Beer Styles 2

2.1 Judging Beer

As a brewer, there are many different beer competitions. Some of the competitions are local (such as a competition within a homebrew club for the best "summer" ale), regional (such as competitions between homebrew clubs or for the best brew in the mountains), or even national (such as the Great American Beer Festival™). The contestants take these competitions very seriously. Much like the BBQ cook-offs outlined on TV, care is taken by the brewers to make sure that they have done the best job possible. Not only can cash prizes be awarded, but also any medal itself is highly coveted and proudly displayed by the brewer.

Each of these competitions requires that the brewer submit a couple of bottles of beer, properly labeled, and including the particular category to judge the beer under. Because there are only so many spots open in each competition, failure to submit the samples properly is often grounds for elimination from the judging. Once the samples have been accepted, the brewer just has to wait as the judges meet, taste, and evaluate each of the beers.

The results, when they finally arrive, outline the beer in terms of its appearance, aroma, and taste. This information can be very helpful to the brewer. It can be used to provide feedback on the quality of the beer as it conforms to the judge's perception of it. For example, it may have a buttery flavor and knowing that the flavor exists may be of assistance to the brewer in tuning the flavors for future batches. The beer may be unusually bubbly, indicating to the brewer some information about the packaging process.

Judges for a brewing competition can have a wide variety of experience. In some competitions, no experience is required. In others, at least one, if not all, of the judges on each tasting panel are required to have some formal training in judging beer flavors. Programs that can provide that training exist and include the Beer Judge Certification Program (BJCP; https://www.bjcp.org). This international volunteer-run organization provides testing and verification of judges.

M. Mosher and K. Trantham, *Brewing Science: A Multidisciplinary Approach*,
DOI 10.1007/978-3-319-46394-0_2

Training for certification as a judge can also be useful, as judges need to not only know about the possible flavors that can exist in beer, but also they must be able to taste them in beer. This means training your palate to identify the banana and clove components in a beer, to recognize and evaluate the carbonation that may or may not be present, and to have experience in recognizing how these components come together in a particular beer.

What areas do beer judges evaluate? This depends upon the competition. But most competitions judge a beer based on its appearance, aroma, taste, and feel in the mouth. The beer is carefully evaluated in each of these categories by the judges and a score generated. Then, beers can be compared based on the scores. With multiple judges, the beer with the greatest score is selected as the winner.

2.1.1 Beer Styles

If all of the beer in the world was made from an identical recipe, judging would be solely based on the process of the brewer, i.e., did the brewer follow the recipe correctly. But this is not the case. Beer in the world is not the same from region to region and even from brewery to brewery. We noted this in Chap. 1.

Beer was historically made from local ingredients. In today's world, this still holds true, in a way. If a brewer cannot get the ingredient, they do not make beer with it. And to carry this a step farther, barley, hops, water, and yeast have many different varieties or cultivars. With the added additions of adjuncts, variability in recipes, and even variability in the brewing process, beer is different everywhere you go.

However, there are beer recipes and processes that are relatively similar to each other. Many different attempts have been made to group these similar beers together into a common classification, known as a *style*. It should be noted and stressed that beers are classified into styles based on their similarities. Beers begat styles, rather than styles giving rise to beers.

For example, the beer style known as the American Lager became solidified after the US Prohibition years. This style began when brewers in the USA noted that to increase production with limited barley supplies, the heavy use of adjunct cereals (such as corn and rice) was needed. Recipes were formulated and explored. The consumers knew what they liked, and over time, they preferred the taste of the beer that they could get. The result was the style of the American Lager.

2.1.2 Conforming to a Style

Conforming to a style means that the beer being examined has characteristics that match those expected for the style. This does not mean that the beer is the best example of the style, nor does it mean that it is a beer that everyone would enjoy drinking. All this means is that the beer has flavor and other characteristics that would be expected.

As we just noted above, everyone does not enjoy every style. To be successful, a brewer in today's market should make beers that customers will drink. This means that a brewer might make a series of styles and test their sales. Those that sell quickly might find a place in the brewery lineup. Those styles that do not sell or sell sluggishly might either be retired from the brewery, or be relegated to seasonal production.

The brewer need not construct recipes that fit within a particular style. Using the "customer is always right" theory, or during exploration of ingredients, the brewer might put together a beer that falls in between styles, combines the characteristics of two or more styles, or just does not conform to any styles. For example, the interest of the beer consumer for the hoppier flavors found in the India Pale Ale style moved the brewery industry in some parts of the USA toward these ales. The success of the IPA style led to breweries trying to push the boundaries of what customers would buy. And the rate at which the new hoppier IPAs were gobbled up led to even more pushes on the boundary. Today, the original IPA style is only a distant memory of what it once was.

