flavor to any liquids stored in it. Wood can impart more than 200 compounds to wine or beer, but of these compounds only about a dozen are detectable by humans and only three are important. These three are Vanillin, Tannin, and Methyloctalactones.

Vanillin[2] is produced when alcohol interacts with naturally-occurring lignins (structural sugars) in the wood and produces a distinct vanilla-like aroma and corresponding sweet flavor.

Tannins are leached into wine or beer from oak barrels. In limited amounts, tannins can impart drying, astringent and acidic characteristics to beer or red wine. Unless carefully treated, however, newly made oak barrels can impart an unpleasant level of astringency to liquids stored in them. European oak imparts more tannins than American oak, which imparts a higher degree of vanillins and toastiness.

Methyloctalactones are responsible for spicy aromas and flavors from wood aging. They can vary in character not only on the species of oak, but also on the origin of the wood and the cooperage techniques used to make the barrel.

The interior of a whiskey or bourbon barrel is charred during production, while the interiors of wine barrels are "toasted." The heavier the charring, the more wood character and smokiness the barrel will contribute to the wine or beer.

As with other flavors, the wood and charcoal flavors imparted by the barrel decrease over time.

Wood-Aging Without the Barrel: *It is often impractical for homebrewers to barrel-age their beers. Fortunately, it is possible to simulate some of the effects of wood-aging by inoculating beer with bacteria cultures, adding plugs of wood, or by dosing the aging beer with small amounts of bourbon, scotch or wine to simulate the effects of spirit- or wine-barrel aging. Chapter 7 of Wild Brews covers this topic in detail and is highly recommended for brewers interested in wood-aging their beers.*

While not perfectly applicable to making oak-aged beer, the BJCP Mead Exam Study Guide also has an extensive section on Oaking mead, which goes into detail about the differences between the flavor characteristics of the various forms of oak.

Part 7: BJCP Category 23 - Specialty Beers

Specialty beers are beers which don't fall into any other category of the BJCP Style Guidelines, making Category 23 (and Category 16E - Belgian Specialty Beers) the "non-style style" which serves as a showcase for homebrewers' creativity.

Generally, beers entered into Category 23 fall into one of three categories:

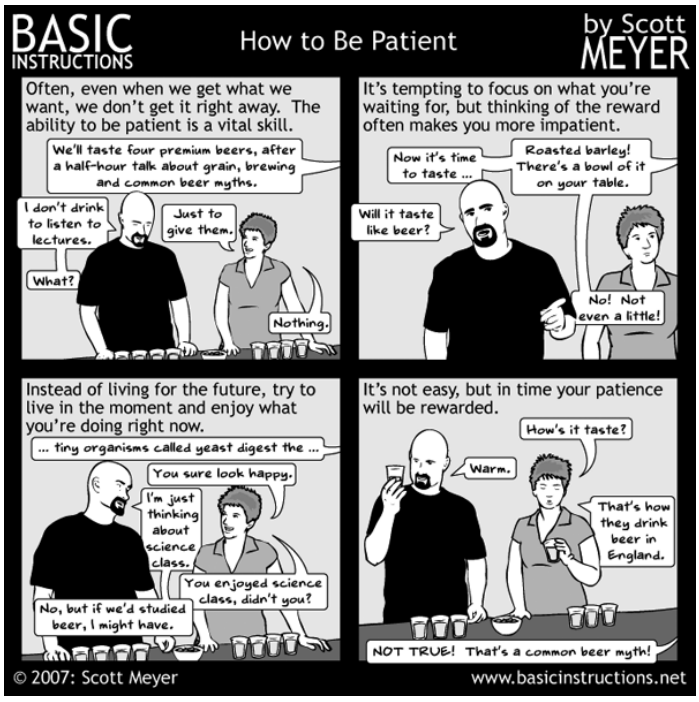
** Variants on existing styles (e.g., Black IPA, Strong Mild, American IPA brewed using Belgian Trappist yeast).*

** Combinations of two or more styles (e.g., fruit and spice beer).*

** Unusual ingredients or techniques (e.g., American IPA brewed using rye or New Zealand hops, honey or maple beers, steinbier, eisbier).*

Rarely, Specialty beers might be recreations of historical beer styles (e.g., medieval style gruit beer, Russian Kvass), imitations of commercial beers which don't fit into the style guidelines (e.g., Sam Adams Boston Lager or Dogfish Head Midas Touch clones), or recreations of beer styles which aren't yet covered by the BJCP Style Guidelines (e.g., Gose, Faro, Sticke Altbier).

Judging Specialty Beers: *When judging any beer in categories 16E and 20-23, keep in mind that the added ingredients or special techniques can alter the base beer. This is particularly important if the brewer declares a specific base beer style. For example, a "Brown American IPA" might have a tiny bit of astringency due to the confluence of amber malts and high hopping levels*



[1] *Modern winemakers can sanitize their barrels using steam or solutions of strong caustic, such as Barol-Kleen™. Historically, however, the only way to sanitize a barrel was to vent sulfur smoke into it which was only partially effective.*

[2] *Vanillin is the active ingredient in both natural and artificial vanilla. Artificial vanilla flavoring is made from vanillin.*