Beer Judge Certification Program

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BJCP BEER EXAM STUDY GUIDE

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Revised 2012 by Scott Bickham and Steve Piatz.
Revised 2014 by Steve Piatz
Revised 2015 by Steve Piatz
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CHANGE LOG

January-March, 2012: revised to reflect new exam structure, no longer interim
May 1, 2012: revised yeast section, corrected T/F question 99
August, 2012: removed redundant styles for question S0, revised the additional readings list, updated the judging procedure to encompass the checkboxes on the score sheet.
October 2012: reworded true/false questions 2, 4, 6, 8, 13, 26, 33, 38, 39, 42, and 118. Reworded essay question T15.
March 2014: removed the Exam Program description from the document, clarified the wording on question T13.
October 2015: revised for the 2015 BJCP Style Guidelines.
February, 2016: revised the table for the S0 question to fix typos, removed untested styles.
September-October, 2017 (Scott Bickham): moved the BJCP references in Section II.B. to Section I; incorporated a study guide for the online Entrance exam in Section II; amended the rubric for written questions S0, T1, T3, T13 and T15; rewrote the Water question and converted the rubrics for each of the Technical and Brewing Process questions to have three components; simplified the wording of the written exam questions' added an introduction to Section IV; added two paragraphs on fining in the Wort Production section (now IV.D); revised the description of phenols in Section IV.E (now IV.F); made substantial revisions and expansions of the off-flavor descriptions in the Troubleshooting section (now IV.G and entitled Beer Characteristics); the Hops Section (now IV.E) was also revised to include better descriptions of the classic hop varieties, and a paragraph on New World hops was added; errors in the Water section (now IV.B) were corrected, and the paragraph discussing the connection between the mineral content of the water and development of historical beer styles was expanded into a list to facilitate studying.
December 2017 (Bruce Buerger and Scott Bickham): updated the BJCP Exam Study Course and added the final version of the Written Proficiency Exam questions as approved by the exam directorate.

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I. INTRODUCTION

Since the inception of the BJCP, several tools have been developed to help potential judges study for the exam. The most widely used are the study guides written by Chuck Cox and Greg Walz. The former was assembled in the early 1990s with the help of readers of the Judge Digest and consists of an outline of the information and terminology needed to pass the exam. The latter is a more verbose discussion of ingredients, brewing procedures and flavors as they relate to beer styles and judging. The outline version is valuable because it encourages independent study; however, the verbose version was used as the foundation for the first BJCP Study Guide because information could be added and updated without radically changing the presentation format.

This new edition of the BJCP Study Guide was written with a different approach that was motivated by the feedback and performance from those who have used other study guides. Most of these contain information that is outdated, incorrect or irrelevant to the types of questions asked on the exam. For example, a study guide should not be a tutorial on homebrewing, but should summarize the aspects of the brewing process that relate to beer flavors and styles. The information presented here was written by a group of technically proficient judges and brewers and tailored to the actual BJCP exam questions. The backgrounds of these authors are summarized at the end of the guide. The material has also been reviewed by the BJCP Exam Committee to ensure that it is technically correct and understandable. The goal was to prepare a document that is not only valuable in studying for the exam, but concise and complete enough to be used as a judging handbook. In addition, it is essential that this study guide be made freely available to potential judges. It is available for downloading in several formats on the BJCP website (http://www.bjcp.org).

The study guide begins with a section describing the BJCP and the motivation and mechanics behind the judging process. Also included are links to BJCP scoresheets, a comprehensive list of possible exam questions and an outline of a study course for beer judges. The BJCP style guidelines are introduced and discussed, and links to the guidelines are provided. Other study guides feature more complete style descriptions, but we found that many potential judges relied on that information as their sole reference for information about beer styles. This may be sufficient to pass the exam, but is no substitute for the wealth of information that is found in Michael Jackson's Beer Companion and The New World Guide to Beer, for example. The last major section of the study guide is a review of technical information about the brewing process and flavors in beer. Although this material was written with the exam questions in mind, it is no substitute for gaining an understanding of the brewing process by reading the references and putting that knowledge to practical use by actually brewing a batch of beer.

We hope that this study guide fulfills its goal of offering a complete, concise and understandable overview of the information needed to pass the exam. We recommend that it be used in conjunction with the following references to gain a complete understanding of beer styles, beer flavors and the brewing process. Good luck!

Note: Metric equivalents have been added for those outside the United States. The conversions have sometimes been approximated to produce round numbers.

A. Additional Reading

The additional readings are split into a number of categories focused on different areas that a BJCP Judge needs to be familiar with. First are the general BJCP items that apply to all judges in all situations followed by beer style knowledge and communicating about beer. The remaining areas are broadly divided up as important for either the Beer Judging Exam or for the Beer Judge Entrance Exam and Beer Judge Written Proficiency Exam (both the Entrance and Proficiency exam cover similar material). Within each of those broad areas the readings are further separated based on depth and complexity of coverage into basic, intermediate, and advanced.

General BJCP References

Current competition materials can be found on the BJCP website in the Competition Center. Other important BJCP references include the most current program rules, information and structure. These documents can be found in the following locations:

1. BJCP Beer Scoresheet	http://www.bjcp.org/docs/SCP_BeerScoreSheet.pdf
2. BJCP Cover Sheet	http://www.bjcp.org/docs/SCP_CoverSheet.pdf
3. BJCP Judge Instructions	http://www.bjcp.org/docs/SCP_JudgeInstructions.pdf
4. Judge Procedures Manual	http://www.bjcp.org/docs/Judge_Procedures_Manual.pdf
5. BJCP Competition Requirements	http://www.bjcp.org/rules.php
6. BJCP Member's Guide	http://www.bjcp.org/membergd.php
7. Sample Scoresheets	http://www.bjcp.org/examscores.php
8. Mastering the BJCP Exam	http://www.bjcp.org/docs/mastering.pdf

Style Knowledge

The references by Michael Jackson and Roger Protz are broad ranging and touch on many different styles while the remaining items in this subsection focus on just a few related styles.

1. Michael Jackson, The New World Guide to Beer (Running Press, Philadelphia, 1988).
2. Michael Jackson, Beer Companion (Running Press, Philadelphia, 1997).
3. Michael Jackson, Ultimate Beer (DK Publishing, New York, 1998).
4. Michael Jackson, Great Beer Guide (DK Publishing, New York, 2000).
5. Michael Jackson, Michael Jackson's Great Beers of Belgium (Media Marketing Communications, Antwerp, 2005).
6. Michael Jackson, Eyewitness Companions: Beer, (DK Publishing, New York, NY, 2007).
7. Roger Protz, The Taste of Beer (Orion Publishing, London, 1998).
8. Terry Foster, Pale Ale, 2nd Ed. (Brewers Publications, Boulder, CO, 1999).
9. Terry Forster, Porter, (Brewers Publications, Boulder, CO, 1992).
10. Jean-Xavier Guinard ,Lambic (Brewers Publications, Boulder, CO, 1990).
11. Darryl Richman, Bock, (Brewers Publications, Boulder, CO, 1994).
12. Greg Noonan, Scotch Ale, (Brewers Publications, Boulder, CO, 1993).
13. Eric Warner, German Wheat Beer (Brewers Publications, Boulder, CO, 1992).
14. Pierre Rajotte, Belgian Ale (Brewers Publications, Boulder, CO, 1992).
15. Michael Lewis, Stout (Brewers Publications, Boulder, CO, 1995).
16. Horst Dornbusch, Altbier (Brewers Publications, Boulder, CO, 1998).

17. Fal Allen and Dick Cantwell, Barleywine (Brewers Publications, Boulder, CO, 1998).
18. Horst Durnbusch, Bavarian Helles (Brewers Publications, Boulder, CO, 2000).
19. Ray Daniels and Jim Parker, Brown Ale (Brewers Publications, Boulder, CO, 1998).
20. Eric Warner, Kölsch (Brewers Publications, Boulder, CO, 1998).
21. David Sutula, Dark Mild Ale (Brewers Publications, Boulder, CO, 1999).
22. Ray Daniels and Geoffrey Larson, Smoked Beer (Brewers Publications, Boulder, CO, 2001).
23. Phil Markowski, Farmhouse Ales (Brewers Publications, Boulder, CO, 2004).
24. Jeff Sparrow, Wild Brews (Brewers Publications, Boulder, CO, 2005).
25. Stan Hieronymus, Brew Like a Monk (Brewers Publications, Boulder, CO, 2005).
26. Stan Hieronymus, Brewing with wheat: the "wit' and weizen" of world wheat beer styles, (Brewers Publications, Boulder, CO, 2010).
27. Mitch Steele, IPA: Brewing Techniques, Recipes and the Evolution of India Pale Ale, (Brewers Publications, Boulder, CO, 2012).

Communicating About Beer

Beer judges need to be able to communicate about beer with others. That communication requires a good beer vocabulary and the ability to write succinctly about beer.

28. BJCP Vocabulary (development in process), http://www.bjcp.org/formervocab.php
29. A sample wine vocabulary, http://en.wikipedia.org/wiki/Wine_tasting_descriptors
30. Garret Oliver, Oxford Companion to Beer, (Oxford University Press, New York, NY, 2012).
31. William Strunk, E. B. White, The Elements of Style, 4th Edition, (Longman, Boston, MA, 1999)

Beer Judging Exam

Basic Tasting/Judging Experience

The experience of critically evaluating beer provides the framework to judge beer well and excel on the Judging Exam. This is lumped into the catch all of Tasting/Judging Experience that can be private practice with just you, a beer and the Style Guidelines or structured taste workshops facilitated by someone else or contest judging where the learning opportunity is to listen to your co-judge.

32. BJCP Beer Faults, http://www.bjcp.org/faults.php

Advanced Judging Knowledge

33. Charlie Papazian, et al, Evaluating Beer (Brewers Publications, Boulder, CO, 1993).
34. Randy Mosher, Tasting Beer: An Insider's Guide to the World's Greatest Drink, (Storey Publishing, North Adams, MA, 2009).

Written Proficiency Exam

Taking either the Beer Judge Entrance Exam or the Beer Judge Written Proficiency Exam requires learning a lot of details about beer and related topics. There are many references on how to learn material. Not all individuals are able to effectively learn by the same technique. The reference here touches on some of the different techniques useful to many people.

35. *How to Memorize*, http://www.wikihow.com/Memorize

Intermediate Brewing Technology

36. John Palmer, How to Brew, (Brewers Publications, Boulder, CO, 2006).

37. Dave Miller, Dave Miller's Homebrewing Guide (Garden Way Publishing, Pownal, VT 1996).

Advanced Brewing Technology

38. Gregory J. Noonan, New Brewing Lager Beer (Brewers Publications, Boulder, CO, 2003).
39. George Fix, Principles of Brewing Science, 2nd Edition (Brewers Publications, Boulder, CO, 1999).
40. George and Laurie Fix, An Analysis of Brewing Techniques, (Brewers Publications, Boulder, CO, 1997).
41. Chris White, Jamil Zainasheff, Yeast: The Practical Guide to Beer Fermentation (Brewing Elements), (Brewers Publications, Boulder, CO, 2010).
42. *Brewing Techniques* (New Wine Press, Eugene, OR). Contains a wealth of information about the ingredients, history and flavors in beer. While no longer being published some articles are available at www.brewingtechniques.com.

College-Level Brewing Technology

43. Wolfgang Kunze, Technology Brewing and Malting, 4th International Edition – in English, (VLB, Berlin, Germany, 2010).
44. Jean de Clerck, A textbook of brewing, Volume 1, (Siebel Institute of Technology, 1957).
45. Jean de Clerck, A textbook of brewing, Volume 2, (Siebel Institute of Technology, 1957).
46. Dennis Briggs, et al, Brewing Science and Practice, (Woodhead Publishing, Boca Raton, FL, 2004).
47. Michael Lewis and Tom Young, Brewing, (Aspen, New York, NY, 2001).

Recipe Formulation

48. Ray Daniels, Designing Great Beers (Brewers Publications, Boulder, CO, 1996).
49. Jamil Zainasheff and John Palmer, Brewing Classic Styles (Brewers Publications, Boulder, CO, 2007).
50. Gordon Strong, Brewing Better Beer, Chapter 6, (Brewers Publications, Boulder, CO, 2011).

Brewing History

51. Roger Protz, The Ale Trail (Eric Dobby Publishing, Kent, 1995).
52. Horst Dornbusch, Prost! The Story of German Beer (Brewers Publications, Boulder, CO, 1997).
53. Gregg Smith, The Beer Enthusiast's Guide (Storey Communications, Pownal, VT, 1994).
54. Charles Bamforth, Beer: Tap into the Art and Science of Brewing (Plenum Press, New York, 1998).
55. Clive La Pensée, Roger Protz, India Pale Ale: Homebrew Classics, (CAMRA, St. Albans, England, 2001).
56. Clive La Pensée, Roger Protz, Stout & Porter: Homebrew Classics, (CAMRA, St. Albans, England, 2003).
57. John Tuck, The Private Brewer's Guide To The Art of Brewing Ale And Porter, (Simpkin & Marshall, London, England, 1822, reprinted by Zymoscribe, Woodbridge, CT, 1995).
58. M. L. Byrn, The Complete Practical Brewer, (Henry Carey Baird, Philadelphia, PA, 1852, reprinted by Raudins Publishing,Chagrin Falls, OH, 2002).
59. W. H. Roberts, The Scottish Ale Brewer and Practical Maltster, (A. and C. Black Whitttaker Company, London, England, 1847, reprinted by Raudins Publishing, Chagrin Falls, OH, 2003).
60. W. Brande, The Town and Country Brewery Book, (Dean and Munday, London, England, circa 1830, reprinted by Raudins Publishing, Chagrin Falls, OH, 2003).

61. Michael Combrune, The Theory and Practice of Brewing, (Worshipful Company of BREWERS, 1762, reprinted by Raudins Publishing, Chagrin Falls, OH, 2004).
62. Robert Wahl, Max Henius, American handy-book of the brewing, malting and auxiliary trades, (Wahl & Henius, Chicago, IL, 1902) also available on Google Books.
63. History of Beer, http://en.wikipedia.org/wiki/History_of_beer

II. BEER JUDGING AND THE BJCP EXAM

The most complete and current information about the BJCP can be found on the BJCP web site (http://www.bjcp.org). The Member Resources section contains a wealth of information about the organization's background, history and evolution.

A. Beer Evaluation and the Judging Process

by Edward W. Wolfe

Beer Evaluation

Product evaluation is an important part of brewing, whether performed informally or formally and whether the product is from a commercial or home brewery. Formal beer evaluation serves three primary purposes in the context of brewing competitions. First, the beer evaluations provide feedback to the brewer concerning how well an individual recipe represents its intended beer style. This feedback can be useful as recipes are fine-tuned and attempts are made to improve the beer. Second, beer evaluations may provide brewers with troubleshooting advice. These diagnostic suggestions are particularly helpful when the brewer cannot identify the source of off-flavors or aromas. A knowledgeable beer evaluator can provide the brewer with suggestions for changing procedures and equipment that can help eliminate undesirable flavor and aroma components. Third, beer evaluation provides a fairly unbiased method for selecting and recognizing outstanding beers in brewing competitions.

Environment

One important condition that is necessary for accurate beer evaluation is the establishment of a suitable environment. The environment should be well-lit, odor-free, and distractions should be minimized. Natural, diffuse lighting is best, with incandescent lighting preferred over fluorescent lighting. Table cloths and walls should be free of patterns that might obscure visual inspection of the beer, and light colored or white walls and tablecloths are ideal. The room in which evaluation takes place should be as free of odors as possible. Restaurants and breweries can be particularly troublesome locations for evaluating beers because food and brewing odors are likely to interfere with a beer judge's ability to smell the beers being evaluated. Smoking and perfumes should also be eliminated as much as possible. In addition, the evaluation environment should be as free from other distractions. Noise should be kept to a minimum, and privacy should be preserved to the greatest extent possible. Every effort should be made to make the beer judges comfortable by carefully selecting chairs and tables, monitoring the temperature of the evaluation room, and providing assistance to judges during the evaluation process (e.g., stewards).

Equipment

A second important condition that is necessary for effective beer evaluation is suitable equipment. That is, judges need sharp mechanical pencils with erasers—mechanical so that the aroma of wood does not interfere with detecting beer aromas and erasers so that comments and scores can be changed. Beer judges also need suitable cups for sampling the beer—impeccably clean plastic or glass, odor-free, and clear. Also, judges need access to style guidelines. Tables should be equipped with water and bread or crackers for palate cleansing, buckets and towels for cleaning spills or gushes, bottle openers and cork screws, and coolers and temporary caps for temporary storage of opened bottles.

Presentation

As for the presentation of beers, two methods are common, each with positive and negative points. One method of presentation permits judges to open and pour the beer into their own cups. A second method of presentation requires stewards to pour beer into pitchers, and the beer is transferred from the pitcher into judges' cups. When judges are allowed to pour their own beers, there is some danger that moving bottles to the evaluation table will stir up yeast and that judges' opinions of a beer's quality will be influenced by the appearance of the bottles that it comes in. On the other hand, when judges transfer beer from a pitcher, it is more difficult to capture many of the fleeting aromas that might dissipate between the time the bottle is opened and the time that judges are presented with the beer. Another problem with using pitchers is that it is more difficult to temporarily store beer samples so that judges can taste them again at a later time.

The Judging Process

Decision Strategies

There are two general decision making strategies that judges use when evaluating a beer. In a top-down decision making strategy, the judge forms an overall impression about the quality of the beer, decides what overall score to assign that beer, and deducts points for each deficient characteristic of the beer based on the overall impression. The problem with this top-down approach to beer evaluation is that it is difficult to ensure that the points allocated to each subcategory (e.g., aroma, appearance, flavor, body) agree with the comments that were made about that feature of the beer. In a bottom-up decision making strategy, the judge scores each subcategory of the beer, deducting points for each deficient characteristic. The overall score is determined by summing the points for each subcategory. The problem with this bottom-up approach to beer evaluation is that it easy to arrive at an overall score for the beer that does not agree with the overall impression of the beer. In short, judges who use a top-down approach to judging beers may "miss the trees for the forest," while judges who use a bottom-up approach to judging beers may "miss the forest for the trees."

Most judges use a combination of these two extremes. Regardless of which approach seems more comfortable to an individual beer judge, there are several general guidelines that judges should follow when assigning scores to beers. In the current BJCP scoring systems, each beer is evaluated on a 50-point scale, allocating 12 points for Aroma, 3 for Appearance, 20 for Flavor, 5 for Mouthfeel and 10 for Overall Impression. This scoresheet can be found on the BJCP website. In addition, there are sliding scales on the bottom right hand corner for rating the stylistic accuracy, technical merit and intangibles of each beer.

Scoring Guidance

Overall scores should conform to the descriptions given at the bottom of each scoresheet. Excellent ratings (38-44) should be assigned to beers that are excellent representations of the style. Very Good ratings (30-37) should be assigned to very good representations of the style that have only minor flaws. Good ratings (21-29) should be assigned to good representations of the style that have significant flaws. Drinkable ratings (14-20) should be assigned to beers that do not adequately represent the style because of serious flaws. A problem rating (13 or lower) is typically assigned to beers that contain flaws that are so serious that the beer is rendered undrinkable. The scoresheet reserves the 45-50 range for outstanding beers that are truly world-class.

In general, the best beers at a competition should be assigned scores in the 40+ range, with real evaluations of the beer identifying some characteristics of the beer that make it non-perfect. A beer receiving a perfect score of 50 must indeed be perfect; it must have absolutely no flaws, exemplify the style as well as or better than the best commercial examples, be perfectly brewery-fresh, and be well-handled and presented. These conditions might not all be under the brewer's control, so achieving a perfect beer at the point of presentation to judges is extremely rare.

When providing feedback about very good beers, it is important to identify ways in which the beer can be improved and mention these characteristics on the scoresheet. Any serious flaw or missing aspect of a particular beer style (such as lack of clove character in a Bavarian weizen) generally results in a maximum score around 30. Also, note the cut-off score of 21 determines if a beer adequately represents a particular style.

A beer that is strongly infected or that contains a flaw so severe that it makes the beer undrinkable can be assigned a score of 13. A score of 13 makes the point that the beer is essentially undrinkable; lower scores can be taken as spiteful. However, this is simply a guideline. If the flaws are so bad that even a 13 is generous, judges can score lower. Simply justify your score using a bottom-up method; assign points for positive attributes that are present. Give the benefit of the doubt for low-scoring beers. If you do score lower than 13, strive to make as many useful comments as possible on how the brewer can improve the beer. Always look for positive comments to make about a beer, and then let the brewer know what aspects of the beer need attention and how to correct any flaws.

Procedure

Beers should be evaluated using the following procedure:

1. Prepare a scoresheet. Write the entry number, style category and subcategory names and numbers, your name, and any other necessary information (e.g., judge rank, e-mail address) on a scoresheet, or apply a pre-printed label.
2. Visually inspect the bottle (if given the bottle). Check the bottle for fill level, clarity, sediment, and signs of problems (e.g., a ring around the neck of the bottle). Identification of such characteristics may be helpful in describing flaws that are discovered during the formal evaluation process. However, be careful not to prejudge the beer based on a visual inspection of the bottle.
3. Pour the beer into clean sampling cup, making an effort to agitate the beer enough to produce a generous head (but not enough to produce a head large enough to interfere with drinking the beer). For highly carbonated beers, this may require pouring carefully into a tilted cup. For beers with low carbonation, this may require pouring directly into the center of the cup, with a 6 inch (15 cm) drop from the bottle. Pour each entry in a manner that gives it its optimum appearance, keeping in mind that some entries may be over- or under-carbonated.
4. Smell the beer. As soon as the beer is poured, swirl the cup, bring it to your nose, and inhale the beer's aroma several times. When a beer is cold, it may be necessary to swirl the beer in the cup, warm the beer by holding it between your hands, or putting your hand on the top of the cup to allow the volatiles to accumulate in a great enough concentration to be detected. Write your

impressions of the beer's aromas. Particularly, note any off aromas that you detect. Do not assign scores for aroma yet.