Today, many IPA-style beers sold on the west cost of the USA are very "hop-forward." In these brews, hops are used for bittering, for flavor, for more flavor, and for aroma. Then, more hops are added after the aroma hops just to make sure enough hop aroma is present. Some brewers even add another batch of hops just to really be sure. And customers line up outside the brewery when the new batch is finally released. Names of the beers hint at the sheer masses of hops used in their creation: Hoptimus Prime, Hopasaurus Rex, Modus Hoperandi, Hop Stoopid, Hoptopus, Hop Slam, Hops of Wrath, …and the list goes on. The new ultra-hoppy IPA caught on and is now ingrained in the typical brewer's portfolio. The pervasiveness of the new version of the IPA has led to beer-style classifiers declaring a new style, the American IPA.

Jokingly, but in most cases accurately, the authors of this textbook have often declared that the US version of any style is "more" than what the style guidelines for the non-US version dictate. Many of the American versions of the styles are more alcoholic than their European cousins. Many are more malty, more hoppy, or more sugary. The deviations are so "out of style" from the versions that they are attempting to emulate, that classifiers have granted new styles for these versions of the beers.

In short, conforming to a style does not have to happen. A brewer can spend the time to do so, but there are no rules that require the brewer to follow the existing guidelines. A brewer can formulate any recipe that they wish to create.

CHECKPOINT 2.1

Why do we say that a beer does not have to conform to a style?

What is a beer style?

2.2 Parameters that Classify a Beer Style

There are many characteristics of a beer that can be evaluated or measured. In this section, we will explore those characteristics and outline the basic parameters that dictate the flavor characteristics for beer styles. To ensure that the current batch of beer is the same as those previously made, the brewer can use these parameters. Alternatively, the consumer can use these values to judge the flavor or other properties of the beer prior to tasting. For example, a consumer may choose a beer with a certain alcohol content, or one with a heavier bitterness to go with the food they are eating.

2.2.1 Physical Parameters

IBU—The bitterness of the beer is often reported using a numerical scale known as the International Bitterness Units (IBU). In the USA, this is the scale of preference. In Europe, the scale used is known as the European Bitterness Units (EBU). In theory, both IBU and EBU should give the same values. However, in practice, the EBU value is slightly lower due to the differences in how the measurements are made.

The bitterness measurement is actually a quantitative measure of the amount of iso-alpha acids that are present in the beer or wort. It is not a measurement of the perceived bitterness when someone takes a drink of the beer; very malty or alcoholic beers have a perceived bitterness that is lower than the measured IBU value would suggest.

Brewing scientists measure the bitterness in beer using a spectrophotometer. The measurement is performed by extracting the acids into a solvent and then determining the amount of light that is absorbed at 275 nm (in the ultraviolet region of the spectrum). The test in the laboratory is fairly straightforward, but does require some time as the beer and solvent must be shaken vigorously for 30 min.

ABV Alcohol content is often one of the first physical parameters that is evaluated by the consumer during sampling of the beer and the brewer during the construction of the recipe. The brewer measures this parameter by many different methods. First, the alcohol content can be estimated by measuring the amount of sugar that has been converted to alcohol. And, if the brewer has access to a laboratory, the alcohol content can be determined by experiment.

In fact, the American Society of Brewing Chemists (ASBC) lists seven different methods for the experimental determination of alcohol content in beer. The variety of methods includes distilling a small sample of beer to move the alcohol and some water away from the rest of the beer sample, then measuring the density of the distillate (Fig. 2.1; Table 2.1). Other methods include the use of chemical instruments such as a refractometer, a gas chromatograph, or an instrument known as an alcoholyzer. For concentrations below 0.5 %, the ASBC recommends use of an enzyme (alcohol dehydrogenase) that is purchased separately. The enzyme converts