5. Visually inspect the beer. Give your nose a rest, and score the appearance of the beer. Tilt the cup, and examine it through backlighting. For darker beers, it may be necessary to use a small flashlight to adequately illuminate the beer. Examine the beer's color, clarity, and head (retention, color, and texture). Write comments about the degree to which the color, clarity, and head are appropriate for the intended style and record a score. Score the beer for appearance, allocating a maximum of one point for each of these characteristics.

6. Smell the beer again. Again, swirl the cup, bring it to your nose, and inhale the beer's aromas several times. Note how the beer's aroma changes as the beer warms and the volatiles begin to dissipate. Write your impressions of the beer's aromas, noting particularly the appropriateness of the malt, hops, yeast, and fermentation byproduct aromas. Also, note any lingering off aromas. Do not assign scores for aroma yet.

7. Taste the beer. Take about 1 ounce (30 ml) of beer into your mouth, and coat the inside of your mouth with it. Be sure to allow the beer to make contact with your lips, gums, teeth, palate, and the top, bottom, and sides of your tongue. Swallow the beer, and exhale through your nose. Write down your impressions of the initial flavors of the beer (malt, hops, alcohol, sweetness), intermediate flavors (additional hop/malt flavor, fruitiness, diacetyl, sourness), and aftertaste (hop bitterness, oxidation, astringency). Do not assign scores for flavor yet.

8. Score the beer for mouthfeel. Take another mouthful of beer and note the appropriateness of the beer's mouthfeel for the intended style. Mouthfeel includes body, carbonation, warmth, creaminess, and astringency. Write comments concerning your impression and assign between 2 and 5 points with higher numbers reflecting appropriate mouthfeel and lower numbers indicating increasing levels of deviation from the intended style.

9. Evaluate the beer for overall impression. Relax. Take a deep breath. Smell the beer again, and taste it again. Pause to consider where the beer belongs in the overall range of scores (e.g., excellent, very good, good, drinkable, problem) and where similar beers are ranked within the judging flight. If you use a top-down decision making strategy, assign an overall score to the beer, then mentally subtract points from the remaining subcategories (i.e., aroma and flavor), consistent with your impressions of how the beer is deficient. Use the overall impression category to adjust your final score to the level you feel is appropriate for this beer. If you use a bottom-up decision making strategy, assign scores to each of the remaining subcategories (i.e., aroma and flavor), and assign a score for overall impression. Finally, write prescriptive suggestions for improving the beer in light of any deficiencies you noted in your evaluation.

10. Check any boxes on the left side of the scoresheet that are consistent with your comments.

11. Check your scoresheet. Add your category scores. If you use a bottom-up approach, double check to make sure you added correctly. If you use a top-down approach, make sure that your subcategory scores sum to equal your overall score. When the other judges have finished scoring the beer, discuss the technical and stylistic merits of the beer and arrive at a consensus score. Be prepared to adjust your scores to make them fall within 5-7 points of the other judges at your table.

12. Complete the Stylistic Accuracy, Technical Merit, and Intangibles scales at the bottom of the scoresheet. Mark the appropriate box on each scale to indicate where the beer lies on each scale.

Notes on Smelling the Beer

When a beer judge smells a beer, the judge is literally inhaling small particles of the beer. The sense of smell works by detecting molecules that are diffused into the air. These molecules are inhaled into the sinus cavity where receptors (olfactory cells) detect and translate the chemical information contained in the molecules into information that the brain can interpret. Several things influence a judge’s ability to detect the variety of aromas in beer. First, there are different densities of the receptors found in different people. Hence, some judges may simply be more sensitive to odors than are other judges. Second, the receptor cells can be damaged through exposure to strong substances (e.g., ammonia, nasal drugs), and this damage may take several weeks to heal. Third, changes in the thickness of the mucus that lines the nasal cavity may influence a judge’s sensitivity. Any molecules that are detected by the olfactory cells must pass through a mucus lining, so daily changes in the thickness of that lining influence our sensitivity from day to day. The thickness of the lining can be influenced by sickness (e.g., colds), or exposure to a variety of allergens or irritants (e.g., pet dander, dust, smoke, perfume, spicy foods). Therefore, judges need to take into account their current levels of sensitivity, given their health and exposure to substances that could interfere with their sense of smell. Finally, the olfactory cells become desensitized to repeated exposure to the same odors. As a result, a beer judge may be less able to detect subtle aromas as a judging session progresses. One way to remedy this problem is to occasionally take deep inhales of fresh air to flush the nasal cavity. Another way to lessen desensitization to certain odors is to sniff something that has a completely different odor (e.g., sniffing your sleeve) (Eby, 1993; Palamand, 1993).

Regardless of a judge’s ability to detect various odors in beer, that ability is useless if the judge cannot use accurately descriptive terms to communicate information to the brewer. Hence, it is important for beer judges to build a vocabulary for describing the variety of odors (and knowledge of the source of those odors). Meilgaard (1993) presents a useful taxonomy of beer-related odors. His organizational scheme categorizes 33 aromas into 9 overall categories (oxidized, sulfury, fatty, phenolic, caramelized, cereal, resinous, aromatic, and sour). Beer judges should make efforts to expand their scent recognition and vocabulary.

Notes on Tasting the Beer

The sense of taste is very similar to the sense of smell. Taste is the sense through which the chemical constituents of a solid are detected and information about them is transmitted to the brain. The molecules are detected by five types of taste buds that are on the tongue and throat; some areas of the tongue are more sensitive to certain basic flavors than others, but the commonly-referenced Tongue Taste Map has been debunked. For example, you can taste bitterness more towards the back of your tongue, but the entire tongue can taste it. The five basic tastes detected by the tongue are sweetness, sourness, saltiness, bitterness and umami (savoriness).

Since all of these flavors are present in beer, it is important that beer judges completely coat the inside of their mouths with beer when evaluating it and that the beer be swallowed. As is true for the scent receptors in the nose, different people have different densities of taste buds and, thus, have different sensitivities to various flavors. Also, taste buds can be damaged (e.g., being burnt by hot food or through exposure to irritants like spicy foods, smoking, or other chemicals), so a judge's sensitivity may be diminished until tastebuds can regenerate (about 10 days). Judges need to be aware of their own sensitivities and take into account recent potential sources of damage when evaluating beers. In addition, taste buds can be desensitized to certain flavors because of residual traces of other substances in the mouth. Therefore, it is best for judges to rinse their mouths between beers and to cleanse their palates with bread or salt-free crackers (Eby, 1993; Palamand, 1993).

Of course, as is true for the sense of smell, a judge's ability to taste substances in beer is useless unless that judge can accurately identify the substance and use appropriate vocabulary to communicate that information to a brewer. Meilgaard's (1993) categorization system for beer flavors includes 6 general categories (fullness, mouthfeel, bitter, salt, sweet, and sour) consisting of 14 flavors that may be present in beer. Judges should continually improve their abilities to detect flavors that are in beer, their abilities to use appropriate words to describe those perceptions, and their knowledge of the sources of those flavors so that brewers can be provided with accurate and informative feedback concerning how to improve recipes and brewing procedures.

Notes on Making Comments about Beer

There are five things to keep in mind as you write comments about the beers you judge. First, your comments should be as positive as possible. Acknowledge the good aspects of the beer rather than focusing only on the negative characteristics. Not only does this help make any negative comments easier to take as a brewer, but it gives your evaluation more credibility. Second, and related, be polite in everything that you write about a beer. Sarcastic and deprecating remarks should never be made on a scoresheet. Third, be descriptive and avoid using ambiguous terms like "nice." Instead, use words to describe the aroma, appearance, and flavors of the beer. Fourth, be diagnostic. Provide the brewer with possible causes for undesirable characteristics, and describe how the recipe or brewing procedure could be adjusted to eliminate those characteristics. Finally, be humble. Do not speculate about things that you do not know (e.g. whether the beer is extract or all-grain), and apologize if you cannot adequately describe (or diagnose) characteristics of the beer that are undesirable.

Other Considerations

Before the Event

Before a judging event, you should take steps to mentally and physically prepare yourself. Thoroughly familiarize yourself with the style(s) that you will judge if you know what those styles are ahead of time. Sample a few commercial examples and review the style guidelines and brewing procedures for those styles. Also, come to the event prepared to judge. Bring a mechanical pencil, a bottle opener, a flashlight, and any references that you might need to evaluate the beers. Also, make sure to come to the event in the right frame of mind. Get adequate rest the night before; shower; avoid heavily scented soaps, shampoos, and perfumes; avoid eating spicy foods and drinking excessively; and avoid taking medication that might influence your ability to judge (e.g., decongestants). You can also prepare your stomach for a day of beer drinking by drinking plenty of water and eating a dinner that contains foods that contain fats the night before the event and by eating extra sugar the morning of the event (e.g., donuts) (Harper, 1997).

Fatigue & Errors

During a judging flight, it is important to keep in mind that errors can creep into your judging decisions as a result of fatigue (palate or physical), distractions, or the order in which beers are presented. More specifically, judges may tend to assign scores (central scoring) in a much narrower range as time progresses simply because palate fatigue causes the beers to taste more and more similar over time. Conversely, judges may assign one or two beers much higher scores than other beers simply because they stand out as being much more flavorful (extreme scoring). In addition, as judges become tired (and possibly intoxicated) during long flights, they may allow impressions of some very noticeable characteristics of particular beers to overly influence their perceptions (and scores) of other characteristics of the beers (halo effect). For example, a weizen that is too dark may (falsely) also seem too heavy and caramel-flavored. Also during long flights, judges need to be mindful of the fact that proximity errors (e.g., assigning scores that are too high to a beer that follows a poor example of the style) and drift (e.g., assigning progressively lower (or higher) scores to beers as time progresses) may influence the validity of the scores that they assign (Wolfe, 1996; Wolfe & Wolfe, 1997).

Unfortunately, it is nearly impossible to know when errors such as these have crept into your judgments. Therefore, it is extremely important to retaste all of the beers in a flight, especially the ones in the top half of the flight. In general, most flights should contain less than 12 beers, so this would entail retasting at least the 6 that receive the highest scores. Each beer should be carefully reevaluated to make sure that the rank ordering of the assigned scores reflects your overall impression of the actual quality of the beers. Only after retasting and a discussion of these impressions should awards be assigned to beers within the flight. Note that the competition coordinator may request that you readjust your scores to reflect any discrepancies between the ordering of awards and the ordering of assigned scores.

When You Are Finished

When you have finished judging a flight of beers, make sure that your scoresheets are complete, that the scoresheets have been organized in a way that the competition organizer can identify the scores and the awards that you assigned, and that the table at which you judged is ready for another judging flight or that (following the final flight of the day) it is cleaned. Most importantly, avoid causing distractions to other judges who have not yet finished judging their flights (e.g., loud conversations, interrupting judges who are still making decisions, etc.). In fact, this would be a good time to leave the judging area for a beer or a breath of fresh air. Also, be conscientious in what you say to others about the beers that you judged. It is often tempting to tell others about the worst beer in your flight or to make remarks about the overall poor quality of entries that you judged. Not only are comments such as these in poor taste, but since you do not know who entered the beers that you judged, you may offend the person to whom you are talking (or judges who are still judging).

Practicing

Of course, one of the best (and most enjoyable) things that you can do to maintain your judging skills is to continually practice by sampling a variety of beers and brewing your own beers. In addition to visiting pubs and microbreweries, you can sample homebrew regularly by attending homebrew club meetings. Entering beers in competitions is also a practical way to compare your flavor perception and troubleshooting skills with those of experienced judges. You can also brush up on your judging skills by coordinating tasting sessions and mini-competitions with other judges or by sampling beers that have been “doctored” to simulate common flavors and flaws in beer (Wolfe & Leith, 1997). Dr. Beer ®

is a commercial example of this program, but several authors have described methods for preparing beers using readily-available ingredients (Guinard & Robertson, 1993; Papazian & Noonan, 1993; Papazian, 1993). Guidelines for a doctored beer session are also given at the end of the BJCP Exam Study Course later in this section.

References and Additional Reading

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B. Three-Tier BJCP Exam Structure

The path towards becoming a BJCP judge has three milestones. The first is passing an online Entrance Examination, which evaluates whether one is sufficiently ready to sit for a practical judging exam. When judges pass that exam with a score of least 80%, then if they also have at least 10 judging experience points, they may take a Written Proficiency Exam which qualifies them for the National and Master judging levels if they score sufficiently high. The following focuses on the beer judging exam, but the basic process is applicable to the mead judging exam and the cider judging exam in development.

The **BJCP Beer Judge Entrance Examination** consists of 180 questions to be answered in a 60 minute time period. There is mixture of multiple choice, true-false and multiple answer questions which are designed to test a prospective judge's knowledge of beer styles, beer characteristics and the brewing process. This entrance exam must be passed to enable a prospective judge to take the BJCP Expanded Judging Examination. The key reference for the style-related questions is the BJCP Style Guidelines, and prospective judges are encouraged to become very familiar with this document before attempting the entrance exam. The 180 questions are drawn from a large pool of questions so each examination will potentially be different. The BJCP does not intend to publish the list of questions in the pool as that will invalidate the quality of the examination – a published pool would be too easy to query for answers without the examinee actually learning the material. The BJCP will monitor for questions that are made public and will work to remove said questions from the examination pool.

The **BJCP Beer Judging Examination** is closed book and requires the judging of six beers as if one were at a competition, with the scoresheets evaluated on the basis of scoring accuracy, perception, descriptive ability, feedback and completeness. Grading is done by volunteer National and Master judges, with their scores and feedback reviewed by both a BJCP Associate Exam Director and a BJCP Exam Director. These reviews ensure that the scores from different exams and graders are consistent between different exams and with the criteria expected for the different judging levels.

The **BJCP Beer Judge Written Proficiency Examination** is closed book and consists of two sections. The first section tests familiarity with the BJCP and the judging process, consists of 20 true/false questions about judging and the organization. Correct answers earn no points, but each incorrect answer results in a 0.5 point deduction from the overall exam score. On the second section there are five essay questions; there are two questions covering beer styles, one is a recipe question, and two questions covering brewing techniques, with the latter focusing on the relationship of ingredients and the brewing process to flavors in the finished beer. The style questions ask for descriptions and comparisons of related beer styles, including information on the historical development, ingredients, style parameters, commercial examples and the brewing process. These questions are drawn from the same set of questions that was used for the essay portion of the **BJCP Legacy Beer Examination**. The questions in section two are each worth 20 percent of the total exam score. See the following two sections of this document for a list of the BJCP exam questions and an example of an answer with enough content and depth to receive a very high mark.

The exam is criteria-based, so if the essay questions are not answered correctly or do not contain enough information (a good rule of thumb is two pages per answer), then it will be difficult to get a passing score on the written portion. Similarly, if the descriptions and feedback on the beer scoresheets are weak, it will be difficult to pass the tasting portion. The recommended materials should therefore be read before the study sessions and reviewed along with the BJCP Study Guide before the exam. The style categories in the questions below are based on the BJCP Guidelines, which are also used by the AHA for its national homebrew competition.

The following is from the instructions to the BJCP exam. It clearly states what a complete answer to the typical exam question should contain.

> *For a passing score, beer style descriptions must include the aroma, appearance, flavor, and mouthfeel descriptions as in the BJCP Style Guidelines. If time permits, for maximum credit, a more complete answer should consider the history of the style, geography, commercial examples, style parameters, unique ingredients, and fermentation techniques and conditions. When a question asks for a classic commercial example of a style the correct answer is one of the styles listed in the BJCP Style Guidelines.*

Although we have never had a real problem in this regard, it is BJCP policy to protect the integrity of the BJCP exam. Modern electronic devices make it too difficult for an exam administrator to be certain people aren't cheating, so exam instructions now include the following:

Use of the following electronic devices are not allowed during the exam:

- Calculators, except for basic four-function models
- Pagers
- PDAs
- Laptop or desktop computers
- Cell phones (In case of an emergency, phones may be left with the Administrator with instructions for answering.)
- Walkman/iPod or other listening devices
- Headphones of any type

Examinees with any special needs are required to contact the Exam Director to work out specific procedures a minimum of 6 weeks in advance of the exam date.

Overview of the BJCP Entrance Exams

The first step in joining the BJCP and becoming a judge is to take and pass one of the BJCP Entrance Exams (beer, mead, or cider). The entrance exam is an online qualifier that allows you to register for a judging exam. Passing an entrance exam does not grant BJCP membership; a judging exam must be passed. The online entrance exam is hosted on an external service. Visit bjcp.coursewebs.com to create an account on the web site, purchase an exam, and take the test. Free practice exams are also available.

The BJCP Entrance Exams have a 60 minute time limit. The number of questions presented varies by exam type.

- The **BJCP Beer Judge Entrance Exam** has 180 questions.
- The **BJCP Mead Judge Entrance Exam** has 200 questions.
- The **BJCP Cider Judge Entrance Exam** is currently under development.

The BJCP supports exams given in English, Spanish, Brazilian Portuguese, and Simplified Chinese. Support for other languages is under consideration. An extended time version is available upon request for prospective judges whose native tongue is not one of the available languages.

Please allow for the full 60 minute time block to complete the exam since the clock will be running even if you are not actively answering questions. The questions are a mixture of True-False (TF), Multiple-Choice (MC), and Multiple-Choice-Multiple-Answer (MA) formats. There will always be a "best" answer for the MC questions, and the MA questions will always have at least one answer that is correct. There is no partial credit for MA questions; all correct answers must be selected.

Exam Fees

The BJCP price applies to those people who are a BJCP member (people who have taken a Judging Exam, and who have received a five-character BJCP ID). All others (including those who have only passed an entrance exam and who only have a four-digit certificate number) pay the Non-BJCP price.

Exam Type	BJCP Price	Non-BJCP Price
BJCP Beer Judge Entrance Examination	US$10	US$10
BJCP Mead Judge Entrance Examination	US$10	US$10
BJCP Cider Judge Entrance Examination	US$10	US$10
BJCP Beer Judging Examination	US$15	US$40
BJCP Beer Judge Written Proficiency Examination	US$25	N/A
BJCP Mead Judging Examination	US$15	US$40
BJCP Cider Judging Examination	US$15	US$40

The online beer entrance examinations also have a 3-for-2 option (three exams for the price of two). Other types of exams do not currently have a similar discount for multiple attempts.

Registering for an Entrance Exam

When you visit the coursewebs site, click on the **Course Catalog** link at the bottom of the page to select the exam you want (type and language). Add the desired exams to your cart, then **Checkout** to purchase the exams. Be sure you have selected the correct course (especially language). If you make a mistake in your exam selection, please contact the Exam Directors immediately before you purchase a second exam. We cannot issue refunds, but will be happy to move your registration to the exam type and language you intended to purchase.

You will be prompted to create an account on the coursewebs site, or to login to an existing account. If you are creating a new account, you will be asked to supply contact information which will be incorporated into our database. It is important that this information is accurate – particularly your email address. After completing the registration, you will be prompted to pay for the exam using a credit card through a secure server. Once payment is accepted, you can launch the Entrance Exam. If you have any questions, please contact the [Exam Directors](#) ***before*** you launch the exam since the 60 minute clock cannot be restarted. Good luck!

Studying for the Entrance Exam

Do not take this exam without studying; you will be wasting your money. Please review the BJCP Beer Judge Entrance Exam Study Guide below, which focuses on the beer exam but is applicable to the other entrance exams. The remainder of this study guide and the Style Guidelines for the type of exam you wish to take should be your primary study materials. It would also be helpful to become familiar with the BJCP Judge Procedures Manual.

Copyright Notice

Please note that the entire question pool is copyrighted by the BJCP. The questions are not allowed to be published or copied without the express written consent of the BJCP. BJCP members violating this copyright may be sanctioned.

C. BJCP Beer Judge Entrance Exam Study Guide

Introduction

To pass the BJCP Beer Judging Entrance Exam, 116 (64%) of the total questions must be answered correctly. The scores on the entrance exam are only based on the number of correct answers; there is no penalty for incorrect or missing answers. The exam is also open-book, which means that those taking the exam can access the BJCP Beer Style Guidelines and other materials during the exam. Many examinees will find it challenging to answer all 180 questions, but the format has proven to be a valuable tool for probing gaps in the examinee's knowledge of beer styles, beer characteristics and aspects of the ingredients and the brewing process that are relevant to judging beer. If passing the entrance exam proves to be a challenge, the prospective judge may not be sufficiently prepared to provide score sheets that encompass the five components that are evaluated on the BJCP Beer Judging Exam: perception skills, scoring accuracy, descriptive terminology, accurate and constructive feedback, and completeness.

References

The primary study materials are listed on the first page of the Report to Participant Form that judges receive after taking the BJCP Beer Judging Exam. The ones listed in the first group below include a useful one page summary of common beer faults and introductory books on homebrewing:

- The 2015 BJCP Style Guidelines (https://www.bjcp.org/docs/2015_Guidelines_Beer.pdf)
- BJCP Study Guide (https://www.bjcp.org/docs/BJCP_Study_Guide.pdf)
- Beer Fault List (https://www.bjcp.org/docs/Beer_faults.pdf)
- *How to Brew*, by John Palmer (http://howtobrew.com)
- *Dave Miller's Homebrewing Guide* and *The Complete Handbook of Home Brewing*, by Dave Miller

We also recommend reading Michael Jackson's Beer Companion, which is somewhat outdated but is a good reference for the terminology that is used to describe the many historical beer styles. Prospective judges with more brewing experience or technical backgrounds can - and should - supplement their study with the following references:

- *Designing Great Beers*, by Ray Daniels
- *New Brewing Lager Beer*, by Greg Noonan
- *Principles of Brewing Science*, by George Fix
- *Brewing Better Beer: Master Lessons for Advanced Homebrewers*, by Gordon Strong

The material in these references encompasses every question on the BJCP Beer Entrance Exam, and studying them should enable anyone to achieve a passing score as long as they retain a reasonable amount of the information. Another key element for successful study is to taste and ideally judge beers (using the BJCP Beer Scoresheet) to better understand how the written descriptions in the BJCP Beer Style Guidelines manifest themselves in the actual flavor and aroma of the beer.