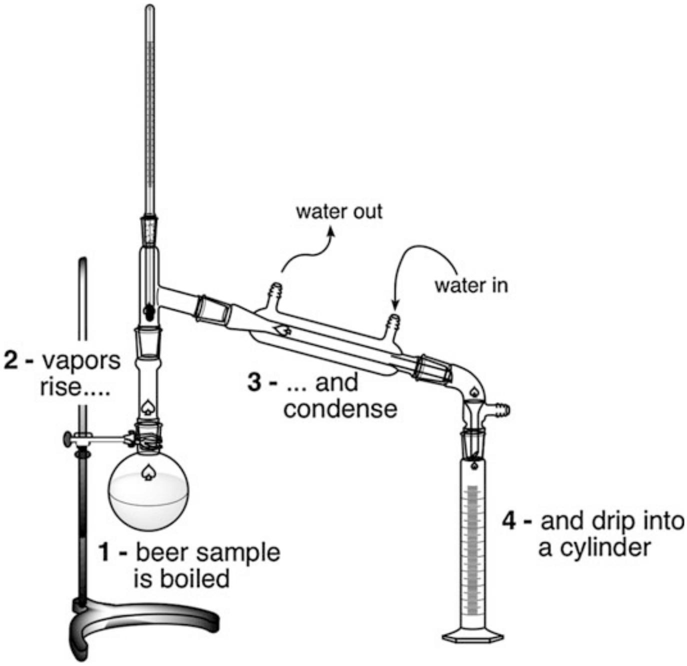

Fig. 2.1 Distillation of sample to determine ABV. A sample of beer is distilled and the alcohol is collected in a separate vessel. When diluted back to the original volume with pure water, the density or refractive index of the sample can be used to determine the amount of alcohol in the original beer sample

Table 2.1 Density of alcohol–water mixtures

ABV (%)	Density (20 °C)	ABV (%)	Density (20 °C)
0	1.000	50	0.9318
5	0.9927	55	0.9216
10	0.9864	60	0.8927
15	0.9808	65	0.8810
20	0.9753	70	0.8692
25	0.9698	75	0.8572
30	0.9638	80	0.8449
35	0.9572	85	0.8324
40	0.9496	90	0.8194
45	0.9412	95	0.8057

The concentration of alcohol in water can be determined by accurately measuring the density of the water at 20 °C ethanol into acetaldehyde, and then, the acetaldehyde is oxidized to acetic acid. An ultraviolet–visible spectrometer (UV–Vis) then measures the concentration of the alcohol.

Alcohol is typically reported in terms of the amount of alcohol by volume (ABV). Concentrations in beer can run from 0.1 to 12 % and beyond. Most beers in the USA have an ABV in the range of 4–7 %. In Europe, the average ABV is a little lower.

ABV does have an effect on the overall flavor of a beer. If the amount of alcohol is high, the drinker will notice warmth in the mouth and stomach. In some cases, if the ABV is very high, the beer will have a pronounced warming effect that might detract from the other flavors of the beer.

OG The original gravity (OG) of the wort before it is fermented is often measured. This parameter is an indicator of the amount of sugars in the liquid. A higher wort original gravity dictates that there are a lot of sugars (both fermentable and unfermentable). A lower original gravity says there are fewer sugars.

The sugar concentration of the original wort does not dictate the amount of alcohol that will be produced. While it can give the brewer an idea about the alcohol concentration, the amount of unfermentable sugars is not known. The unfermentable sugars, as their name implies, will not be converted into alcohol by the yeast during fermentation. Instead, these sugars contribute to the sweetness and thickness of the beer after fermentation has taken place.

OG can easily be measured using a glass device known as a hydrometer (see Fig. 2.2). This instrument is placed into a sample of wort and allowed to float. The higher it floats in the sample, the higher the original gravity. The lower it sinks into the sample, the lower the original gravity. The gravity of the liquid can also be measured easily by simply obtaining the weight of an accurate volume of the liquid. For example, the brewer could determine the gravity by obtaining the mass of a quart of liquid.

Gravity is just another name for the density of the sample. Density, or the mass of the sample per unit volume, can be represented by the brewer in the units of grams/milliliter (g/mL) or kilograms/cubic meter (kg/m^3). And if the gravity (or density) was determined by measuring the mass of a quart of liquid, the brewer would divide the mass of the liquid by the volume of a quart. Typically, though, this is done using SI units such as grams and milliliters. For example, a standard pale ale might have an original gravity of 1.048 g/mL or 1048 kg/m^3. Sometimes, a brewer may refer to a wort's density by just reporting the last two numbers of the density. This type of reporting has been called the gravity units (GU). Therefore, an OG of 1.048 may be referred to as 48 gravity units (or 48 GU).

The gravity can also be determined using other scales that reflect the amount of sugar directly. In the brewing industry, the scale created in 1900 and named after the German Fritz Plato is used. The scale is known as the Plato scale and represents numbers in degrees Plato (°P). This scale was based on the one developed in 1843

Fig. 2.2 The hydrometer. This simple device is inexpensive and extremely versatile in the brewing laboratory. It is placed into a sample of liquid and the density of the liquid read from the scale at the *top*

by Karl Balling (i.e., the Balling scale), but improves upon that scale by using percent sucrose (by weight). Dissolving a known mass of table sugar in a known mass of water provides the scale. For example, 10.0 gm of sugar in 90.0 gm of water gives rise to a 10 % solution (10.0 g sugar/90.0 g water + 10.0 g sugar) that is reported as 10 °P.