Question Types and Categories

The remaining 160 questions on each exam focus on beer styles (57.5%), beer characteristics (22.5%) and processes and ingredients (20%). The content of these questions is based on the questions that appeared on the essay portion of the legacy BJCP exam and now form the base for the BJCP Written Proficiency Exam. The breakdown of the question types is:

- True/False (TF): 92
- Multiple Choice (MC): 54
- Multiple Answer (MA): 24

The table below presents a more detailed breakdown of the question types and categories that are used to generate the questions on each randomly generated online exam.

It's helpful to analyze these question counts to indicate what level of preparation is needed to pass the exam. If all of the BJCP Program questions are answered correctly, then completely random guesses on the TF (50% probability) and MC (20% probability with five possible answers) will yield an overall score of (20+46+11)/180 = 43%. While we do occasionally see scores at this level or lower, random guessing is not a viable strategy for passing an open-book exam. However it does illustrate that random guessing can propel an examinee to 2/3 of the score required for passing.

With a reasonable amount of study, prospective judges should be able to narrow down the answers to most of the MC questions to two possibilities (50% probability if guessing) and improve the success rate on the TF questions to 75%. These adjustments correspond to an overall score of just over 64%, which is exactly what is needed to pass the entrance exam. Also remember that the entrance exam is open-book, which means that the BJCP Style Guidelines and the BJCP Study Guide can be accessed during the exam to narrow down the number of possible answers. However, attempting to take the entrance exam without a reasonable amount of preparation will force the examinees to spend too much time thumbing through the references to find the correct answers. This approach will likely not provide them with enough time to attempt to answer all 180 questions on the exam.

Category	TF	MC	MA
BJCP Program/Ethics	20		
Belgian and Sour Ales	4	4	
Brown and Dark Ales	8	4	
English and American Ales	4	4	
Lagers	8	4	
Wheat Beers	4		
IPAs and Strong Ales	4		
Pale Ale Comparison	6		
Dark Ale Comparison	6		
Lager Comparison	6		
Mixed Style Comparison	6	8	12
Beer Characteristics	24	12	
Process and Ingredients	12	8	12

Each of the multiple-answer questions on the exam begin with the phrase "Check all that apply." There are only 24 questions of this type on each online exam, so it is quite easy to pass without even reading or answering them (which is one possible strategy). But many prospective judges enjoy the challenge of trying to answer questions which require more thought, and we include them on the entrance exam because one purpose of an exam is to test what is not known or understood. Closing these gaps will help prospective judges be better prepared for the BJCP Beer Judging Exam. In terms of exam-taking strategy, the wording to the correct answer to the MA questions relating to beer styles is closely matched to the BJCP Style Guidelines, and the incorrect answers include one or more characteristics which are regarded as stylistic flaws.

Questions on BJCP Ethics, Levels and the Judging Process

Twenty questions of each online exam are randomly selected from the 124 True/False questions and accompanying answers that are listed in the BJCP Study Guide. Given that these questions pertain to the program that aspiring judges want to join, there is little excuse for missing any of these questions. The examinee should also be able to answer these questions fairly quickly, which leaves more time to answer the questions on beer styles and the impact of the brewing process on beer characteristics.

Questions on Beer Styles

The questions on beer styles are based on the first 26 styles in the 2015 BJCP Beer Style Guidelines, so the Historical, Smoked and other beers in styles 27-34 do not need to be part of the study materials. The exam questions also focus on the styles that are more common in homebrew competitions as well as those that frequently served during the BJCP Beer Judging Exam. Three examples of the questions on beer styles are given below and should be straight-forward to answer for those who have some familiarity with the descriptions presented in the BJCP Beer Style Guidelines.

- (TF) Light malt sweetness is part of the flavor profile of a Belgian Blond Ale
- (TF) Diacetyl in a British Brown Ale is acceptable due to the yeast strain
- (TF) Decoction mash is the preferred brewing method for Dunkles Bock

The MC questions on beer styles, like the one given below, usually have one answer that is fairly obvious given the information in the BJCP Style Guidelines. The phrase “most appropriate” is also a key piece of information for this particular question.

- (MC) The hops most appropriate for Strong Bitter are: (a) Kent Goldings and Fuggles, (b) Styrian Goldings and Saaz, (c) Cascade, (d) Hallertauer and Tettnanger, or (e) Any low alpha acid varieties

Questions on Beer Characteristics

Most of these questions should be quickly answered by prospective judges who have a basic knowledge of the origin and control of the flavor descriptors that are listed on the left side of the BJCP Beer Scoresheet (https://www.bjcp.org/docs/SCP_BeerScoreSheet.pdf). It’s also helpful to know which styles are permitted to exhibit some of the common flavor characteristics such as diacetyl, DMS and astringency. Examples of TF and MC questions are given below to illustrate that one does NOT need to be a microbiologist to correctly answer the technical questions on the Entrance Exam.

- (TF) Beer that is light in body is thick and chewy
- (TF) Smoky is a flavor or aroma associated with phenols
- (TF) All IPA styles should have a harsh, hop-derived astringency
- (MC) A beer with a notable green apple aroma most likely has which flaw? (a) DMS, (b) Phenolics, (c) Acetaldehyde, (d) Tannins, or (e) Fusel alcohols

Questions on Ingredients and the Brewing Process

As with the questions on Beer Characteristics, the information needed to answer these questions can be found in the BJCP Study Guide or the references listed above. These questions are directed at aspects of the brewing process that impact beer characteristics, and knowing this linkage is sometimes useful when providing feedback to the brewer when judging. A few examples of TF and MC questions are provided below.

- (TF) All-grain brewers can decrease the body of their beer by increasing the mash saccharification temperature
- (TF) Weissbier yeast are typically lager strains
- (TF) Chloramines used to inhibit bacterial growth can produce off-flavors if not removed
- (MC) The typical duration of lagering is: (a) Two to six weeks, (b) Two to six hours, (c) Two to six days, (d) Two to six months, or (e) Two to six years

During the Exam

Questions are presented in groups of five on each page, but you may need to scroll down to access all the questions. At any time you can click on the **Summary** button to see which questions have not been answered (they will be colored red). If you want to temporarily skip a question, click on the **Mark** box near the question number to help identify questions to answer later.

After the Exam

Upon submitting your answers (or when the time limit has been reached), you will immediately be notified whether you passed or failed the exam. You will not receive a numerical score; only the pass or fail status. You will also get an email message with a list of topics on which your percentage correct was below the passing threshold. This feedback should be used to guide future study, regardless of whether you pass or fail.

Next Steps after Passing the Exam

Congratulations are certainly in order; this is not an easy exam. You will be emailed a certificate with your name, the date you passed the exam, and a certificate number. Please retain this email and certificate for your records; you will need a copy of the certificate when you register for a Judging Exam.

Next Steps after Failing the Exam

Not everyone passes the exam, but you are allowed to retake it as many times as needed. More study and preparation, including a careful review of the failing topic areas, is recommended. Retaking the exam immediately is also not recommended since you will not have sufficient time to address gaps in your knowledge of beer styles.

D. BJCP Beer Judge Written Proficiency Examination

The written proficiency examination consists of two sections: the BJCP ethics, levels and judging process section, and the essay portion.

Questions on BJCP Ethics, Levels and the Judging Process

The questions in this section are remedial for a BJCP judge eligible to take the **BJCP Beer Judge Written Proficiency Examination**. Any judge National or higher judge should know this stuff. It should take almost no time to answer these questions. **You get no additional credit for getting the answers correct but you can lose up to 10% of your essay score if you get them all wrong.** These questions based on the BJCP Judging Procedures Manual and the details on the requirements for the BJCP Judging Ranks. Each individual question answered incorrectly subtracts the equivalent of 0.5% from your total score, yielding a 10% deduction for a completely failing all 20 questions. We expect senior BJCP judges of the type eligible to take the **BJCP Beer Judge Written Proficiency Examination** to know this material, thus the penalty scoring. The 20 questions are drawn from the following pool of true/false questions:

Number	Answer	Question
1	T	A competition organizer may serve as the judge director and may also serve as a judge, provided this person has no knowledge of the association between entries and entrants[1].
2	T	A competition's judge director may serve as a judge, provided this person has no knowledge of the association between entries and entrants.
3	T	A competition organizer may serve as the judge director, provided this person has no knowledge of the association between entries and entrants.
4	F	A competition's judge director may not serve as a judge, even if this person has no knowledge of the association between entries and entrants.
5	F	A competition organizer may not serve as a judge, even if this person has no knowledge of the association between entries and entrants.
6	T	A competition's judge director may serve as the competition organizer and may also serve as a judge, provided this person has no knowledge of the association between entries and entrants.
7	T	An individual with knowledge of the association between entries and entrants may not serve as a judge.
8	F	A member of the competition staff with access to information that associates entries with entrants may serve as a judge, provided this person does not divulge information about entries and entrants to other judges.
9	T	The "head" judge at a table should try to tutor apprentice or lower-rank judges if time permits.
10	F	The steward at the table has sole responsibility for completing the Cover Sheets for beers in each flight.
11	T	The "head" judge at the table has sole responsibility for completing the Cover Sheets for beers in each flight.
12	T	The "head" judge at a table should fill out Cover Sheets for beers in his or her flight as directed by the competition management.
13	F	The "head" judge at a table has no responsibility for filling out Cover Sheets for beers in his or her flight unless directed to do so by the competition management.
14	T	The "head" judge at the table has sole responsibility for completing the Cover Sheets for beers in each flight but with the agreement of the steward may delegate the completion of the Cover Sheets to the steward.
15	T	The "head" judge, with the agreement of the steward, may delegate filling in of the Cover Sheets for beers in his or her flight to the steward.
16	F	There is no need for the "head" judge to complete the Flight Summary Sheet - the competition organizer can obtain all that information from the cover sheets.

[1] But the competition organizer can NOT receive judging experience points if they serve as a judge.

Number	Answer	Question
17	T	If possible, there should be at least one BJCP-ranked judge in every flight.
18	T	When Non-BJCP judges evaluate entries in a competition, each Non-BJCP judge should be paired with a BJCP judge.
19	T	Non-BJCP judges may only evaluate entries if authorized by the judge director, and Non-BJCP judges should be paired with BJCP judges when possible.
20	T	To reduce stray odors and flavors present, beverages and foods other than water, bread or crackers should not be brought to the judging table.
21	F	It is acceptable to bring food items other than bread, crackers, and water to the judging table.
22	F	You must filter out strong scents from fellow judges or the environment from your mind rather than discussing the problem with the competition organizer.
23	T	Strong scents from the environment or other judges or stewards should be brought to the attention of the competition organizer.
24	F	Because entries cannot have any identifying marks, it is OK for a judge to judge beers in a category he or she has entered.
25	T	If a judge is assigned to judge a category that he/she has entered, that judge should ask the competition organizer to reassign him/her to another category.
26	F	If a judge is assigned to a category that he or she has entered, the judge should go ahead and evaluate the entries in that category without notifying the judge director or competition organizer.
27	F	Judges should not review the style being judged from the BJCP Style Guidelines while at the judging table prior to judging that style.
28	T	Judges may invite stewards to taste the beers in a flight, if there's enough sample to share.
29	T	It is acceptable to change the order in which you judge the beers on your flight sheet from how it was printed.
30	F	Beers must be evaluated in the sequence specified on the flight sheet.
31	F	If you have eaten spicy or greasy food within a few hours prior to judging, you should use mouthwash or antiseptic rinse before judging.
32	T	You should avoid eating spicy or greasy food within a few hours prior to judging.
33	T	Spicy or greasy foods should be avoided prior to a judging event because they can reduce a judge's sensitivity to the aromas and flavors of beer.
34	T	Perfumed shampoos and colognes should be avoided prior to a judging event because they can reduce a judge's sensitivity to the aromas of beer.
35	F	It is a good idea to take a decongestant prior to a judging event to increase your sensitivity to the aromas of beer.
36	F	Calibrations beers are selected to be the standard against which entries should be judged.

Number	Answer	Question
37	T	It is the responsibility of the “head” judge, in consultation with the other judges in a flight, to assign a consensus score to each entry.
38	F	It is not necessary for scores produced by the judges on a panel to be within seven points (or less if directed by the competition director) of each other.
39	T	After discussing the initial scores, judges should adjust their final scores to be within seven points (or less if directed by the competition director).
40	T	Judges must adjust their scores to be within seven points (or less if directed by the competition director) of each other as part of developing a consensus score for the beer.
41	T	The consensus score assigned to the beer is not necessarily an average score.
42	T	When judging, It is important to evaluate entries quickly and also complete the score sheets thoroughly and completely..
43	T	On average, experienced judges should be able to completely evaluate a beer, including arriving at a consensus, in 10 minutes.
44	F	When there is a discrepancy in the scores for a given beer, the lower-ranked judges should yield to the opinion of the highest ranked BJCP judge at the table.
45	T	It is acceptable to remove offensive smelling entries from the judging table after they have been evaluated.
46	F	A judge must disqualify an entry if the bottle has raised lettering or the cap has identifying marks.
47	F	A judge may disqualify an entry if it has an improper bottle or cap.
48	T	Only the judge director or competition organizer can disqualify an entry.
49	T	The results of the bottle inspection does not affect the scoring.
50	T	Snide or rude comments are unacceptable on scoresheets.
51	T	Pour each entry in a manner that gives it its optimum appearance, keeping in mind that some entries may be over- or under-carbonated.
52	F	When you suspect an entry has been placed in the wrong flight based on the style being judged, you should request that it be judged in a different flight instead.
53	T	When you suspect an entry has been placed in the wrong flight based on the style being judged, you should consult with the judge director or competition organizer.
54	T	Sniff the entry immediately after pouring to ensure proper evaluation of volatile aromatics.
55	F	There is no need to sniff the aroma immediately after pouring the entry into the glass.
56	T	Judges should complete the evaluation of each entry before moving on to the next.

Number	Answer	Question
57	F	It is not necessary to offer any feedback for improvement if you score a beer above 40.
58	T	It is common practice to refrain from sharing your thoughts while judging a beer until the other judges have completed their scoresheet.
59	F	If you are very familiar with a beer style, it is preferable to disregard the BJCP Style Guidelines and rely on your personal expertise instead.
60	F	If rushed, it's acceptable to write only comments and an overall score on a scoresheet, leaving the scores for the subsections blank.
61	F	If rushed, it's acceptable to write only 1-2 comments on a scoresheet as long as the numeric score is filled out.
62	F	If a beer is a "gusher" or has an unpleasant aroma upon opening, a judge may assign a courtesy score of 13 without tasting and commenting on the characteristics of the beer.
63	T	All beers should be tasted and scored, even if they are "gushers" or have an unpleasant aroma upon opening.
64	F	It is appropriate to penalize the entrant if the beer is not served at the proper temperature.
65	T	If the beers are not served at the proper temperature, judges should work with the competition staff to resolve the problem.
66	F	In each section of a scoresheet, you should only comment upon the most prominent features of each entry, not subtle characteristics.
67	F	Judges' comments must not include phrases like "if you used .."
68	F	Judges' comments must not include phrases like "did you .."
69	T	Judges' comments must include a complete evaluation of the sensory aspects of the entry and how those aspects relate to the style guidelines.
70	T	Judges' comments should be constructive and reflect knowledge of the brewing, fermentation, bottling, and handling process.
71	T	Judges' comments need to provide information on how to improve the entry as warranted.
72	T	Scores should not be assigned to the aroma section immediately because the entry's aroma profile may change over time.
73	F	Each section must be scored with a number prior to writing any comments, to best capture your first impressions.
74	F	To assure objectivity, you should never write your full name or put contact information on the scoresheet.
75	T	You should write your full name and judging rank on each scoresheet.
76	T	You should always fill out the "Style Scales" on the scoresheet, as a good check against your scores.

Number	Answer	Question
77	F	You should use the “Overall Impression” section of the scoresheet to refer to how the entry compares to other entries in the flight.
78	T	You should use the “Overall Impression” section of the scoresheet to comment on how much you enjoyed the entry or provide suggestions for how to improve the beer.
79	T	A score in the "Outstanding" range is reserved for entries that not only lack flaws but also have the hard-to-define "extraordinary" character that great beers have.
80	F	The courteous lower limit for scores assigned to "Problematic" beers is 6 points, with one point for each section of the scoresheet.
81	T	The courteous lower limit for scores assigned to “Problematic” beers is 13 points.
82	F	If judges require more pours than one bottle to judge an entry, the “head” judge should ask the steward to request a second bottle from the cellar master[2].
83	F	It is preferable to use ink on scoresheets so that your scores and comments cannot be altered by contest personnel.
84	T	It is preferable to use mechanical pencils, rather than wooden pencils, on scoresheets so that wood odors do not interfere with beer aromas.
85	T	It is acceptable to request a second bottle to give the entry a fair chance at an accurate judging if a beer is a “gusher” or tastes infected.
86	T	Entrants may contact the judge, the competition director, or their BJCP Regional Representative if they are dissatisfied with any aspect of their scoresheets.
87	T	When your flight has finished, you should avoid having conversations that might distract other judges who have not yet finished their flights.
88	F	When your flight has finished, it is acceptable to visit other flights still in progress to see how beers you have entered are faring.
89	T	Because it may have been entered by a person in the room, it is polite to refrain from publicly deriding a “problem” beer that you have scored during a competition.
90	T	Judges from outside the table should not be consulted on a beer unless the judges at the table cannot reach a consensus score, and then only if they all agree to the consultation.
91	F	BJCP Apprentice judges have not yet taken the BJCP Beer Judging Exam.
92	T	Novice is not an official BJCP judge rank.

[2] The emphasis here is on learning to judge a beer with just a few ounces in your glass. Obviously, for a gusher you would request a second bottle if it was available but you should not ask for an additional bottle just because you are pouring too much.

Number	Answer	Question
93	T	One can obtain the BJCP Recognized rank without acquiring judging experience points.
94	T	One can obtain the BJCP Recognized rank without acquiring non-judging experience points.
95	T	To become a BJCP Certified judge, it is sufficient to pass the Entrance Exam, score at least 70% on the Beer Judging Exam and earn 5 judging points.
96	F	To become a BJCP Certified judge, it is sufficient to pass the Entrance Exam, score at least 70% on the Beer Judging Exam and earn 5 experience points.
97	F	The maximum score on the Beer Judging Exam for the BJCP Certified rank is 79%.
98	F	To become a BJCP National judge, it is sufficient to score 80% on the Beer Judging Exam and accumulate 20 experience points.
99	F	To become a BJCP National judge, it is sufficient to score 80% on the Beer Judging Exam and accumulate 20 experience points, with at least half of them from judging.
100	F	One can obtain the BJCP National rank without acquiring judging experience points.
101	T	One can obtain the BJCP National rank without acquiring non-judging experience points.
102	F	BJCP Master judges must have a minimum score of 90% on the combined written and tasting exams and at least 40 judging points.
103	F	BJCP Master judges must score at least 90% on the combined written and tasting exams and earn at least 50 experience points, with at least half of them from judging.
104	F	The maximum score on the combined written and tasting exams for the BJCP National rank is 89%.
105	F	BJCP Master judges must score at least 90% on the combined written and tasting exams and fulfill a Grand Master Service Requirement.
106	F	BJCP Grand Master judges must score at least 95% on the combined written and tasting exams.
107	T	BJCP Grand Master judges must score at least 90% on the combined written and tasting exams.
108	T	Each additional BJCP Grand Master level requires an additional 100 experience points.
109	T	BJCP Honorary Grand Master judges do not have to take the BJCP exam.
110	F	The BJCP Honorary Grand Master rank is bestowed upon professional brewers when they judge at homebrew competitions.
111	T	Honorary Master is a temporary rank bestowed on operatives of the BJCP.

Number	Answer	Question
112	T	The BJCP Grand Master rank requires the same minimum score on the combined written and tasting exams as the Master rank.
113	F	The BJCP Grand Master rank requires the same minimum experience points as the Master rank.
114	F	The only difference in requirements between the BJCP Master and Grand Master ranks is that the Grand Master rank requires a GMSR.
115	T	Each BJCP Grand Master level has additional requirements for exam grading.
116	T	A BJCP Grand Master Service Requirement can be fulfilled by grading exams.
117	F	A BJCP Grand Master Service Requirement can be fulfilled by organizing competitions.
118	F	A BJCP Grand Master Service Requirement can be fulfilled just by serving on the BJCP Board.
119	T	At least one-half of the experience points required for any BJCP judge rank must be from judging.
120	F	Judging at homebrew competitions is the only way to earn BJCP judging points.
121	T	BJCP judges can earn non-judging experience points for participating in BJCP Continuing Education Program activities.
122	T	Judging experience points can only be earned by judging in a competition or proctoring a BJCP exam.
123	F	Stewards at homebrew competitions earn BJCP judging points if they taste the beers with the judges.
124	T	Stewards at homebrew competitions earn BJCP experience points.

The Essay Portion of the Written Proficiency Examination

The remainder of the written portion of the exam consists of five essay questions, each worth 20% of the total essay score. They will be two Style questions, one question relating to Recipe formulation and execution, a question on Beer Characteristics and one question on Ingredients and the Brewing Process.

Beer Style Questions

For the style-related questions, the grading rubric for each answer is explicit in the exam question. The questions have the form:

S0. Describe, compare and contrast these three styles: *style-1*, *style-2*, and *style-3*. Your answer should address the following topics:

25%	**Compare and contrast** the three styles based on their ingredients, characteristics or background information (history, fermentation or serving methods).
10%	For each of the styles, name one classic **commercial example** as listed in the 2015 BJCP Style Guidelines.
15%	**Parameters:** Provide typical values or ranges for the original gravity (OG), IBU, ABV and color (SRM or textual description) of the three styles.
50%	**Describe** the aroma, appearance, flavor and mouthfeel of each style according to the BJCP Beer Style Guidelines.

The style groupings for question S0 are drawn from the following list. The ID column is for internal use and does not appear on the exam. When the exam is updated and a pairing is deleted, the ID is not reused, and new pairings are assigned new IDs.

ID	*Style-1*	*Style-2*	*Style-3*
1	American Amber Ale	American Brown Ale	American Pale Ale
2	American Amber Ale	American Pale Ale	California Common
3	American Barleywine	Double IPA	English Barleywine
4	American Barleywine	English Barleywine	Wee Heavy
5	American Barleywine	Old Ale	Wee Heavy
6	American Brown Ale	American Pale Ale	California Common
7	American Brown Ale	British Brown Ale	Dark Mild
8	Pairing removed		
9	American IPA	Double IPA	English IPA
10	American Pale Ale	Belgian Pale Ale	Strong Bitter
11	American Pale Ale	English Barleywine	Wee Heavy
12	American Stout	Foreign Extra Stout	Irish Stout
13	American Stout	Irish Stout	Oatmeal Stout
14	American Stout	American Porter	Irish Stout
15	American Stout	Irish Stout	Sweet Stout
16	American Stout	Foreign Extra Stout	Oatmeal Stout

17	American Porter	American Stout	Foreign Extra Stout
18	American Stout	Foreign Extra Stout	Sweet Stout
19	Pairing removed		
20	Pairing removed		
21	American Wheat Beer	Lambic	Weissbier
22	American Wheat Beer	Weissbier	Witbier
23	Baltic Porter	Belgian Dark Strong Ale	Imperial Stout
24	Belgian Blond Ale	Belgian Dubbel	Belgian Tripel
25	Belgian Blond Ale	Belgian Golden Strong Ale	Belgian Tripel
26	Belgian Blond Ale	Belgian Pale Ale	Saison
27	Belgian Dark Strong Ale	Double IPA	Wee Heavy
28	Belgian Dark Strong Ale	Belgian Dubbel	Weizenbock
29	Belgian Pale Ale	Bière de Garde	Saison
30	Berliner Weisse	Flanders Red Ale	Lambic
31	Berliner Weisse	Gueuze	Lambic
32	Berliner Weisse	Weissbier	Witbier
33	Pairing removed		
34	Bière de Garde	California Common	International Amber Lager
35	Blonde Ale	Cream Ale	Kölsch
36	Pairing removed		
37	Czech Premium Pale Lager	German Pils	International Pale Lager
38	American Lager	Czech Premium Pale Lager	German Pils
39	American Porter	English Porter	Irish Stout
40	Pairing removed		
41	British Brown Ale	English Porter	Munich Dunkel
42	English Porter	Munich Dunkel	Schwarzbier
43	Pairing removed		
44	California Common	Irish Red Ale	Märzen
45	Pairing removed		
46	Cream Ale	Kölsch	Munich Helles
47	International Dark Lager	Munich Dunkel	Schwarzbier
48	Doppelbock	Eisbock	Helles Bock
49	Doppelbock	Dunkles Bock	Eisbock
50	Doppelbock	Dunkles Bock	Helles Bock
51	Doppelbock	Dunkles Bock	Weizenbock
52	German Pils	German Helles Exportbier	Munich Helles
53	Foreign Extra Stout	Irish Stout	Sweet Stout
54	American Porter	Irish Stout	Schwarzbier

55	Pairing removed		
56	Dunkles Weissbier	Weissbier	Weizenbock
57	Altbier	International Amber Lager	Irish Red Ale
58	Altbier	International Amber Lager	Märzen
59	Altbier	Best Bitter	Märzen
60	Altbier	Märzen	Vienna Lager
61	Dunkles Bock	Eisbock	Helles Bock
62	English Barleywine	Imperial Stout	Wee Heavy
63	English Barleywine	Old Ale	Wee Heavy
64	Flanders Red Ale	Lambic	Oud Bruin
65	American Porter	Baltic Porter	Foreign Extra Stout
66	American Porter	Foreign Extra Stout	Sweet Stout
67	Fruit Lambic	Gueuze	Lambic
68	German Pils	Munich Helles	Schwarzbier
69	International Amber Lager	Irish Red Ale	Märzen
70	American Lager	American Light Lager	International Pale Lager
71	Dark Mild	Ordinary Bitter	Scottish Light
72	Pairing removed		
73	Munich Helles	Munich Dunkel	Märzen
74	Munich Helles	Märzen	Vienna Lager
75	Best Bitter	International Amber Lager	Märzen
76	Dunkles Bock	Märzen	Rauchbier
77	Scottish Export	Scottish Heavy	Wee Heavy
78	Dark Mild	Scottish Heavy	Scottish Light
79	Scottish Export	Scottish Heavy	Scottish Light
80	Ordinary Bitter	Scottish Heavy	Scottish Light
81	Scottish Heavy	Scottish Light	Wee Heavy
82	Scottish Export	Scottish Light	Wee Heavy
83	Pairing removed		
84	Best Bitter	Ordinary Bitter	Strong Bitter
85	Lambic	Weissbier	Witbier
86	Dunkles Bock	Märzen	Munich Dunkel
87	American Lager	American Wheat Beer	Cream Ale
88	American Light Lager	Czech Pale Lager	German Leichtbier
89	Festbier	Helles Bock	Munich Helles
90	Czech Amber Lager	Dunkles Bock	Märzen
91	American Pale Ale	Best Bitter	British Golden Ale
92	Australian Sparkling Ale	Best Bitter	British Golden Ale

93	Foreign Extra Stout	Irish Extra Stout	Irish Stout
94	Foreign Extra Stout	Sweet Stout	Tropical Stout
95	British Strong Ale	English Barleywine	Old Ale
96	American IPA	Belgian Golden Strong Ale	Belgian IPA
97	Pairing removed		
98	Pairing removed		
99	Pairing removed		
100	Pairing removed		
101	Pairing removed		
102	Pairing removed		
103	Pairing removed		
104	Pairing removed		
105	American Barleywine	American Strong Ale	Double IPA
106	Belgian Tripel	German Pils	Trappist Single
107	Czech Amber Lager	International Amber Lager	Vienna
108	Czech Pale Lager	Czech Premium Pale Lager	German Pils
109	American Barleywine	American Wheat Beer	Wheatwine
110	American Porter	American Stout	Imperial Stout

Recipe and Procedure Question

T14. Provide a complete ALL-GRAIN recipe and procedure for brewing a(n) <STYLE*>. Please use the table below to help organize your response.

15%	**Style Description:** Provide a brief description of the of the target style according to the 2015 BJCP Style Guidelines.
15%	Provide the **target parameters** for your recipe, including starting batch size, specific gravity (OG), final specific gravity (FG), and bitterness in IBUs or HBUs, and color (SRM or a textual description).
40%	List the **ingredients**, explain why they are appropriate for target style, provide their quantities, and explain how the quantities were calculated.
30%	Discuss the complete **brewing procedure** from mashing through packaging, and give style-based reasoning to support each aspect of the process.

**Styles may include:*

Belgian Tripel
Doppelbock
American Porter
Irish Stout

Märzen
American IPA
Weissbier
Strong Bitter

Festbier
Czech Premium Pale Lager
German Pils
Double IPA

Beer Characteristic Questions

T1. Describe and discuss the following beer characteristics: a) *characteristic-1*, b) *characteristic-2*, and c) *characteristic-3*. Your answer should address the following topics:

30%	Describe each characteristic and how it is perceived.
40%	Identify the causes and controls for each characteristic.
30%	Identify styles in which each characteristic is appropriate and inappropriate.

The choices will be drawn from:

a) cloudiness
b) buttery
c) low head retention
d) astringency
e) phenolic
f) light body
g) fruitiness
h) sourness
i) cooked corn
j) bitterness
k) cardboard
l) sherry-like
m) acetaldehyde
n) alcoholic

T3. What are *body* and *mouthfeel*? Explain how the brewer controls body and mouthfeel in the beer, addressing the following topics:

40%	Define body, describe how is it perceived, discuss how the brewer controls the body of the beer, and provide examples of styles in which is is desirable to have a light or full body.
45%	List three aspects of Mouthfeel (excluding Body), describe how they are perceived, and discuss how the brewer can control these characteristics.
15%	Provide examples of styles in which each of these three Mouthfeel characteristics is appropriate.

Ingredient Questions

T4. Discuss hops and their role in determining beer flavor and aroma. Your answer should address the following topics:

30%	Describe hop characteristics and their impact on beer flavor and aroma.
30%	Discuss how the hop characteristics are extracted.
40%	Identify five distinct beer styles with which specific or historical varieties are associated.

T8. Discuss the importance of water in the brewing process. Your answer should address the following topics:

20%	Discuss two characteristics of water that are important for the brewing process.
20%	Summarize two methods brewers use to adjust and control the pH of their brewing water.
60%	Discuss how the mineral content of the water played a role in the development of four world beer styles.

T15. Discuss the role of malt and yeast in determining beer characteristics. Your answer should address the following topics:

45%	Identify and describe different types of malts by their colors and the flavors they impart to the beer.
20%	List four distinct beer styles with which specific malts are associated.
35%	List five distinct yeast strain selection considerations and describe their impact on the finished beer.

Brewing Process Questions

T9. Define these brewing techniques and discuss their effects on the finished beer: a) *kräusening*, b) *adding gypsum*, and c) *fining*.

30%	Kräusening
30%	Adding gypsum
40%	Fining

T11. Define *diastatic* and *proteolytic* enzymes, discuss their roles in the brewing process and describe how they affect the characteristics of the finished beer.

20%	Define each enzyme.
40%	Discuss their roles in the brewing process.
40%	Discuss how they impact the characteristics of the finished beer.

T13. Discuss the mashing process. Your answer should address the following topics:

50%	Explain what happens in the mashing process, including times and temperatures as appropriate.
30%	Identify and describe three mashing techniques.
20%	Discuss the advantages and disadvantages of each of the mashing techniques identified.

Example of a Complete Answer

Q: Describe and differentiate Abbey and Trappist beers. Give commercial examples of each[3].

A: The primary difference between Abbey and Trappist beers is that the latter is an appellation which restricts its production to the seven Trappist monasteries in the Low Countries. They are Chimay, Orval, Achel, Rochefort, Westmalle and Westvleteren in Belgium and Schaapskooi in the Netherlands. Abbey beers on the other hand, are brewed either at non-Trappist monasteries or by commercial breweries to which Abbeys have licensed their names. Commercial examples of these include Affligem, Leffe and Grimbergen.

Both Abbey and Trappist breweries are best known for the Belgian Dubbel and Tripel styles. The former is a moderately strong, flavorful beer with an OG in the 1.062-75 range, 6-7.6% alcohol, and enough hop bitterness to balance – approximately 15-25 IBUs. The color is generally deep ruby to brown, with caramelized candi sugar syrup or other unrefined sugars providing much of the color. The flavor is dominated by a rich malty sweet character with notes of chocolate, toast and/or caramel. It typically has moderate fruity esters reminiscent of plums, raisins and black currents and sometimes notes of bubble-gum, banana or red apple. The alcohol provides a supporting role, and should be soft without any hot or solvent character.

Belgian Tripels are much paler in color at 4-7 SRM, but have higher OG (1.075-85) and alcohol levels (7.5-9 %). The malts used are almost entirely pilsner, with light candi sugar syrup or pale adjuncts used to increase the alcohol content and prevent the beer from being too cloying. Hop rates are higher at 20-40 IBUs to balance the higher OG, and this style often has a low to moderate spicy or floral noble hop flavor and aroma. The fermentation character is more assertive in this style than in Dubbels and includes low to moderate phenols that provide spicy, peppery notes. The esters typically provide citrus notes and sometimes a slight banana character. The alcohol level can be as high as 9%, but the flavor should be soft and subtle without any hot or solvent character. Westmalle Dubbel and Tripel are classic examples of these styles.

Some Trappist breweries also produce beers which would better fit into the Belgian Dark Strong category due to high ester levels or unusual brewing procedures. These include Chimay Grande Réserve, Rochefort 8 and 10, and Westvleteren 12 – all of which have very distinctive signatures from the yeast. One of the most unusual beers in Belgium is made by Orval and is the only (readily available) beer brewed by that monastery. It has a moderate gravity in the 1.055-60 range, is dry hopped with Styrian Goldings and undergoes a secondary fermentation with a mixture of five yeast strains that includes *Brettanomyces*. As the beer ages, the flavors become more complex, picking up leathery/oaky and even phenolic notes from the yeast.

[3] This question is NOT used on the exam.

E. BJCP Exam Study Course

Originally created by Scott Bickham in 1995 for those preparing for the BJCP Legacy Examination. The syllabus is still completely applicable to the three tier BJCP Exam Structure implemented in 2012 and has been updated to conform the 2015BJCP Beer Style Guidelines.

The ten session course outlined below is a modification of ones that have been effective in preparing judges for the BJCP exam. One or two members of the study group are usually assigned to the task of collecting commercial and homebrewed examples of a given style. They should also prepare and distribute handouts that outline the background and characteristics of each style, as well as a technical topic relevant to the exam. All but one of the beers are then served blindly and discussed, with positive and negative attributes identified. After the tasting session, a technical topic concerning ingredients, the brewing process, or beer flavors is reviewed. Finally, the study group judges the remaining beer using the BJCP Beer Scoresheet, with a 15 minute time limit, and then compare comments and scores with those of the most experienced judges participating in the session.

The total time for each class should be approximately three hours, depending on the number of commercial examples and depth of the presentations and discussions. The commercial examples should be selected from the classic examples listed in the 2015 BJCP Beer Style Guidelines. The number of beers served in each class should be limited to 8-10, depending on the alcoholic strength and sample size, to prevent palate fatigue and promote responsible drinking. It should be easy to persuade local National and Master judges to lead or participate in the review sessions but the preparation work can also be divided among those studying for the exam.

Note that this type of course qualifies for experience points within the BJCP Continuing Education Program. Please refer to the BJCP web site for details: http://dev.bjcp.org/education-training/bjcp-training-portal/

Class 1. Pale Lagers: American Lager, Cream Ale, International Pale Lager, Czech Pale Lager, Czech Premium Pale Lager, German Pils, German Helles Exportbier, Munich Helles, Festbier, Helles Bock.

Technical topic: Malt, including the malting process, types, adjuncts, kilning and the styles with which different malts are associated.

Class 2. Amber and Dark Lagers: International Amber Lager, International Dark Lager, Czech Amber Lager, Czech Dark Lager, Vienna Lager, Kellerbier, Märzen, Munich Dunkel, Schwarzbier, Dunkles Bock, Doppelbock, Eisbock.

Technical topic: Water, including minerals, pH, hardness, adjustment, and the effect on the development of world beer styles.

Class 3. British Bitters, Pale Ales and IPAs: Ordinary Bitter, Best Bitter and Strong Bitter, British Golden Ale, Australian Sparking Ale, Blonde Ale, American Pale Ale, American Amber Ale, English IPA, American IPA, Specialty IPA.

Technical topic: Mashing, including types used for different beer styles, mash schedules and enzymes.

Class 4. Brown, Red and Scottish Ales: Mild, British Brown Ale, Scottish Light, Scottish Export, Scottish Heavy, Wee Heavy, American Brown Ale, Irish Red Ale, California Common.

Technical topic: Hops, including varieties, IBUs, hopping schedule and the association with different beer styles.

Class 5. Stout and Porter: Irish Stout, Irish Extra Stout, Sweet Stout, Oatmeal Stout, Tropical Stout, Foreign Extra Stout, American Stout, Imperial Stout, English Porter, American Porter, Baltic Porter.

Technical topic: Yeast and fermentation, including characteristics of different yeast strains, bacteria, by-products and relationship to world beer styles.

Class 6. Barleywines and Strong Ales: British Strong Ale, Old Ale, English Barleywine, Double IPA, American Strong Ale, American Barleywine.

Technical topic: Brewing procedures, including sparging, boiling, fining and carbonation methods. Reasons for each should be discussed, along with potential problems.

Class 7. German Ales and Wheat Beers: American Wheat Beer, Kölsch, Altbier, Weissbier, Dunkles Weissbier , Weizenbock, Wheatwine.

Technical topic: Beer Characteristics I, which includes a discussion of how positive and negative attributes are perceived and produced, the beer styles with which they may be associated and corrective measures. The flavor descriptors on the beer characteristic section of the BJCP Study Guide should be split into two sections.

Class 8. Strong Belgian and Trappist Ales: Belgian Blond Ale, Saison, Belgian Golden Strong Ale, Trappist Single, Belgian Dubbel, Belgian Tripel, Belgian Strong Dark Ale.

Technical topic: Beer Characteristics II.

Class 9. European Sour and Belgian Ales: Witbier, Belgian Pale Ale, Bière de Garde, Berliner Weiss, Oud Bruin, Flanders Red, Lambic, Gueuze.

Technical topic: Recipe formulation, including the selection of appropriate hops, malt, water, yeast and brewing procedure for different beer styles.

Class 10. Doctored beer seminar. This is an informative and practical method of learning how isolated flavors taste in beer. A clean lager is generally doctored with near-threshold amounts of compounds which either occur naturally in beer or mimic those that do. Examples include artificial butter for diacetyl, sherry for sherry-like oxidation, vodka for alcohol, almond extract for nuttiness, grape tannin for astringency, hop oils for hop flavor and aroma, and lactic and acetic acid for sourness. Recommended amounts are given in the table below. Note that some of these compounds have very strong flavors, so they should be diluted in water or beer before adding to the base beer. For example, a detectable amount of lactic acid is approximately 0.4 ml of 88% USP lactic acid to a 12 oz. (355 ml[4]) sample of beer. Since most of us do not have access to pipettes to measure such a small quantity, 1/8 tsp may be added to 3/8 tsp distilled water, and 1/3 tsp of this solution added to the reference beer. This is equivalent to adding 1/12 tsp times 5 ml/tsp, or approximately 0.4 ml of lactic acid.

Recommended amounts of several substances are listed in the table at the end of this section. For more information refer to the Focus on Flavors articles in Brewing Techniques, which are available online through www.morebeer.com for a modest fee. The base beer should be a clean light lager with a crown (non-twist-off) cap so that it can be resealed after doctoring. The amounts in the table below are

[4] The standard measure of canned and long-neck bottled beer in the United States.

appropriate in a 12 oz. (355 ml) sample, but may be scaled to larger volumes. Note that spices and other solids should be extracted in vodka, since the addition of dry substances to a carbonated beer will cause gushing. For the same reason, the beers and adulterants should also be chilled to the same temperature before combining.

The material in these classes can be comfortably covered in a time frame of three to five months, depending on the needs and experience of the study group. Shorter courses have the advantage of keeping the material fresh, while longer courses allow more intensive reading and reviewing in between classes. Note that the lead time required to schedule a BJCP exam is typically at least six months, so keep this in mind when planning the study sessions. For more information, e-mail may be sent to the BJCP exam directors at exam_director@bjcp.org.

Flavor	**Adulterant**	**Quantity**
Sour/Acidic	USP lactic acid	0.4 ml (1/3. tsp of solution of 1/8 tsp lactic acid plus 3/8 tsp distilled water)
Sour/Acidic	White wine vinegar	3/4 tsp
Bitterness	iso-hop extract	1 or 2 drops, to taste
Sweetness	sucrose (table sugar)	1/4 tsp dissolved in 1/2 tsp water
Astringency	Grape tannin	2 tsp of solution of 1/8 tsp tannin dissolved in 5 Tbsp water
Phenolic	Chloroseptic	0.4 ml (1/3 tsp of solution of 1/8 tsp Chloroseptic plus 3/8 tsp distilled water)
Clovelike	Clove solution	Make solution of 8 cloves soaked in 3 oz. (90 ml) of beer and add liquid to taste (about 4 tsp)
Sulfitic	Potassium metabisulfite[5]	Make solution of one tablet dissolved in 3 oz. (90 ml) of beer and add to taste (about 1/2 tsp)
Alcoholic	Ethanol	2 tsp (increases alcohol by 2.7%). 3 tsp vodka may also be used
Sherry-like	Dry sherry	3/4 tsp
Nutty	Almond extract	0.1 ml (1/8 tsp of solution consisting of 1/8 tsp almond extract plus 5/8 tsp. distilled water)
Papery/Stale	N/A	Open bottles to air, reseal, and keep at 100 °F (40 °C) or warmer for several days
Diacetyl	Butter extract	4-5 drops
Estery	Banana extract	6-7 drops
Lightstruck	N/A	Expose commercial beer in green bottles to sunlight for 1-3 days[6]

[5] Should not be tasted by persons with asthma or sulfite allergies.
[6] While lightstruck commercial examples can be readily found, lightstruck homebrew is extremely rare in competition settings.

III. BJCP STYLE GUIDELINES

A. Introduction

by David Houseman

The BJCP Style Guidelines use some specific terms with specialized meaning: “Category”, “Subcategory” and “Style.” When thinking of beer, mead and cider styles, the subcategory is the most important label—”subcategory” means essentially the same thing as “style” and identifies the major characteristic of one type of beer, mead or cider. The larger “categories” (or “style families” are arbitrary groupings of beers, meads or ciders, usually with similar character but some subcategories are not necessarily related to others within the same category. The purpose of the structure within the BJCP Style Guidelines is to group styles of beer, mead and cider for competition purposes; do not attempt to derive additional meaning from these groupings.

Historically, types of beers were a consequence of the local water, ingredients and technology available at the time. In most cases, brewers did not set out to develop a specific “style,” or type of beer. For example, the high sulfates in the hard water around Burton-on-Trent resulted in a drier flavor that accentuated the bitterness of well-hopped ales, while the soft water in Plzen enabled the brewers to produce a pale lager with a high hop bitterness and soft palate that would not be possible with hard water. Thus these classic styles were determined by the water of the region. Style guidelines also make distinctions between similar styles. There are a number of Pilsners brewed in Germany, and although there are variations, they can all be broadly classified in the German Pilsner style, but are sufficiently different from the Bohemian Pilsners to deserve a separate sub-classification in the beer taxonomy.

Beer styles are not static but change over time in history as ingredients, brewing technology and consumer demand change. For example, the IPA described in the style guidelines originated in the UK, but is now rarely brewed due to the high taxes imposed on beers of this strength. History and geography highly impact the development of brewing; it is important that BJCP judges have an understanding of these factors. The examinee should be able to discuss these factors on the exam and use this depth of knowledge when providing feedback to brewers.

The beers documented in the BJCP Style Guidelines are those that are most commonly brewed by homebrewers in the US. It is not a complete list of all known beers, even those available throughout the world today. This style guide is continually kept up to date as newer information is made available. Its purpose is to provide a definition of the commonly brewed beers which should be used by both the brewer and the judge as criteria against which each style is evaluated. The BJCP Style Guidelines are not intended to be the complete source of information for the prospective BJCP judge, although the latest edition is quite complete and thorough. It’s recommended that the potential judge read and study Michael Jackson’s New World Guide to Beer and Beer Companion, the *Classic Beer Style Series* and other sources of information to obtain a complete understanding of the history, geography, and characteristics of the beers described in the BJCP Style Guidelines. The BJCP Style Guidelines, however, should serve as an accurate, quick reference to the different types of beers.

Most of the figures for starting gravity (SG), percent alcohol by volume (v/v), International Bittering Units (IBU) and color (degrees Lovibond or SRM) are taken from one of several sources assimilated by the BJCP Style Committee, including brewers of well-regarded commercial examples.

To receive full credit for beer style questions on the BJCP exam, examinee should provide at least approximate SG and IBU ranges for the style and, where relevant, other parameters such as alcohol content.

It is strongly suggested that the section of this study guide providing sample exam questions pertaining to beer styles be read carefully. These provide an indication of the range and type of questions to expect on the BJCP exam. You will note that not only will you potentially be asked to "describe" styles but also to "differentiate" among them. In this case, it is expected that you will be able to compare the similarities and differences of the indicated styles. In almost all cases, the examinee is expected to provide relatively well known commercial examples of different styles requested on the exam. While the examinee may not have traveled to the respective countries to try local commercial beers or these beers may not be available in your area, it still is expected that you will have knowledge of the commercial examples from the BJCP Style Guidelines, Michael Jackson's books and other references.

LAGERS are produced using bottom-fermenting lager yeasts, *Saccharomyces pastorianus* (formerly known as *S. uvarum* or *S. carlsbergensis*). This family of yeasts works well at lower temperatures, generally between 45 and 55 °F (7 and 13 °C). This colder fermentation reduces or eliminates the production of esters and other flavor components, generally resulting in a cleaner tasting beer. During the fermentation and lagering process, at temperatures down to approximately 32 °F (0 °C), the lager yeast remains active, continuing to reduce fermentation by-products, resulting in a cleaner, mellower flavor in the finished beer. Lagers are a relatively new beer style, only produced commercially after the introduction of mechanical refrigeration in the 1800s.

ALES are produced using top fermenting ale yeast, *Saccharomyces cerevisiae*. These strains of yeast works at warmer temperatures and ferment out faster than their lager counterparts. Fermentation byproducts such as fruity, estery flavors are usually evident and make up a significant part of the ale profile. Ale yeast are usually temperature-sensitive and will flocculate and become dormant when lagered at cool temperatures for extended periods of time.

MIXED STYLES use one or more variations of temperature and yeasts, such as fermentation with ale yeast at colder temperatures, use of ale and lager yeasts in combination, use of lager yeasts at warmer, ale-like temperature, or use of special yeast strains.

BELGIAN STYLES are generally ales, but with sufficient differences in process and taste profile to warrant their inclusion as a separate style section. Some Belgian styles, such as the Lambics, use a combination of wild yeasts and various bacteria in their fermentation process.

The **SPECIALTY**, **CIDER** and **MEAD** categories should be understood by the potential BJCP judge since s/he will not know in advance which categories s/he may have to judge in an actual competition and a judge should be prepared to judge any category. However, they are not required knowledge for the BJCP Beer Exam.

The BJCP Style Guidelines were extensively revised in 2004, and a minor update was produced in 2008. The current style guidelines can be found on the BJCP Website in the Style Center: http://www.bjcp.org/stylecenter.php.

The BJCP Beer Exam only covers beer styles. No meads or ciders are on the exam. No fruit, spice or specialty beers are covered on the exam. A separate BJCP Mead Exam has been implemented, and a separate BJCP Cider Exam is planned for the future.

IV. INGREDIENTS AND THE BREWING PROCESS

A. Introduction

This section of the BJCP Study Guide is not intended to be a comprehensive discussion of ingredients and the brewing process, but rather a synopsis that contains enough information to earn National or Master level scores on the technical questions on the BJCP Written Efficiency Exam. Those questions are T4 (hops), T8 (water), T9-T11 (brewing process), T13 (mashing), T14 (all-grain recipe) and T15 (malt and yeast). Judges should review the references listed in Section I to obtain a more complete understanding of these topics.

B. Water

by Ginger Wotring, revised in 2017 by Scott Bickham

Water constitutes 85-95% of beer, with the remainder being compounds derived from malt, hops, and yeast. As a general rule, if tap water is drinkable, it may be used in brewing, although some mineral adjustments may be needed to mimic the water used in some historical beer styles. Most tap water is also treated with chlorine to inhibit bacterial growth, and this should be removed to produce high-quality beer. Note that the processes used to make reverse osmosis (RO) and distilled water strips out trace minerals such as iron, manganese, copper, and zinc, which are essential for yeast metabolism, so mineral water is often a better choice. Finally, most water contains very low concentrations of bacteria, so it must be sterilized by boiling at some point in the brewing process.

Alkalinity, pH and Hardness

Water is a solution of ions with negative (anions) and positive (cations) charges. The water molecules (H_2O) themselves are also partially dissociated into hydroxide (OH^-) and hydrogen (H^+) ions, and the *pH*, a chemical shorthand term referring to the concentration of hydrogen ions, indicates the relative concentrations of these ions. Neutral water has equal OH^- and H^+ concentrations corresponding to a pH of exactly 7. Lower pH values indicate a higher H^+ concentration and acidic water, while higher pH values correspond to a higher OH^- concentration and thus alkaline water. In brewing, the pH is determined by the hardness, alkalinity and buffering salts derived from the ingredients.

Alkalinity is a measure of the capacity of the dissolved anions to neutralize reductions in the pH value of the solution. The most important anion at the pH of brewing water and wort is bicarbonate (HCO_3^-), because HCO_3^- is the primary ion that determines the alkalinity of water. Bicarbonate reacts with Calcium (Ca^{+2}) ions when boiled to form a calcium carbonate precipitate and water:

$$Ca^{+2} + 2HCO_3^- = CaCO_3\ (ppt) + H_2O + CO_2\ (gas)$$

Boiling drives off CO_2, thus forcing Calcium and HCO_3^- ions from solution and reducing the alkalinity. *Permanent hardness* is a measure of the cations that remain after boiling and racking the water from the precipitate, and is primarily due to Ca^{+2} and Magnesium (Mg^{+2}) ions. These cations are permanent if they are derived from sulfate or chloride salts and temporary if they originate in carbonate or bicarbonate salts.

When a grist consisting of 100% Pils malt is mashed using distilled water, which has a pH of 7.0, the mash pH typically ends up between 5.7 and 5.8. This pH reduction is due to the enzymatic degradation of phytin in the malt to form phytic acid and calcium or magnesium phosphates, which precipitate. Most of the phytic acid combines with free Ca^{+2} to form more calcium phosphate, releasing hydrogen ions in the process. Most brewing water has enough calcium or magnesium for this process to regulate the mash pH to the target 5.1-5.5 range, which is appropriate for the breakdown of starches and proteins.

Some water supplies have too much alkalinity for this process to be effective, in which case the mash pH can be reduced to the proper level by adding lactic or phosphoric acid to the brewing liquor when brewing pale-colored beers. Another method of adjusting the mash pH is through the addition of acidulated malt, which is produced by using lactic acid generated by the naturally occurring lactobacillus on the grain. When using toasted, caramel and roasted malts to brew amber and darker-colored beers, the natural acidity of the malts can have a significant effect on the pH. For example, using a dark crystal or roasted malt for 20% of the grainbill can reduce the pH by 0.5, which is usually sufficient to bring it to the proper level for starch conversion. The need to include malts kilned at higher temperatures in the grist played a role in the development of several historical beer styles, as will be discussed below.

Ions in Brewing

The most important cation in brewing is calcium, which is essential for reducing the mash pH to the appropriate range. It also helps keep oxalate salts in solution (they form haze and gushing if they precipitate), reduces the extraction of tannins, and assists in protein coagulation in the hot and cold breaks. Magnesium ions participate in the same reactions, but are not as effective. Yeasts require 10-20 ppm Mg as a nutrient, but higher amounts give a harsh, mineral-like taste. Another cation is sodium, which accents the sweetness of beer at low levels, but tastes salty at higher concentrations. This salty-sweet character is part of the flavor profile of the Gose style.

The most important anion in brewing is bicarbonate (HCO_3^-), because it determines the alkalinity of the brewing water. Bicarbonate neutralizes acids from dark and roasted malts, reacts with calcium to reduce the hardness and promotes the extraction of tannins and coloring compounds. It is normally in solution with small amounts of carbonate (CO_3^{-2}) ions, but the bicarbonate is by far the most important component at typical pH values of water and wort. The sulfate (SO_4^{-2}) ion does not play a significant role in the brewing process, but accents hop bitterness and dryness at the high concentrations found in the waters at Burton-on-Trent. Another anion is chloride (Cl^-), which enhances sweetness at low concentrations, but high levels can hamper yeast flocculation.

Famous Brewing Waters

The ions described above are found in different concentrations depending on the source of the water, as shown in the table below for several major brewing centers (data is in ppm and taken from John Palmer’s *How to Brew*):

Mineral	Calcium	Magnesium	Sodium	Sulfate	Bicarbonate	Chloride
Plzen	10	3	3	4	3	4
Dortmund	225	40	60	120	220	60
Munich	109	21	2	79	171	36
Edinburgh	100	18	20	105	160	45
Vienna	163	68	8	216	243	39
Dublin	118	4	12	54	319	19
London	52	32	86	32	104	34
Burton	352	24	44	820	320	16

These water compositions have played an important role in the development of world beer styles. *How to Brew* provides a good linkage between the mineral content of these waters and historical beer styles that is summarized below:

Pilzn - The very low hardness and alkalinity allow the proper mash pH to be reached with only base malts. These characteristics, combined with the lack of sulfate, yields the rounded malt character and mellow hop bitterness of the Czech Premium Pale Lager style.

Dortmund – The higher level of all minerals in this city and other regions of Northern Germany enables brewers of the Dortmunder Export and German Pils styles to produce pale lagers that are bolder, drier, and lighter in color than their counterparts from the Czech Republic.

Munich and Edinburgh – The mineral profiles of the waters of these cities are remarkably similar. The darker malts used to brew amber and dark German lagers and Scottish ales balance the carbonates and acidify the mash, yielding a very smooth malt character. The relatively low sulfate content also provides a mellow hop bitterness.

Vienna - The level of calcium in the water of this city is too low to balance the bicarbonate level to achieve a sufficiently low pH when brewing pale colored lagers. However by kilning malt at higher temperatures, the malt developed more color and acidity, and this led to the birth of the reddish-amber colored Vienna lager style.

Dublin – The water from this city has an ever greater imbalance of calcium and bicarbonate than Vienna, and this led to creation of the Irish Stout style, which is brewed using a high percentage of roasted barley and malts. This style has a relatively high IBU level, but the finish is softened by the low levels of sodium, chloride and sulfate in the water.

London - The bicarbonate level of London water is nearly twice that of calcium, and brewers were forced to use a higher percentage of dark malts to balance the mash pH. The high sodium content and low sulfate content of the water help smooth out the flavor profile of brown British beers such as Dark Mild and English Porter.

Burton-on-Trent – The calcium and sulfate are both much higher than for any other city listed in the table above, but the calcium is nearly perfectly balanced by the bicarbonate. This enabled brewers to produce British Bitters which were lighter in color than the ales brewed in London. The high level of sulfate and low level of sodium produce an assertive, clean hop bitterness.

Water Adjustment

The waters at these brewing centers may be reproduced by adding various salts to locally available water. For additions meant to improve the buffering capacity of the mash, the volume of the water should be used. For salt additions to change the flavor profile of the finished beer, the target volume of the beer should be used. The most common salt additions are gypsum ($CaSO_4.2H_2O$ -- $CaSO_4$ hydrated with two water molecules), Epsom salts ($MgSO_4.7H_2O$), non-iodized table salt (NaCl), calcium carbonate ($CaCO_3$) and calcium chloride ($CaCl_2.H_2O$). The addition of gypsum and Epsom salts is known as Burtonizing, since it elevates the hardness and sulfate concentrations to levels similar to that found at Burton-on-Trent. Other salts may be used, but these are by far the most common additives in brewing.

Further Reading

1. Dave Miller, Dave Miller's Homebrewing Guide (Garden Way Publishing, Pownal, VT 1996).
2. Gregory J. Noonan, New Brewing Lager Beer (Brewers Publications, Boulder, CO, 1996).
3. George Fix, Principles of Brewing Science (Brewers Publications, Boulder, CO, 1989).
4. John Palmer, How to Brew (originally published in 2006).

C. Malts and Adjuncts

by Dave Sapsis

Barley Malt

Barley is the most common source of the fermentable sugars in beer. The barley kernel is the seed of a plant of the grass family, *Gramineae*. Barley malt is formed by sprouting barley kernels to a desired length, then stripping off the rootlets and kilning (drying) the kernels to a specific color. These kernels consist of a germ, which is the actual germinating portion, and the endosperm, which is the starch or reserve food source for the germinating embryo. Both are surrounded by the husk, which is almost all cellulose. The acrospire is the portion of the developing plant that will become the above-ground shoot. Growing from the germ, the length of the acrospire has historically been used as an index of malt progress. As germination proceeds, enzymes acting on both proteins and carbohydrates are activated and transformed. The degree of germination is called modification; modification usually refers to the degree to which the protein/gum matrix of the endosperm has been broken down, and the degree to which proteins have become soluble in water.

A variety of measures can be used to indicate the degree of modification of malt. It is important to recognize that while the malting process is designed to initiate enzyme development that will be used to catalyze mashing reactions, the effects of varying malting regimes is dependent on barley strain. While undermodified malts usually have a more complete set of enzymes, they also have more proteins that require additional enzymatic breakdown to avoid protein-polyphenol induced haze (i.e., chill haze). The goal of the maltster is to accomplish the appropriate degree of protein degradation and starch availability, while not allowing too much carbohydrate substrate to be used up in plant development. Thought of another way, the maltster tries to manage desirable malt characteristics while still maximizing the potential yield from the barley.

It has become increasingly difficult to find truly undermodified malt that requires extensive protein rests as part of the mashing schedule. Measured both as a function of soluble Nitrogen (Kolbach Index) and as coarse:fine difference in extract, most modern malts have undergone a high level of protein degradation and most of the formerly bound starch is free in the friable endosperm. While there is no *de facto* assurance that malt will be suitable for brewing to a particular style, it is beneficial to understand modern barley growing and malting practices.

Selection

Two types of barley are commonly used in brewing. They are distinguished by the number of fertile flowers on the heads along the central stem. Two-row barley (*Hordeum vulgare*) has only two of the six flowers on the head fertile and able to produce kernels. Six row barley has all kernels fertile. An intermediate variety, called four-row, is in fact a six-row variety. It is not widely used in brewing due to the high protein content of the kernels.

Two-row barley will have bigger kernels, and thus higher yield than six-row. It usually has a lower nitrogen and protein content and also has a lower husk content, which makes 2-row beers taste less grainy. Six row barley, however, generally gives more yield per acre and has a higher diastatic power (more enzymes), so it is the choice whenever large amounts of adjuncts are used. The extra husk content of six-row also aids in providing a lautering filterbed.

Malting

The process of malting is done to convert the large, insoluble starch chains of the endosperm to water-soluble starches, and to activate both the proteolytic and diastatic enzymes that will reduce the proteins and starches into desirable components in the mash. The most important enzymes for malting are debranching enzymes, which break 1-6 links in α-glucans, and β-amylase, which produces maltose units by breaking 1-4 links near reducing ends. During the germination phase, the cell walls are broken down by the cytase enzyme complex, which includes hemicellulases and the β-glucanases. This clears a path for other enzymes into the endosperm so that degradation can proceed more easily.

Malting is basically sprouting the grains to a desired modification. The acrospire grows from the germ end of the corn to the opposite end. The ratio of the acrospire length to the length is the degree of modification, expressed as a percent or ratio. A ratio of 1.0 is indicative of fully-modified malt. Such a malt will be low in protein content and will have the endosperm almost fully converted to water-soluble gum. However, the starch content and potential yield will be reduced through its consumption during the growth of the acrospire and the rootlets.

American and Continental malts are generally less modified. Continental malt is modified only to 50-75%, which retains more of the endosperm for fermentability and creates greater nitrogen complexity, but at the price of reduced enzyme activity. American six-row is also modified to between 50-75%, but the higher protein and nitrogen content of six-row gives greater enzyme strength. Both Continental and American malts require a protein rest (at ~122 °F, 50 °C) to degrade the albuminous proteins into fractions that can be both used to promote yeast growth and give good head retention.

The barley is steeped in 50-65 °F (10-18 °C) water for about two or three days, then allowed to germinate for six to ten days between 50 and 70 °F (10 and 20 °C). The acrospire will usually grow to 50% at about the sixth day of germination. At the end of germination, the malt is gradually raised in temperature to 90 °F (30 °C), held there for 24 hours to permit enzyme action, and then gradually raised to 120 °F (50 °C). It is held at this temperature for 12 hours to dry the malt, as it is essential that the malt be bone-dry before being heated to kilning temperatures to prevent the destruction of the enzymes.

Kilning

Kilning, or roasting the malt, combined with the degree of modification, determines the type and character of the grain. Vienna malts are low-kilned at around 145 °F (63 °C), British and American pale malts at between 130 and 180 °F (55 and 80 °C) and Czech malts are raised slowly from 120 to 170 °F (50 to 75 °C) to dry, and then roasted at 178 °F (80 °C). Dortmund and Munich malts are first kilned at low temperatures before the malt has dried, then the temperature is slowly raised to 195-205 °F (90-95 °C) for Dortmunder malt, and 210 to 244 °F (100-120 °C)for Munich malt. This process creates flavor and body-building melanoidins from amino acids and malt sugars. Amber malt is well-modified, and then dried and rapidly heated to 200 °F (95 °C). The temperature is then raised to 280-300 °F (140-150 °C) and held there until the desired color is reached.

Crystal and caramel malts are fully modified, then kilned at 50% moisture content. The temperature is raised to 150-170 °F (65-75 °C) and held for 1 1/2 to 2 hours. This essentially mashes the starches into sugars inside the grain husk. The malt is then heated to the final roasting temperature, with the time and temperature determining the Lovibond color index.

Chocolate and Black Patent malts are undermodified (less than 1/2), dried to 5% moisture, then roasted at 420-450 °F (215-230 °C) for up to two hours, depending on the degree of roastiness desired. The high heat helps degrade the starches, so no protein rest is require for these malts even though they are not fully modified. Malts kilned over smoky beechwood fires, as in Bamberg, pick up a rich, heavy smokiness (which is imparted to the beer) from the phenols in the smoke. Whiskey malt is made in a similar manner by smoking over peat fires.

Kilning at the maximum temperature is generally done only until the grains are evenly roasted. They are then cooled to below 100 °F (40 °C) and the rootlets removed. Malts should be allowed to rest for a month or so before being mashed.

Other Malted Grains

The most widely used malted grain besides barley is wheat, which is a key ingredient in German and American wheat beers and used in small quantities in others to improve head retention. It has sufficient diastatic power to breakdown its own proteins and starches, but since it does not have a husk, it is usually mashed with barley malt in order for an adequate filter bed to be formed during the lautering stage. The protein and β-glucan content of wheat is high compared to barley, so a more extensive mash schedule with an extended protein rest may be needed when large quantities are used. Other malted grains used in brewing include rye, oats and sorghum, but these are more commonly used in their raw forms.

Malt Content

The barley corn contains sugars, starches, enzymes, proteins, tannins, cellulose, and nitrogenous compounds for the most part. The starches will be converted into simple and complex sugars by diastatic enzymes during the mash. Proteins in the kernel serve as food for the germ. These are primarily reduced by proteolytic enzymes into polypeptides, peptides and amino acids. Since enzymes are proteins, the protein content of the malt is an indication of its enzymatic strength. Peptides of the B-complex vitamins are also present and necessary for yeast development. The phosphates in the malt are responsible for the acidification of the mash and are used by the yeast along with other trace elements during the fermentation.

Cellulose, polyphenols and tannins are present in the husk and can lead to harsh flavors in the finished beer if they are leached out by hot or alkaline sparge water. Fatty acids and lipids support respiration of the embryo during malting, but oxidative off flavors and low head retention may result if excessive levels are carried into the wort. Hemicellulose and soluble gums are predominantly polysaccharide in nature and for about 10% of the corn weight. The gums are soluble, but the hemicellulose must be reduced by the appropriate enzymes into fractions that permit good head retention, otherwise they may cause clarity problems in the finished beer.

Cereal Adjuncts

Unmalted cereal grains have been introduced into brewing because they offer a cheap source of carbohydrates and tend to make a minimal contribution to the wort protein level. They can therefore be used in conjunction with high-protein malts such as American 6-row to give a more fermentable wort and a less filling beer. The starches must be gelatinized before mashing, either by doing a preliminary boil in the double-mash procedure or by flaking them through hot rollers. The most common cereal grains are corn (flaked maize, refined corn grits, corn starch or corn grits), rice grits, sorghum (in Africa), flaked barley, flaked rye and wheat (hard red winter wheat or flaked wheat). The corn and rice adjuncts are used heavily in the American light lager styles, while raw wheat is a key ingredient in Belgian white and lambic beers.

Other Adjuncts

An adjunct is defined as any unmalted source of fermentables in brewing. These include corn and cane sugars, which provide a cheap source of sugar, but are fully fermentable and tend to yield more alcohol and dry out the beer. Honey is a common adjunct in specialty beers, and although it contributes some aromatics, the high sugar content tends to make a beer thinner and more alcoholic than its all-malt counterpart. To achieve a fuller palate, malto-dextrin syrup or powder may be used, but the dextrin content may also be increased by adjusting the malt bill or mashing procedure. Finally, adjuncts that add color, flavor and fermentables include caramel, molasses, maple syrup and licorice.

Color

Beer color is determined by the types of malts used, and is an important characteristic of any style. Two scales are used for color determination - the EBC scale used in Europe, and the SRM scale in the USA. Both scales go from low to high, with low numbers referring to lighter colors. For example, an American light lager would be around 2-3 SRM, a Pilsner between 2-5, an Oktoberfest in the 7-14 range, and a Dunkles Bock in the 14-22 range. Some stouts can be over 60 degrees in color and are essentially opaque. The beer color is primarily determined by the malt, but factors such as the intensity and length of the boil also play a role. For a detailed discussion of beer color, the reader is referred to Ray Daniels' three-part series on beer color that begins in the July/August 1995 issue of Brewing Techniques.

Further Reading

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3. George Fix, Principles of Brewing Science, pp. 22-47, 87-107 (Brewers Publications, Boulder, CO, 1989).
4. George and Laurie Fix, An Analysis of Brewing Techniques, pp. 10-14 (Brewers Publications, Boulder, CO, 1997).

D. Wort Production

by David Houseman and Scott Bickham

Mashing

The primary goal of mashing is to complete the breakdown of proteins and starches that was begun during the malting process. This is accomplished by several groups of enzymes that degrade different substrates during a series of rests at specific temperatures.

Acid Rest

With pale lager malts, this enzymatic degradation begins with the acid rest, where phytase breaks down phytin into calcium- and magnesium-phosphate and phytic acid. This helps acidify the mash when the brewing water has low calcium content and roasted grains are not part of the grist. This rest occurs at temperatures in the 95-120 °F (35-50 °C) range. Another group of active enzymes in this range are the β-glucanases, which break down hemicellulose and gums in the cell walls of undermodified malts. Some adjuncts, particularly rye, have high levels of these substances, and stuck mashes or other problems can result if they are not degraded to simpler substances by the β-glucanases.

Protein Rest

For most malts, the mash begins with the protein rest, which is normally carried out at temperatures in the 113-127 °F (45-53 °C) range. This process begins with the proteinases, which break down high molecular weight proteins into smaller fractions such as polypeptides. These polypeptides are further degraded by peptidase enzymes into peptides and amino acids, which are essential for proper yeast growth and development. Proteins of molecular weight 17,000 to 150,000 must be reduced to polypeptides of molecular weight 500-12,000 for good head formation, and some of these further reduced to the 400-1500 level for proper yeast nutrition.

Starch Conversion

The final enzymatic process involves the conversion of starches into dextrins and fermentable sugars. The starches must be gelatinized for this to take place, and this occurs at temperatures of 130-150 °F (55-65 °C) for barley malt. The gelatinization temperature is higher for raw grains, such as corn grits, so these adjuncts must be boiled or hot-flaked before adding to the mash. The breakdown of starches is carried out by the combined action of debranching, α-amylase and β-amylase enzymes during the saccharification rest. Debranching enzymes break the 1-6 links in starches, reducing the average length and complexity of the molecules. The diastatic, or amylase, enzymes work in tandem, with the β-fraction breaking off maltose units from reducing ends and the α-fraction breaking 1-4 links at random. Temperatures below 150 °F (65 °C) favor β-amylase, producing a more fermentable wort, while temperatures above 155 °F (68 °C) favor α-amylase, producing a more dextrinous wort.

The simplest sugars produced in the above manner are monosaccharides, with only one basic sugar structure in the molecule. Monosaccharides in wort include glucose, fructose, mannose and galactose. Disaccharides are made up of two monosaccharides coupled together, and include maltose, isomaltose, glucose, melibiose, and lactose. Trisaccharides (three monosaccharides) include maltotriose, which is slowly fermentable and sustains the yeast during lagering. Oligosaccharides constructed of glucose chains (many monosaccharides joined together), are water soluble and called dextrins. The relative concentrations of these sugars are determined by the types of malt and whether the mash schedule favors α-amylase or β-amylase activity.

Mash-out

After this phase is completed, many brewers mash-out by raising the temperature of the mash to 168 °F (76 °C) and holding it there for several minutes. This ensures the deactivation of the amylase enzymes, halting the conversion of dextrins to fermentable sugars. It also reduces the viscosity of the wort, helping to make the lautering easier and more efficient. There is some controversy whether this step is necessary depending on the final mash temperature. However, it is generally agreed that the best extraction rates are achieved when the mash is heated to this range.

Mashing Procedures

The mashing process begins by doughing-in the crushed grains with approximately 1-2 liters of water per pound of grain (2-4 liters per kilogram). The starch granules take up water with the aid of liquefaction enzymes, and the rests described above are carried out according to the degree of modification of the malt. The simplest mashing method is the single-step infusion, where the malt is combined with hot water to reach a temperature appropriate for starch conversion. This is the method of choice for fully-modified malts such as those used to brew British ales. It has the advantage of requiring a minimum of labor, equipment, energy and time, but prohibits the use of undermodified malt or adjuncts. A step-infusion mash allows a little more flexibility by moving the mash through a series of temperature rests. The temperature is increased by external heat or the addition of boiling water. This requires more resources than a simple infusion mash, but undermodified malts may be used.

Decoction mashing involves the removal of a thick fraction of the mash (usually one-third) and running it through a brief saccharification rest at a relatively high temperature. It is then boiled it for 15-30 minutes before mixing it back into the main mash. This is repeated as many as three times, depending on the modification of the malt and the beer style. The decoction helps explode starch granules and break down the protein matrix in undermodified malt, improving the extraction efficiency, and also promotes the formation of melanoidins. These compounds are formed from amino acids and reducing sugars in the presence of heat and are responsible for the rich flavors in malty lagers. This mashing method is the most resource intensive, but is the traditional method for many lagers. A possible side-effect of the extended mash schedule is the extraction of higher levels of tannins and DMS precursors from the grain husks, though this is not significant at typical mash pH levels.

A fourth mashing method is the double mash, which can be viewed as a combination of infusion and decoction. As the name implies, it involves two separate mashes: a main mash consisting of crushed malt, and a cereal mash consisting of raw adjuncts and a small charge of crushed malt. The latter is boiled for at least an hour to gelatinize the starches and is then added to the main mash, which has undergone an acid rest. The mixture is then cycled through protein and saccharification rests using the step-infusion method. The double mash is the most common way of producing beer styles such as American light lagers that contain a high proportion of corn grits or rice.

Lautering

Lautering is the process of separating the sweet wort from the grain fractions of the mash. It is usually done in a vessel—appropriately called a lauter tun—that holds the grain and wort with some form of strainer in the bottom to separate the liquid wort from the grain. In most homebrewing setups, the mash tun, where the mash process occurs, and the lauter tun are the same unit. Where the brewer chooses to utilize two vessels and convey the mash contents from the mash tun to a special purpose lauter tun care must be taken to not introduce oxygen into the hot wort. This hot side aeration can introduce oxidative off flavors the finished beer that are often perceived as sherry-like, wet paper or cardboard-like.

Lautering consists of draining the wort off the grain and sparging, or the addition of hot liquor (treated brewing water) to the top of the grain bed to rinse the sugars from the grain. This procedure should be done slowly, with the wort returned to the tun until the run-off is clear. This initial runoff and return of wort to the lauter tun is called a vorlauf and is critical to preventing astringency and haze in the finished beer. Lautering too fast will give poor yield, poor extraction rates, and possibly flush starch and protein fractions into the wort. Failing to re-circulate the initial runoff through the lauter tun until it is reasonably clear will have a similar effect.

A temperature range of 160-170 °F (70-77 °C) should be maintained throughout the entire process; this ensures that the greatest extraction of sugars from the grain without excess tannin extraction from the husks. Temperatures above 170 °F (77 °C) will leach tannins and permit undissolved starch balls to explode and get past the filterbed, and gums and proteins may also be released into the wort. This starch will pass on to the finished beer without being fermented until broken down over a period of time by wild yeast or bacteria present.

Another potential problem is a stuck sparge, which may be caused by an inadequate amount of filtering material in the grain bed—usually barley husks—that allow wort to pass freely while holding back the bits of material to be filtered. When mashing with high quantities of wheat or rye malt that will not have their own husks to aid as a filter, it’s usually necessary to add additional filter material such as rice hulls, which themselves are neutral to the flavor or gravity of the resulting beer. Wheat, rye, oats and some other cereal grains also contribute a much higher proportion of gums that can help cause a stuck mash. These often require a β-glucanase rest in order to break down these gums and aid the resulting sparge.

Sparging is the addition of rinse water, or hot liquor, to the lauter tun. In general, the water chemistry of the sparge water should match that used in mashing. The pH should be approximately 5.7 in order to prevent the mash pH from exceeding 6.0, which promotes the extraction of excess tannins.

The sparge rate should be slow, with the water (at 170 °F, 77 °C) added gently so that the filter bed is not disturbed. A hydrometer reading of the first runs from the tun should be about twice the value desired in the finished beer. If not, it should be returned to the tun. Sparging should cease when the gravity drops to below about 1.010 or the pH of the runoff increases above 6.0. Monitoring of the runoff is essential in order to stop the collection of wort before excess tannins are extracted. Learning to taste the sweet wort to recognize when to stop the collection will provide the brewer with an intimacy of the process that doesn't require the use of the hydrometer or pH meters and papers.

Boiling

Boiling wort is normally required for the following reasons:

1) Extracts, isomerizes and dissolves the hop α-acids
2) Stops enzymatic activity
3) Kills bacteria, fungi, and wild yeast
4) Coagulates undesired proteins and polyphenols in the hot break
5) Evaporates undesirable harsh hop oils, sulfur compounds, ketones, and esters.
6) Promotes the formation of melanoidins and caramelizes some of the wort sugars (although this is not desirable in all styles)
7) Evaporates water vapor, condensing the wort to the proper volume and gravity (this is not a primary reason, it's a side effect of the process)

A minimum of a one hour boil is usually recommended for making quality beer. When making all grain beer, a boil of 90 minutes is normal, with the bittering hops added for the last hour. One exception to boiling was historically used to brew the Berliner Weisse style. Here, the hops were added to the mash tun, and the wort is cooled after sparging and then fermented with a combination of lactobacillus from the malt and an ale yeast.

Boiling for less than one hour risks under-utilization of hop acids, so the bitterness level may be lower than expected. In addition, the head may not be as well formed due to improper extraction of isohumulones from the hops. A good rolling boil for one hour is necessary to bind hop compounds to polypeptides, forming colloids that remain in the beer and help form a good stable head. An open, rolling boil aids in the removal of undesired volatile compounds, such as some harsh hop compounds, esters, and sulfur compounds. It is important to boil wort uncovered so that these substances do not condense back into the wort.

Clarity will be also be affected by not using at least a full hour rolling boil, as there will not be a adequate hot break to remove the undesired proteins. This will also affect shelf life of the bottled beer, since the proteins will over time promote bacterial growth even in properly sanitized beer bottles. The preservative qualities of hops will also suffer greatly if the wort is not boiled for one hour, as the extraction of the needed compounds will be impaired.

Boiling wort will also lower the pH of the wort slightly. Having the proper pH to begin the boil is not normally a problem, but if it is below 5.2, protein precipitation will be retarded and carbonate salt should be used to increase the alkalinity. The pH will drop during the boil and at the conclusion should be 5.2-5.5 in order for proper cold break to form and fermentation to proceed normally. Incorrect wort pH during the boil may result in clarity or fermentation problems.

The effects of boiling on the wort should match the intended style. It is often desirable to form melanoidins which are compounds produced by heat acting on amino acids and sugars. These add a darker color and a maltier flavor to beer. When desired, an insufficient boil will not form enough melanoidins for the style. Boiling the initial runnings of high gravity wort will quickly caramelize the sugars in the wort. This is desired in Scottish ales, but would be inappropriate in light lagers.

Vigorously boiling wort uncovered will evaporate water from the wort at a rate of about one gallon (four liters) per hour, depending the brewing setup. In order to create a beer with the appropriate target original gravity, changes in the wort volume must be taken into account. Longer boil times or additions of sterilized water may be required to hit the target gravity.

Chilling

After boiling for a sufficient amount of time, the wort should be chilled at rapidly as possible, using either an immersion or counter-flow system. This minimizes the risk of contamination by *Lactobacillus* or wort-spoilage bacteria and produces an adequate cold break. This cold break consists of protein-protein and protein-polyphenol complexes and is often promoted by the addition of Irish Moss or Whirlfloc tablets to the kettle near the end of the boil. There is some debate on whether the cold break should be completely removed. On one hand, it can provide carbon skeletons that can be used by the yeast for sterol synthesis, but on the other, excessive levels may lead to elevated levels of esters and fusel alcohols and promote the formation of chill or permanent haze in the finished beer.

Fining

Irish Moss and Whirlfloc tablets are categorized as kettle fining agents since they are added during the last 10-15 minutes of the boil to aid in in coagulation and precipitation of proteins during the cold break. Irish moss is a dried form of a red seaweed variety that grows along the rocky Atlantic coastlines of Europe and North America. Whirlfloc tablets are also derived from seaweed, but with an enhanced flocculation ability due to the addition of purified carrageenan, which is the active ingredient in Irish Moss.

Fining agents can also be added at the end of fermentation to promote the sedimentation of residual protein-polyphenol complexes or yeast. These include silica hydrogels, gelatin, isinglass and polyclar. Gelatin and isinglass are collagen-based agents derived from animal hooves and fish bladders, respectively. They are used by dissolving small quantities in hot (but not boiling) water and adding the solution to the fermenter a few days prior to racking or bottling. Polyclar is a powdered plastic material with positively charged molecules that attach to the negatively-charged protein-polyphenol molecules to form larger aggregates that sink to the bottom of the fermenter.

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E. Hops

by Peter Garofalo, updated in 2017 by Scott Bickham

Introduction

Hops are the spicy and bitter counterpart to the malt backbone of beer; they are essential to beer as we know it. Prior to the widespread acceptance of hops, various bitter herbs, seasonings, and spices were used to balance the malt sweetness. Hops also contribute many secondary attributes to beer: they provide a measure of bacteriological stability, aid in kettle coagulation, and contribute to a stable head.

Brewers' hops are the cone-like flower of the *Humulus lupulus* vine, a relative to the cannabis plant. The essential ingredients are concentrated in the lupulin glands, located at the base of the bracteoles, or leaves of the cone. The bracteoles are attached to the central stem of the hop cone (strig). The lupulin resin contains alpha acids and essential oils that contribute the characteristic bitterness, flavor, and aroma that are associated with hops in beer. The amount of alpha acid is usually expressed as a weight percent, and is determined by extractive and chromatographic methods.

History

Many varieties of hops are known, though they are generally divided into two subsets: aroma and bittering hops, although some are considered to be "dual-purpose." The finest of the aroma hops are referred to as "noble," due to their prized aromatic and subtle bittering properties; the noble varieties include Saaz, Spalt, Tettnanger, and Hallertauer Mittelfrüh, although some sources list other varieties. Aroma hops are generally lower in alpha acid content, but contribute desirable flavor and aroma characteristics. Bittering varieties are higher in alpha acid content, but their flavor and aroma characteristics are generally considered to be less refined. There are no hard and fast rules about aroma, bittering, and dual-purpose hops; the categorization is subjective. Generally, aroma hops consist of such varieties as Saaz, Tettnanger, Hallertauer, Spalt, East Kent and Styrian Goldings, Fuggles, Cascade, Willamette, Liberty, Crystal, Ultra, and Mount Hood. Bittering varieties include Brewer's Gold, Nugget, Chinook, Eroica, Galena, and Bullion. Dual-purpose varieties include Northern Brewer, Columbus, Cluster, Perle, and Centennial, among others.

Hops were introduced in beer making prior to 1000 A.D., and came into widespread use in the 16th century when they were legislated as a required ingredient in the famous Reinheitsgebot, or German Beer Purity Law of 1516. Hops are still grown in many of the traditional regions, such as the Zatec region of the Czech republic, home of Zatec Red, or Saaz variety. Hop varieties have been enriched through intensive cross-breeding, which has given us many of the newer, disease-resistant varieties.

Bitterness arises from the alpha acids, which consist of humulone, cohumulone, and adhumulone; the proportions of each will vary according to hop variety. They are isomerized into iso-alpha acids in a vigorous boil, rendering them much more soluble in the wort, in addition to increasing their bitterness. The essential oils, which contribute to flavor and aroma of the finished beer, consist of dozens of compounds. Many of these are volatile, and hence do not survive extended boil times. For this reason, flavor and aroma hops are generally added during the last 30 minutes of the boil.

Brewing hops are available in many forms: whole hops, plugs, pellets, and extracts. Whole hops are simply dried hop cones, and are the most traditional form of hops. Plugs (also known as type-100 pellets), are whole hops compressed into 1/2-ounce (15 gram) disks. Pellets are ground into powder, and then extruded through a die. Hop extracts include isomerized extracts, which may be used to add bitterness; hop aroma essences are also available.

Bitterness from Hops

The bitterness imparted by hops is quantified in various ways, with varying degrees of precision. The simplest method is the Alpha Acid Unit (AAU), also known as the Homebrew Bittering Unit (HBU). This basic measure is simply the weight of hops in ounces (one ounce = 28.35 grams) times the alpha-acid content, expressed as a percent. In order to be meaningful, the brew length must be specified when using AAUs or HBUs. The main downfall of the AAU/HBU quantification method is that it describes the potential bitterness without accounting for many critical factors which determine the actual bitterness.

The more precise method of quantifying hop bitterness is the International Bittering Unit, or IBU. The IBU is a measure of the concentration of isomerized alpha acids present in the finished beer, and is expressed in milligrams per liter, or parts per million (ppm). The relationship between the quantity of hops used and the IBU level depends on many factors: length of the boil, wort gravity, vigor of the boil, wort pH, age/condition of hops, hop form (whole, plugs, or pellets), hopping rate, plus several other less important elements. The relative IBU level does not always translate directly to the perceived bitterness of the finished beer. The ionic makeup of the brewing water, particularly carbonate and sulfate levels, directly affect the perception of bitterness. The degree of attenuation also plays a role in the amount of bitterness that is needed to reach a balance for a given style.

The IBU content of a beer may be expressed as: $IBU = 7489 \times (W \times A \times U)/V$, where 7489 is a conversion from milligrams/liter to ounces/gallon, W is the weight of hops in ounces, A is the alpha acid content as a decimal, U is a percent utilization factor, and V is the final volume of beer, in gallons. [In metric, this formula is $IBU = 1000 \times (W \times A \times U)/V$ where 1000 is a conversion from milliliters to liters, W is the weight of hops in grams, A is the alpha acid content as a decimal, U is a percent utilization factor, and V is the final volume of beer in liters.] The most important variable in the equation is the utilization factor, which depends on the aforementioned parameters. Utilization normally tops out at about 30 % in the home brewery; often, it is significantly lower. Some additional factors which affect the value of U are boiling temperature, whether or not hop bags are used, and filtration losses. U is the product of all correction factors and may be estimated by any of several methods for each set of conditions. In any case, a different utilization is typically assumed for each hop addition (when multiple additions are used); in this manner, the IBU contribution for each hop addition may be estimated, and then totaled. It should be noted that the only way to determine the IBU level in the finished beer is through a direct measurement in the laboratory.

The relationship between the various correction factors and hop utilization is often not simple, but certain tendencies are well known. Utilization is reduced by: reducing the contact time of hops with boiling wort; reducing the boiling temperature of the wort; increasing the wort gravity; using whole hops instead of pellets; increasing the hopping rate; using hop bags to contain the hops during the boil; using older hops; decreasing wort pH; using more flocculent yeast; and filtering the beer. Some bitterness is also lost to oxidation or staling of the finished beer.

The desired level of bitterness, as measured by IBUs, varies widely for different styles. For example, an Festbier is expected to have about 18 to 25 IBU, while a Czech Premium Pale Lager might have 30 to 45 IBU. Each style has different bitterness, flavor, and aroma expectations; only the α-acid level may be accurately quantified. Another way to characterize the bitterness of a given style is the BU:GU ratio introduced by Ray Daniels. This is simply the IBU content divided by the last two digits of the original specific gravity.

Hops are often added at different points in the brewing process, with the goal of contributing bitterness, flavor, or aroma to the finished beer. Bittering hops are usually most efficient at yielding their iso-alpha acids with 60 to 90 minutes of vigorous wort boiling. Hops boiled for 10 to 40 minutes are often referred to as “flavor hops,” since they contribute less bitterness, but retain some essential oils which contribute characteristic flavors. Hops added at or near the end of the boil contribute little or no bitterness, some flavor, and aromatic quality to the finished beer. Hops added during or after fermentation (“dry” hops) contribute a fresh hop aroma. Hop-derived compounds can also be altered in the finished beer. Oxidation (staling) reduces bitterness, and may also add a harsh edge to flavor, as well as diminishing aroma.

First Wort Hopping

The technique of first wort hopping is also gaining favor among homebrewers. It essentially consists of adding a portion of the hop charge (some insist that most or even all of the hops should be added at this point) to the first sweet wort runnings from lautering, during which time the higher pH is thought to extract some of the finer qualities of the hop flavor. The hops are kept with the wort throughout the boil, and contribute a more refined bitterness, though the exact amount is a matter of debate. What is beyond debate is the fresh hop flavor imparted by first wort hopping; some have speculated on possible formation of stable complexes, or perhaps esters, at the temperature range encountered in the mash runoff. Another possibility is the removal of undesirable, somewhat volatile constituents during the extended heating and boiling time; this coincides with the observation that even with increased IBU levels provided by first wort hopping, the resulting bitterness is usually described as smoother and more pleasant. Surprisingly, the technique also contributes aroma; in fact, first wort hopping has been suggested as a replacement for late hop additions. Less clear is how the aroma boost compares to dry-hopped aroma. The technique is an old German method that was originally used for hop-centered styles, such as Pilsener; recently, it has gained favor for a wide range of homebrewed styles. It was originally intended as a means for extracting more bitterness, and it has been found (analytically) to provide a favorable bittering and flavor compound profile.

Varieties

Hop varieties are often associated with particular beer styles; in fact, some styles are virtually defined by their hop character. British ales are normally associated with native hop varieties (East Kent Goldings, Northern Brewer, Challenger and Fuggles, for example), and most are expected to embody the characteristic flavor and aroma attributes associated with these hop varieties. Golding hops provide an earthy, peppery and lemon-like character; Fuggles hops are also earthy, but with cedar, tobacco and floral notes; while Challenger hops have a tea-like earthiness with light citrus notes.

Continental styles, particularly the more hop-oriented ones, are also often associated with more local Continental hop varieties. Czech Premium Pale Lagers, for example, are partially defined by the characteristic spicy Saaz aroma and flavor. On the other hand, German pale lagers are usually associated with German hop varieties, such as Tettnanger, Hallertauer Mittelfrüh, and Spalt. All of these noble hop varieties provide a slightly peppery or woody spiciness, often accompanied by a soft floral or light citrus character. Altbiers, which often have subdued hop aromas and flavors, have a clean bitterness that is associated with the use of low-alpha Spalt hops. Even less hop-accented lager styles such as Dunkles Bock and Munich Helles benefit from the soft hop bitterness produced by low-alpha noble hop varieties.

American styles, especially such hoppy examples as American pale ale and American brown ale, benefit greatly from the floral, citrusy character of the dominant American varieties such as Cascades, Centennial, Columbus or Chinook. In fact, it is often the hop character that sets these styles apart from their European prototypes. Cascade and Centennial hops both provide grapefruit and floral notes, with the latter usually being a little more floral. Columbus and Chinook are both high-alpha hops that provide assertive pine-like or pine resin character, along with herbal and light citrus notes.

Many hoppy beer styles such as American IPA, Double IPA and American Strong Ale are made with generous additions of the so-called “New World” hops. Amarillo is the eldest member of this family and provides orange-blossom notes when used in modest amounts, but become catty when larger amounts are used as finishing hops or for dry-hopping. As the name implies, Citra hops impart an orangey or orange-rind character that is often accompanied by tropical fruit notes such as mango, passion fruit and pineapple. Simcoe is another popular hop that has notes of grapefruit, pine and tropical fruit when used in small amounts, but at higher levels, has an aroma that recalls raw onions. Another New World hop variety that judges should recognize is Mosaic, which has a distinctive blueberry-like aroma, along with notes of tangerine, pineapple and ripe peaches.

It is important to note that the region of cultivation is as important as the hop variety in determining the character of the crop. Classic European hop varieties exhibit different characteristics when they are grown in the United States than when the same varieties are grown in European soil. Therefore, the place of origin is every bit as important as the genealogy when selecting the appropriate hop variety for a particular application.

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F. Yeast and Fermentation

by Chuck Hanning and Scott Bickham

Introduction

Most beer styles are made using one of two unicellular species of microorganisms of the *Saccharomyces* genus, more commonly called yeast. Generally, either an ale yeast strain (known as *S. cerevisiae*) or a lager yeast strain (known as *S. pastorianus* or by older terminology *S. carlsbergensis* or *S. uvarum*) is used for the appropriate style. Functionally these yeasts differ in their optimum fermentation temperatures, ability to ferment different sugars, environmental conditions, and ability to settle out upon completion of fermentation, and production and/or metabolism of fermentation by-products. The choice of the strain of ale or lager yeast and how these factors are controlled during the various stages of fermentation will determine how well a beer is made to style. While a list of all the possible strains is beyond the scope of this guide, readers are encouraged to review reference (1) for a more thorough review. Most yeast suppliers provide detailed descriptions of the various commercial strains they carry (2), as do homebrew shops or other retailers of their products.

One of the common terms used to describe yeast is apparent attenuation. The attenuation of a particular yeast strain describes its ability to decrease the original gravity of wort upon fermentation. It is commonly listed as a percent, in which the numerator is the difference between final and original gravity and denominator is the original gravity. Because the density of ethanol is less than water, when a hydrometer is used to measure this attenuation, it will be measuring the apparent attenuation not the real attenuation (if the alcohol was replaced by water). Another common term used to describe different yeasts is flocculation, which is the ability of the yeast to settle out of the beer upon completion of fermentation; it can vary significantly with strain.

The environmental conditions that differ with each yeast type and strain are alcohol tolerance, oxygen requirements, and sensitivity to wort composition. Alcohol tolerance describes how well a yeast strain will continue to ferment as the alcohol concentration increases during fermentation. Most lager yeast can ferment up to about 8% alcohol by volume, and some ale strains can ferment up to 12% (2, 3). Oxygen requirements can differ with each strain as well; some need much more oxygen to be able to ferment without problems. Lastly, different worts will have different relative amounts of sugars present. The various strains can respond differently to the same wort upon fermentation.

The by-products that are produced (and also metabolized) by the yeast are esters, fusel alcohols, diacetyl, and sulfur compounds. Esters are produced by yeast combining an organic alcohol and an acid. While approximately 90 different esters have been identified in beer, ethyl-acetate, isoamyl-acetate and ethyl-hexanoate are most commonly above their flavor thresholds. These impart a fruity, sweet aroma to the beer. Another by-product of fermentation is fusel alcohols, which contain more carbon atoms than the most common alcohol, ethanol. These are produced by the metabolism of amino acids (4), and tend to add harsher, more solvent-like tones the beer. Yet another by-product is diacetyl, which is generally reduced to more benign compounds during the secondary fermentation, but premature removal of the yeast (among other things) can lead to elevated levels. Its presence imparts a buttery note to the beer. It is produced by an oxidation reaction, which can be repressed by the production of the amino acid valine (5). Lastly, there are several sulfur compounds that can be produced by the yeast. One of these is hydrogen sulfide, which smells like rotten eggs. Other sulfur compounds exist, but their production is not yet completely understood (1).

Ale Yeast, for the purposes of beer fermentation, tend to work best in the 55-75 °F (13-24 °C) temperature range. Apparent attenuation can range from 69 to 80%. These yeasts can fully ferment the common sugars glucose, fructose, maltose, sucrose, maltotriose and the trace sugars xylulose, mannose, and galactose. They can partially ferment raffinose. These yeasts have traditionally been called top fermenting because they form colonies (groups of yeast that cling together) that are supported by the surface tension of the beer. Ale yeasts produce esters since they require higher temperatures to remain active. Styles that use these yeasts have varying degrees of fruity and sweet smelling aromas. It should be noted that the yeast used to produce the German weizen style are special strains that generate high concentrations of the clove-like phenols and “bubblegum” and “banana” esters, which are the signatures of this style.

Lager Yeast generally tend to work best between 46-56 °F (8-13 °C), but California Common Lager yeast is an exception, having a range of 58-68 °F (14-20 °C). Apparent attenuation usually ranges from 67-77%. Lager yeasts can ferment raffinose in addition to the sugars that are fermentable by ale yeasts. These yeasts have traditionally been called bottom fermenters, since they do not cling together to form colonies on the surface, but instead fall to the bottom of the fermenter. Lager yeasts can be further subdivided into the Frohberg type (also called dusty or “powdery”) which ferment quickly, and do not flocculate as well. Due to the longer time it remains suspended in the wort, this subtype will have a greater attenuation. The other subtype of lager yeast is the Saaz type (also called the S.U. or “break”). These strains tend to flocculate more readily, and hence tend to have a lower attenuation (6). Lager yeasts, in comparison to ale yeasts, produce beers that lack the esters and fusel alcohols, since they are active at cooler temperatures. Lager beer styles should have a cleaner aroma to them, reflecting only the malt and /or hop aromas used to make the wort.

Bacteria, specifically *Lactobacillus delbrückii*, are used in the production of the Berliner Weiss style of wheat beer with an intense lactic sourness. Other microorganisms are also used in the production of some Belgian ales, specifically lambics. Lambics have varying degrees of sourness which is appropriate for their style. Yeasts of the *Brettanomyces* genus and various bacteria generate these flavors. Bacteria are commonly divided into two broad classes based on a laboratory Gram stain. The Gram-negative bacteria involved in lambic production are *Escherichia coli* and also various species of *Citrobacter* and *Enterobacter*, but fortunately they cannot tolerate even moderate alcohol levels and do not survive in the finished beer. The Gram-positive bacteria involved are from genus *Pediococcus* and *Lactobacillus*. These microorganisms use a different pathway than that of *Saccharomyces* yeast known as a mixed acid fermentation pathway. It involves the esterification of the various alcohols to the corresponding carboxylic acids, thus generating lactic sourness (7). At low contamination levels, these Gram-positive bacteria may also be responsible for the sweet, butterscotch or buttery notes associated with diacetyl and related vicinal diketones.

The Yeast Life Cycle

When yeast are pitched into fresh wort, the overall process of fermentation can be divided into several stages or phases, all of which are part of the life cycle. While these stages can each be described separately, the transitions between each are continuous and should not be thought of as distinct parts of the life cycle. Also the relative time spent in each phase depends on several factors including the composition of the wort, the environment and the amount of yeast pitched. Most technical brewing references break the yeast life cycle into five phases of growth: lag, accelerating, exponential, decelerating and stationary (8, 9). Readers familiar with earlier versions of the BJCP Study Guide may recall that prior to this revision, the growth phase was referred to as a distinct phase in yeast development. Although that notation is consistent with some homebrewing references, the five phases listed above are more common in microbiology textbooks and technical brewing references.

The first phase of the cycle is called the lag phase, which is sometimes referred to as the latent phase. During this time the yeast will adapt to the new environment they are now in and begin to make enzymes they will need to grow and ferment the sugars in the wort. The yeast will be utilizing their internal reserves of energy for this purpose, which is the carbohydrate glycogen. The yeast will acclimatize itself and assess the dissolved oxygen level, the overall and relative amounts of the amino acids and the overall and relative amounts of sugars present. Some of these amino acids, small groups of amino acids called peptides, and sugars will be imported into the cell for cell division. Normally this period is very brief, but if the yeast is not healthy, this period can be very protracted, and ultimately lead to problematic fermentation (1, 10).

Based on these factors, the yeast will then move into the next phase of the life cycle, the accelerating phase. This is sometimes referred to as the low kräusen stage. During this time the yeast will start to divide by budding to reach the optimal density necessary for the true fermentation. The rate of cell division continuously increases during this phase. If an adequate amount of healthy yeast has been pitched and the proper nutrients are present, there should only be one to three doublings of the initial innoculum. The oxygen that was used to aerate the wort is absorbed during this time to allow the yeast to generate sterols, which are key components of the cell wall (10). It has also been proposed that cold trub can provide the unsaturated fatty acids needed for sterol synthesis (11, 12). Furthermore, it has been proposed that if an adequate amount of yeast has been pitched, such that cell growth is not necessary, then the oxygenation is not necessary (10, 13). While this theory has not been completely accepted (14, 15), perhaps further research will elucidate other variables which may be involved in this phenomenon. This sterol synthesis is the default pathway used in an all malt wort; however if the wort contains greater than 0.4% glucose then this pathway will not be used and the yeast will instead ferment the glucose, even in the presence of oxygen. This effect is called glucose repression, or the Crabtree effect.

During the exponential phase, the growth rate is constant at the maximum rate determined by the yeast strain, temperature and wort composition. This phase is also referred to as the logarithmic (log) or the high kräusen phase. The yeast have now completely adapted to the condition of the wort, and the transport of both amino acids and sugars into the cells for metabolism will be very active. During this period, esters are formed by the esterification of fatty acids by ethanol and also possibly by the esterification of higher alcohols. Fusel alcohols can be produced by the conversion of amino acids to higher alcohols via deamination, decarboxylation and reduction processes. To minimize the formation of esters and fusel alcohols, the brewer should ensure that: (a) a healthy amount of freely available nitrogen (FAN) is available in the wort, (b) the wort is chilled to a maximum of 75 °F (24 °C) for ales and 55 °F (13 °C) for lagers prior to pitching the yeast, (c) the chilled wort is sufficiently but not excessively aerated prior to pitching the yeast, and (d) the fermentation temperature is maintained within the optimum range for the yeast strain.

The fourth stage of the yeast life cycle is the deceleration phase or late kräusen phase, during which the growth rate gradually decreases. At this point, ale yeast strains will have metabolized most of the sugars present in the wort. Lager yeast strains, on the other hand, may still be reducing the extract by four gravity points/day, and this is important because it is during this time that the yeast begin to metabolize some of the fermentation by-products they had previously excreted during the low kräusen phase. Specifically, a diacetyl rest may be performed to help with the re-absorption and subsequent reduction of the diacetyl and the related diketones during this time. The temperature of the beer may be allowed to rise up to 68 °F (20 °C) during the diacetyl rest.

The final stage is the stationary phase, during which the number of yeast cells remains approximately constant. The kräusen begins to fall, and the yeast drop out of suspension, or flocculate. During this deceleration phase, the specific gravity of the beer approaches its terminal point, and the yeast will begin to flocculate. This is the optimum time to rack the beer into a secondary fermenter, which allows for the attenuation of the last remaining extract, usually consisting of the trace sugars. Also removal of the excess yeast and trub will prevent formation of off flavors due to autolysis and/or reactions with trub substrates. For ale styles this period may be very brief, while lager styles may be four to six weeks, or even as long as six months in the case of strong lager styles. When lagering, it is important not to chill the beer too quickly, which might cause premature flocculation before the fermentation has been completed and all the by-products have been reabsorbed. The general rule of thumb is that a temperature drop should be no more than 5 °F (3 °C) per day; otherwise it is possible to cold shock the yeast. It is also important during this time to prevent reintroduction of air, since this can lead to oxidation flavors and may introduce contaminants that can infect the beer.

During packaging of the beer, fresh yeast may often be reintroduced, particularly if it has been lagered for an extended period of time and/or the remaining yeast are not that viable. Two common methods are 1) bottle conditioning, or the addition of a fresh yeast starter and corn sugar (glucose), as is commonly done for Trappist-style Belgian ales, and 2) kräusening, or the addition of freshly fermenting beer as is often practiced with German lagers. For bottle conditioned beers, a 250 ml starter is usually added for a five gallon (20 liter) batch along with the sugar; which provides fresh yeast to metabolize the added sugar. In the case of kräusening, an actively fermenting batch at high kräusen stage is added to the beer being primed. The volume of kräusen added is typically 20% by volume of the beer being primed. Adding this actively-fermenting beer serves two purposes; it carbonates and also helps clean up any off flavors generated from the previous fermentation.

Control of Fermentation By-Products

Esters may be controlled by the choice of yeast strain, wort gravity, wort aeration, and fermentation temperature. In general, ale yeast strains produce higher ester levels, although there are variances among different ale strains. Lager yeast strains can, if fermented too warm, also produce esters as is practiced in the making of French Bière de Garde styles. Wort gravity also is a factor; the hallmark esters of Belgian Trappist styles are not only due to the yeast strains used but also a result of their high gravity wort. Wort aeration also plays an important role, as the ester production pathway directly competes with the absorption of oxygen and metabolism into sterols (16). Lastly, fermentation temperature also plays an important role. A four-fold increase in ester production may be observed as a result of increasing the fermentation temperature from 60 to 68 °F, 16-20 °C (1).

Phenols can be produced by certain wild yeast strains. Hence, their control in styles in which they are not desired is a matter of proper sanitation. One exception to this is German wheat beers, which contain the phenol 4-vinylguaiacol, which give a clove-like flavor. This phenol is produced by a special strain of S. cerevisiae when its precursor ferulic acid is available in the wort. The level of this amino acid may be increased by including a ferulic acid rest at 111 °F, 44 °C in the mash (17). Please refer to the Beer Characteristics section below for more information.

Fusel alcohols are metabolized from amino acids. As mentioned previously, their production is increased as the fermentation temperature is increased. Also, like esters, fusel alcohols increase with wort gravity. Lastly, various wild yeasts tend to produce excessive amounts of fusel alcohols; hence, proper sanitation is important for their reduction (1).

Diacetyl precursors are produced during yeast metabolism, but they are not converted into diacetyl until the active stages of fermentation. Factors that increase the probability of this occurring include higher fermentation temperatures and the introduction of oxygen, but the yeast strain is also an important consideration. Diacetyl and related compounds can only be removed by the yeast, and only through the conversion to the nearly flavorless compound, butanediol. Several factors can help with this process, including maintaining a sufficiently high fermentation temperature during the decelerating and stationary phases. As noted above, higher fermentation temperatures also promote the formation of diacetyl, but the effect on the reduction is even greater, so the net result is a lower level of diacetyl in the finished beer. This is often a confusing dichotomy for beer judges, but it is the key motivation for performing a diacetyl rest for a lager beer style. Diacetyl reduction is also highly dependent on ensuring that the yeast remains in contact with the beer, so premature removal of the beer from the yeast can also lead to an elevated diacetyl level. Finally, as noted above, diacetyl can be produced by Gram-positive bacteria, hence proper sanitation and control during yeast propagation will help minimize its presence (1).

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G. Beer Characteristics

by Scott Bickham

Introduction

This section is intended to give an overview of the more important flavors and flaws that may be encountered while judging. Some of these flavors may be desirable in some styles, but not in others, and the appropriateness will depend on the concentration. For this reason, not all of these characteristics are considered to be off-flavors. A one-page summary of common beer faults is located on the BJCP web site: http://www.bjcp.org/faults.php, but this section of the BJCP Study Guide has more complete descriptions that would be considered Master-level answers for the Beer Characteristic (T1) and Body/Mouthfeel (T3) questions on the BJCP Beer Written Proficiency Exam. These descriptions were updated and expanded in 2017, with substantial edits that reflect advancements in our understanding of the origin of beer flavor characteristics and how they are perceived. While some of the descriptions do mention the chemical compound(s) responsible for the flavor, the emphasis is not so much on the chemistry as on how they are perceived and the beer styles in which they are appropriate or inappropriate.

Acetaldehyde

This compound has the taste and aroma of fresh-cut green apples, and sometimes has notes of grass, green leaves or latex paint. It is normally reduced to ethanol by yeast during the secondary fermentation, but oxidation of the finished beer may reverse this process, converting ethanol to acetaldehyde. Elevated levels are generally present in green beer or if the beer is prematurely removed from the yeast. It can also be a product of bacterial spoilage by *Zymomonas* or *Acetobacter*. This flavor can also be the result of inadequate wort oxygenation, and while the resultant yeast by-products are normally metabolic intermediates, they can remain after fermentation in some cases. While acetaldehyde is normally considered to be a flaw, a low level is acceptable in the aroma and flavor of Kellerbiers, which typically have more yeast character than German beers that have been lagered.

Alcoholic

This flavor may be detected as a spicy, vinous character in the aroma and taste and is often accompanied by a warm or prickly mouthfeel. The simplest and most prevalent alcohol in beer is ethanol, which is produced by the fermentation of glucose and other simple sugars. Higher, or fusel, alcohols are usually present at sub-threshold concentrations, but elevated levels are associated with underpitching yeast, low levels of dissolved oxygen prior to pitching or low levels of free available nitrogen (FAN). These deficiencies force the yeast to metabolize fatty acids in the trub as a source of oxygen and carbon, producing a greater fraction of long chain alcohols. High gravity worts and high fermentation temperatures also tend to increase the concentration of these higher alcohols through increased yeast activity. Alcoholic characteristics are desired in strong ales and lagers such as Eisbock, Imperial Stout and English and American Barleywines, as long as they are not coupled with any appreciable solvent notes associated with elevated ester or fusel alcohol levels.

Astringency

This flavor is a mouth-puckering sensation that is comparable to chewing on grape skins or grape seeds, or by steeping black tea leaves for an extended period of time. It can be produced by the extraction of tannins from grain husks due to overcrushing, oversparging, or sparging with water having a pH over 6.0 and/or a temperature higher than 170 °F (77 °C). Water with high sulfate or magnesium content can enhance the level of astringency. Astringency may also be produced by polyphenols that result from spoilage by acetobacter or wild yeast. Another possible source is oxidation, in which case the responsible compounds are polyphenols and aldehydes. Finally, spices such as coriander, orange peel and cinnamon can also contribute astringent flavors, but these tend to mellow with age. Over-attenuation and low dextrin levels can increase the perception of astringency.

While astringency is undesirable in most beer styles, a low level is acceptable in some beer styles. Some heavily-hopped ales such as American IPA are allowed to have light astringency as long as the finish is not harsh. Low astringency is also permissible in some dark ales such as American Porter due to the use of roasted malts. Flanders Red Ale may have a low to medium astringency, which is one distinguishing characteristic from Oud Bruin, in which astringency is inappropriate.

Bitterness

The main sources of bitterness in beer are iso-alpha acids, which are produced when alpha acids in hops are isomerized during the boil. When properly executed, the bitterness in hoppy beers will linger into the aftertaste but should not be harsh. Excessive bitterness, on the other hand, is perceived as a harsh, dry taste, mostly on the back of the tongue. It can be due to over-hopping, especially when high alpha hops are used. It can also be a consequence of using aged hops, since the oxidation of beta acids produces unpleasantly bitter compounds that are water soluble and can end up at high levels in the finished beer. Bitter compounds may also be produced by oxidation or contamination by wild yeast, in which case there are usually other off-flavors such as astringency.

High levels of bitterness are appropriate in many well-hopped beers styles, including IPAs and American Barleywine. In some dark beer styles such as American Porter and Imperial Stout, the bitterness from hops can be accented by the roasted notes from the dark malts, but the finish should not be overly acrid, burnt or harsh. High sulfate water is sometimes used when brewing British Bitters, English IPA and German Pils, and in these styles, the mineral character can enhance the dryness of the finish and enhance the bitterness from the hops.

Body

The body of a beer is characterized as its fullness, viscosity, or thickness on the tongue and palate. Descriptors range from watery or characterless to satiating or thick. Body is a component of mouthfeel, which encompasses physical sensations such as astringency, alcoholic warmth and carbonation; the combination of all those components determines how the beer stimulates the palate. The body is primarily determined by the levels of dextrins and medium-length proteins. Lack of dextrins is caused by low saccharification temperatures, excessive use of completely fermentable adjuncts or by using highly attenuative yeast strains. A low protein level may be caused by excessively short or long protein rests, or by executing the step at temperatures that are too high or too low. A high alcohol content can also lighten the apparent body of the beer since the density of ethanol is less than that of water. Similarly, high carbonation levels will decrease the sensation of the fullness of the beer on the palate due to the effect of the dissolved gas on the density of the beer. Common remedies for light body include adding dextrin malt or unmalted flaked grains such as barley, oats or wheat to the grist. Light body is appropriate in American Light Lagers and Lambics, but not in strongly malt-accented styles such as Barleywines, Scotch Ales, and Doppelbocks.

Cheesy (Isovaleric Acid)

Isovaleric acid is perceived primarily in the aroma with notes compared to aged hard cheese or described as goaty, sweaty or putrid. Individual sensory thresholds for this off-flavor vary by several orders of magnitude, so levels that some judges will regard as offensive may not be detected by others. Isovaleric acid usually originates from the use of old hops or hops that have been improperly dried or stored at high temperatures in the presence of oxygen. In this oxidative process, an isovaleryl group is removed from the humulene alpha acid and becomes flavor-active. Isovaleric acid is also produced by *Brettanomyces*, which at low levels can contribute to the complexity of English Old Ales. Higher levels may be encountered in European Sour Ales (with the exception of Oud Bruin) and American Wild Ales. Otherwise, it is considered to be a flaw and should be addressed by using fresh hops that have been stored correctly – ideally in the freezer in an oxygen-free, vacuum-sealed container, or by proper sanitation if produced by *Brettanomyces*.

Diacetyl

This compound is responsible for an artificial butter, butterscotch or toffee-like aroma and taste. It may also produce a slickness on the palate. A significant number of tasters cannot perceive diacetyl at any concentration, so judges should be aware of their limitations. Low levels of caramel are sometimes mistaken for diacetyl, but off-flavor training should help judges recognize the difference. Diacetyl is a fermentation by-product which is normally absorbed by the yeast and reduced to more innocuous compounds called diols. High levels can result from prematurely separating the beer from the yeast or by exposing the wort to oxygen during the fermentation. Low FAN levels or mutation may also inhibit the ability of yeast to reduce diacetyl. Diacetyl is also produced during the initial stages of contamination by lactic acid bacteria, notably *Pediococcus damnosus*.

Note that high fermentation temperatures promote both the formation and the elimination of diacetyl, but the latter is more effective. For that reason, lager breweries often employ a diacetyl rest, which involves holding the beer in the 60-65 °F (15-18 °C) range for a few days after racking to the conditioning tank. Though rarely used by homebrewers, kräusening is a technique that can be used to eliminate diacetyl in beer. The technique introduces fresh yeast that is actively multiplying and is thus able to rapidly remove diacetyl. A low level of diacetyl is permissible in some styles, but it should never be obtrusive. These styles include Czech Lagers, English Bitters, Brown and Dark British Beers and Irish Red Ale. Diacetyl is not appropriate in German lagers (Kellerbier being the exception), Irish Stout, American ales or Belgian ales.

DMS/Vegetal

DMS, or dimethyl-sulfide, is one member of a family of chemical compounds that produce the aroma and taste of cooked vegetables, notably corn, celery, cabbage, onion or parsnips. In extreme cases, it may even be reminiscent of shellfish or water in which shrimp has been boiled. A related compound is dimethyl-trisulfide (DMTS), which is perceived as having a flavor similar to cooked onions or onion soup. This flavor profile is different from the freshly-cut onion character of some members of the mercaptan family (see the Onion-like/Catty descriptor below).

DMS is normally produced by the heat-induced conversion of S-methyl-methionine (SMM), but most of it evaporates during a long, open, rolling boil. A short, weak or closed boil, or slow cooling of the wort may lead to an abnormally high level of DMS in the finished beer. Some DMS is also scrubbed out during a vigorous fermentation, which is why lagers and cold-conditioned ales may have a slightly higher level than warm-fermented ales. Wild yeast or *Zymomonas* bacteria may produce a high enough level of DMS to make the beer undrinkable. Pilsner malt contains as much as eight times the SMM of pale malt or other malts kilned at moderate to high temperatures, so beers based primarily on 2-row or 6-row Pils malt sometimes have a light DMS character. This is a much more common cause of cooked-corn character in beer than a covered boil. A low level of DMS is acceptable in many pale lagers, including American Lager, Cream Ale, International Lager, Munich Helles and German Pils. DMS is not appropriate in ales, Czech lagers, amber lagers or dark lagers.

Estery/Fruity

This is an aroma and taste that recalls bananas, strawberries, pears, apples, plums, papaya and/or other fruits. The responsible compounds are esters, which are formed from the combination of an alcohol and an organic acid. High ester levels are a product of the yeast strain, high fermentation temperature, high gravity worts, the metabolism of fatty acids in the trub, low yeast pitching rate, and/or low wort aeration. These flavors are desirable in most ales, particularly Belgian and British styles. The most prevalent ester in beer is ethyl acetate; however it has a high odor threshold and is usually only detected as a nail-polish remover (acetone) aroma at high concentrations. At low levels, this ester has an aroma reminiscent of pears. The three most commonly perceived esters in beer are: isoamyl-acetate, which provides the banana notes in German Weissbier; ethyl butyrate, which has notes of tropical fruits and bubble gum and is part of the flavor profile of many Belgian ales; and ethyl hexanoate, which has the aroma of red apples.

Fruity character can also be derived from hops, which contain hydrocarbons that are responsible for the woody, herbal, piney and resiny character of fresh hops. While these compounds are found at very low levels in kettle-hopped beers, they are unstable when heated and form aromatic compounds such as geraniol and linalool, which provide floral notes, and limonene, which has citrus and lemongrass notes. While these compounds are technically alcohols, the aromatics they contribute to hoppy beers are located in the same section of the Beer Flavor Wheel as esters and are often grouped with fruity esters when judging.

Grassy

This is the flavor and aroma of freshly cut grass or green leaves. Responsible compounds include hexanal and heptanal, which are aldehydes produced by the oxidation of alcohols in the finished beer or from the deterioration of improperly stored malt or hops. This is particularly true when these ingredients are stored in a moist environment, which is why "wet-hopped" beers made with fresh hops that have not been fully dried can have grassy notes. Some English and American hop varieties such as Fuggles and Mosaic can produce grassy notes, especially when used as late-kettle or dry hops. Most hop varieties will lend a grassy flavor if they are left in contact with beer for too long, so limiting dry-hopping to ten days or less and using fresh hops will minimize the risk of developing this characteristic. Low levels of grassy flavors and aromas are acceptable in dry-hopped examples of English IPA, American Pale Ale and IPAs, but excessive amounts are considered to be a flaw.

Head Retention

Good head retention is measured visually in terms of the time required for the head to collapse to half of its initial height. This should be at least one minute in well-brewed and conditioned beers. The beading of the foam should also be uniform and tight, leaving lace on the glass as the beer is consumed. Good head retention is promoted by several factors, including isohumulones, high original gravity, moderate alcohol content, dextrins and the levels of high- and medium- molecular weight proteins. Adequate carbonation is also essential. Most of these variables are style-dependent, but in general, the brewer can increase the protein content by adjusting the length and temperature of the protein rest and using adjuncts such as flaked wheat and barley. Fatty acids carried over from the trub and unclean glassware are both detrimental to head stability, since they decrease the surface tension of the foam – causing the bubbles to collapse prematurely. Beer styles that should have good head retention include German Pils, Witbier, and Belgian Blond Ale. Styles which may have low or impaired head retention include Eisbock, Imperial Stout and English and American Barleywines.

Husky/Grainy

This is perceived in both the aroma and the flavor, with notes of raw or germinating grain and is often accompanied by a dry astringency.   The responsible compounds are aldehydes in the malt, and elevated husky/grainy notes can result in beer if the malt is too finely crushed, the grain husks are shredded, the mashing time is excessive, the temperature or pH of the sparge water is too high, or the grains are oversparged. Pilsner malt has a high level of these aldehydes, and this can result in a light grainy character that is acceptable in most pale lagers, including International Pale Lager, German Pils and German Helles Exportbier. Roasted malts can impart a grainy character that is acceptable in some dark beer styles such as Dark Mild, Scottish Ales, Oatmeal Stout and American Porter as long as it is not harsh. Altbier and Irish Red Ales can also exhibit some graininess in the flavor and aroma.

Lightstruck

This off-flavor smells like a skunk or freshly-roasted coffee beans. The compound responsible for the lightstruck character is one of the mercaptans found in the scent glands of skunks. These compounds are formed in beer when ultraviolet light cleaves an isohumulone molecule, and the resulting radical combines with a sulfur compound. Beer stored in clear or green glass bottles is more susceptible to this reaction. Lightstruck flavor is not desirable in any style but is fortunately rare in bottle-conditioned homebrew because the yeast helps inhibit the reaction and because of the predominant use of brown bottles. However many filtered European imports possess this quality due to poor handling or storage conditions.

Metallic

This character is perceived in the aroma and flavor is usually caused when the metals such as iron, copper and nickel are leached into the brewing water, the mash or the wort. They can sometimes arise from oxidation of lipids in improperly stored malt or during beer ageing. Very small amounts of these minerals are essential for yeast health, but too much produces flavors described as blood-like, inky or like coins. Brewers who obtain their water from a well should ensure that the water is treated to remove any dissolved metals, and porcelain-enameled steel brewing kettles should be discarded if the porcelain becomes chipped or cracked. Stainless steel brewing equipment generally does not contribute any metallic character as long as the surfaces that come into contact with the wort are allowed to passivate (oxidize) prior to use.

Musty

Musty aromas and flavors are also described as being earthy, moldy or like damp cellars, old books or decomposing wood. This off-flavor is generally a result of the growth of mold or mildew on malts, malt extracts or brewing equipment and is not appropriate in any style. The remedies include using fresh ingredients, storing open bags of malt in a cool, dry environment and sanitizing brewing equipment prior to use. Mildew can also grow on the interior of refrigerators used for fermenting lagers, and this character can leech into the beer and produce musty flavors. This situation can be prevented by periodically cleaning the interior surfaces of the refrigerator with a sanitizer solution. Musty flavors can also result from oxidation, in which case the beer may have corked or "cellared" notes. These were once regarded as acceptable and even desirable in the Bière de Garde style, but the current consensus is that this characteristic is more of a feature of mishandled commercial exports rather than how a fresh, authentic example should taste.

Onion-like/Catty

These flavors and aromas are produced by mercaptans, which are sulfidic compounds that can have a wide range of characteristics, including grapefruit, floral, tropical fruit, fresh-cut onions or garlic, catty, burnt rubber or raw sewage. They are usually formed by yeast through the metabolism of sulfur-containing amino acids, but they are also found in hop oils – particularly in some of the New World hop varieties. The mercaptans derived from hops have very low perception thresholds and can significantly influence the aroma of beer, either positively or negatively. At low concentrations, some of the mercaptans found in Citra and Mosaic hops have pleasant aromas similar to passion fruit, grapefruit, tropical fruit and sauvignon blanc grapes. At higher concentrations, they develop aromas that some tasters negatively compare to blackcurrent leaves, cat urine or underarm sweat, but others positively label as being "dank." The oils of Summit and Simcoe hops both contain a mercaptan which has an aroma like freshly-cut onions, and some dry-hopped examples of American IPAs and Double IPAs exhibit this characteristic. Higher mercaptans with aromas similar to raw sewage or burnt rubber are produced by yeast autolysis or bacterial contamination and are not appropriate in any style.

Paper/Cardboard

These characteristics are perceived in both the aroma and flavor and are primarily due to oxidation, which produces the aldehyde (E)-2-nonenal (formerly known as trans-2-nonenal). Depending on the beer style and extent of the oxidation, the flavors can be perceived as being like cut cucumbers, recycled paper, lipstick or wet cardboard. Pale-colored and low-gravity beers are more susceptible to developing these characteristics when oxidized, while darker beers with more malt complexity tend to develop the sherry-like flavors described below. (E)-2-nonenal has an extremely low flavor threshold of about 0.1 ppb and is inappropriate in any style. The threat of oxidation occurring in packaged homebrew can be minimized by avoiding splashing the beer while racking and bottling, ensuring that an adequate fill level with less than 2” (5 cm) of headspace, using oxygen scavenging bottle caps, and storing the beer at cool temperatures.

Phenolic (Clove-like/Spicy)

These flavors and aromas are due to phenols, notably 4-vinyl guaiacol, which produces the signature clove-like character in German Weissbier and some Belgian ale styles. These phenols are produced by special strains of *S. cerevisiae,* from the amino acid precursor, ferulic acid, and the level may be enhanced by incorporating a ferulic acid rest at around 111 °F, 44 °C (17). Some Belgian ale styles such as Saison sometimes exhibit peppery flavors and aromas which are also due to yeast-derived phenols. The levels of these phenols in the beer also depend on the fermentation temperature, with high temperatures favoring higher levels.

Phenolic (Medicinal/Wild Yeast)

As noted in Section IV, some wild yeast produce unpleasant phenols flavors and aromas described as medicinal, plastic-like, smoky or reminiscent of adhesive strips or electrical tape. Hence their control is usually a matter of proper sanitation. Chlorophenols are particularly offensive members of this family with additional bleach-like flavors that are derived from chlorinated water or sanitizer residue. Phenols may also be extracted from grain husks by overcrushing, oversparging or sparging with hot or alkaline water, and these compounds typically also produce an astringent mouthfeel. The leathery, horse blanket and barnyard characteristics in *Brettanomyces*-driven styles such as Lambic and American Wild Ale are also due to phenols, but these flavors are indicative of wild yeast contamination when they inadvertently appear in other styles.

Sherry-like

This is the aroma and taste of dry sherry and is often accompanied by hazelnut, almond or dried fruit notes. The flavor is produced by the oxidation of melanoidins, which are compounds that provide a rich malt character in fresh samples of some beer styles but transform into sweet sherry-like flavors when oxidized. One of the most common products of this oxidation is benzaldehyde, which has the flavor and aroma of bitter almonds, marzipan, dried cherries and cherry stones. A low to moderate sherry-like character is acceptable and adds complexity to Old Ales and English Barleywines. Well-aged examples of Weizenbock and Oud Bruin may also low sherry-like notes. High levels of these oxidative compounds give winey and slightly sour notes reminiscent of prune juice and indicate that the beer is past its prime. Sherry-like character is not appropriate at any level in lighter, low-gravity beer styles.

Solvent-like

This describes a pungent aroma and flavor similar to acetone, paint thinner or turpentine and is often accompanied by a hot, burning sensation in the mouthfeel. It is due to high concentrations of ethyl acetate and other esters, and possible fusel alcohols such as propanol and butanol. Possible sources include underpitching yeast, insufficient aeration of the chilled wort prior to fermentation, and fermenting on the trub – especially at elevated temperatures. Some yeast strains are more prone to producing these flavors than others, but this can usually be addressed through temperature control. Very low levels of solvent-like notes can add complexity and a pleasant “boozy” character to strong ale styles such as Old Ale, Barleywines and American Strong Ale but should never be excessively hot or unpleasant. Otherwise they are inappropriate and should be controlled by better management of the aeration and fermentation.

Sour/Acidic

This is one of the basic tastes, and the two most common acids responsible for this flavor in beer are lactic and acetic acid, which both have related esters that may be perceived in the aroma. Lactic acid is produced by Gram-positive bacteria such as *Lactobacillus* and *Pediococcus*, which are present in dust and saliva. It has the same sour character found in yogurt and sourdough bread. Acetic acid can be produced by several contaminants, including *Acetobacter*, *Zymomonas*, and yeast in the *Kloeckera* and *Brettanomyces* families. It's the sour component of vinegar, which must contain at least 4% acetic acid, and should be a familiar flavor to judges due to its use in many marinades, condiments and pickled food products.

High levels of sour and acidic flavors generally indicate a sanitation problem, but they are an important part of the profile of European Sour Ales (Berliner Weiss, Flanders Red Ale, Oud Bruin and Lambic) and Gose. Light (lactic) sourness is acceptable, but not required, in Belgian Witbier and Saison. Note that some examples of Weissbier have light citrus notes derived from the wheat malt which can be perceived as being slightly acidic, but any appreciable sourness in this style is inappropriate. Some dark beers such as Imperial Stout and Baltic Porter can have a slightly acrid (pungent or sharp) character from roasted malts, but this is different from the sour flavors due to lactic or acetic acid, which are undesirable in these styles.

Sulfury

The most common sulfury characteristic noted in beer is due to sulfur-dioxide, which is natural by-product of fermentation that is usually scrubbed out by a vigorous fermentation or dissipated during lagering. At high levels, it recalls the aroma of a struck match, but at lower levels provides a fleeting sulfury background note that is appropriate in German light lagers and Kölsch. This sulfury character is also appropriate and can be more persistent in Kellerbier and Australian Sparkling Ale. Some British styles (including Bitters and English IPA) sometimes have a mineral or sulfury character, but in this case, is derived from sulfates in the water rather than yeast. Sulfury flavors are more common in wines and ciders due to the common use of potassium or sodium meta-bisulfite as a preservative and antioxidant; however they are rare in US commercial beers because sulfite additives are legally restricted (<10 ppm without labeling).

Another sulfury compound sometimes encountered in beer is hydrogen-sulfide, which at low to moderate levels, has the aroma of rotten eggs. It is produced early in fermentation – particularly by lager yeast strains – but as with sulfur-dioxide, is generally scrubbed out by carbon-dioxide. At very low levels, it gives a desirable "fresh" character to many German lagers. At higher levels, the rotten egg character is more noticeable and unpleasant and should be addressed by changing yeast strains, ensuring that there is an adequate supply of FAN during primary fermentation and/or lagering for a longer time period. Bacterial contamination by *Zymomonas* can produce very high levels of hydrogen-sulfide which recall wastewater and raw sewage (this compound is the main component of sewer gas).

Sweet

Sweet flavors are due to the presence of unfermented residual sugars in the beer. High levels of residual sugars can result from flocculent or low-attenuating yeast strains (as in Scottish Ales). Abnormally high levels can be a consequence of poor yeast health linked to low FAN levels or low levels of dissolved oxygen prior to pitching. Both of these factors can lead to a "stuck" fermentation, which leaves the beer with a high final gravity and sweet worty flavor. High gravity worts, high dextrin content and the addition of lactose (Sweet Stouts) also play a role in determining the sweetness of the finished beer. Other components of the beer that can increase the perceived sweetness include ethanol (up to around 5% ABV) and the level of chloride in the water.

The level of sweetness can be controlled by adjusting the original gravity, the mash temperature, the amounts of caramel malts, the amounts of unfermentable or completely fermentable adjuncts, the length of the boil and the attenuation of the yeast. The appropriate level of residual sweetness will be style-specific and depends on the malt-hop balance and desired level of dryness in the finish. A high residual sweetness is desirable in strong beers such as Wee Heavy, English Barleywine and Eisbock, but inappropriate in dry styles such as American Lager, Berliner Weiss, Gueuze and Saison.

Yeasty

Yeasty character is not the same as fermentation character, which includes the ester, phenol and alcohol flavors described elsewhere in this section. Rather, yeasty character describes either the bread dough notes of fresh yeast or the meaty/brothy notes of autolyzed yeast. In the former case, there may be enough yeast in suspension to produce a light sheen or haze in the appearance, and high levels of suspended yeast can also contribute to bitterness (yeast "bite") and mouthfeel (a powdery sensation). The fresh yeast character is appropriate in unfiltered German lagers, Australian Sparkling Ale, Gose and some Belgian ales. Yeasty character is inappropriate in most other beer styles, particularly in lagers (unless they are designated as unfiltered) and British Bitters, in which finings are used to clarify cask-conditioned versions. Yeasty character can be controlled by using more flocculent yeast strains and by cold-conditioning the beer to facilitate sedimentation of the yeast after fermentation is complete.

Autolysis is the process whereby yeast cells self-destruct in the absence of other nutrients. It occurs in beers which were left on the yeast for too long after the fermentation has finished, or sometimes in bottle-conditioned beers that have been aged in a warm environment. Autolysis results in aromas and flavors of Vegemite, beef broth, or in extreme cases, like burnt rubber (mercaptan). These flavors are generally not desirable in beer, although low levels are often considered positive in vintage Champagnes, where their toasty notes are a key component of the "sur lie" (on sediment) character.