Degrees Plato and density are not identical in values nor do they have a linear relationship between themselves. The relationship is very close to linear, but is not, especially as the amount of sugar increases in the water. However, a quick way to convert the gravity to an approximate °P value is to divide the decimal portion of the density by 4. Alternatively, the formula below will provide the conversion. In other words, a gravity measurement of 1.048 g/mL would be approximately equal to a solution of 12 °P. Some hydrometers have both the density and the Plato scales written on them.

$$(\boldsymbol{Gravity} - \mathbf{1}) \times \mathbf{250} \approx {}^{\circ}\boldsymbol{P} \tag{2.1}$$

FG Final gravity (FG) is the density of the beer after fermentation has been completed. Just like OG, this is measured in units such as grams/milliliter (g/mL) or kilograms/cubic meter (kg/m^3). This is a measure of the amount of sugars that remain in the beer and that were not fermented. In other words, this is a measure of the amount of unfermented sugars.

In some cases, it is also a measure of the amount of fermentable sugars that were not fermented by the yeast. This would occur if the yeasts quit working on the production of alcohol due to some reason (such as going dormant when the concentration of alcohol got too high for the yeast to remain living in solution.)

FG is also measured easily using a hydrometer. Alternatively, the final gravity can be determined by weighing a known volume of the beer. To measure the density, though, factoring in the density of the liquid alcohol must be taken into account. Luckily, the density of alcohol–water mixtures is well known (see Table 2.1). And, the density of the alcohol water mixture does not deviate much from that of water alone in the ABV range of most styles of beer. However, as the concentration of alcohol climbs above 10 % ABV, the amount of error in the FG reading increases.

SRM The standard reference method (SRM), used in the USA, refers to the measurement of the color of the beer sample. The value of the color can also be reported as the EBC (European Brewery Convention) value. SRM and EBC differ by about a factor of 2. Measuring the amount of light absorbed by the beer sample at 430 nm and multiplying the value by 12.7 determines the value of SRM. The EBC method multiplies the value by 25. The ASBC methods of analysis require that the sample of beer is degassed (so that bubbles do not interfere) and that the sample is entirely free of turbidity (or cloudiness). In some cases, this means filtering the solids or centrifuging the sample. For example, measuring the color of a hefeweizen (an often cloudy German wheat-style beer) dictates that the sample be filtered. Alternatively, the SRM values can be determined by comparison of the beer color with a chart or colored disks that represent the colors along the scale from 1 to 40.

Colors for beers can range from a very light straw or yellow color (SRM 1–2) to a very dark or almost black beer (SRM > 40) as shown in Fig. 2.3. A spectrum representing all of the wavelengths of light that typical beer samples absorb illustrates that there is a continuous set of colors that beer can absorb. Coupled with the fact that multiple samples with fairly similar SRM values can have very different appearances, beer researchers have been working on identifying a different way to quantify the color of a beer. For example, it is entirely possible that an Irish Red Ale could have the exact same SRM as a Belgium Dubbel even though they have a very different appearance.

One such way to report the color of the beer involves the use of tristimulus color theory. This theory suggests that all colors can be accurately reported using the combination of three primary colors in differing amounts. When working on a

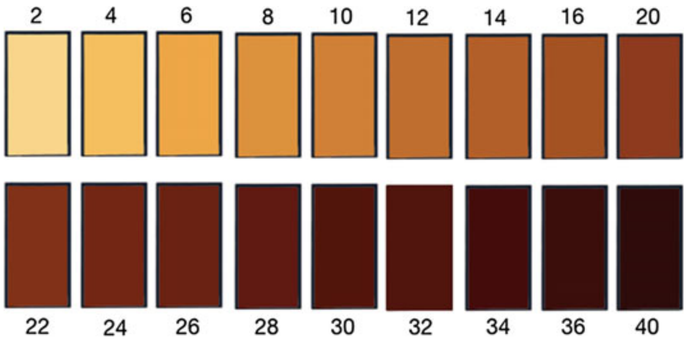

Fig. 2.3 SRM colors for beer and wort analysis

computer, we sometimes create colors by inputting values for the amount of red, the amount of green, and the amount of blue to mix to make the color. This is known as the RGB value for the color, one example of a tristimulus method for reporting the color.

For beer, however, the tristimulus color is reported in L*a*b* values, where L* is a number representing the "lightness" of the color (0 = black; 100 = white), a* is a number representing the position of the color between green and red (<0 = green; >0 = red), and b* is a number for the position of the color between blue and yellow (<0 = blue; >0 = yellow). The three numbers are required in order to represent the actual color of the sample.

The ASBC has developed a method for determining the tristimulus color of a beer sample. The method requires the measurement of the absorbance of light at many different wavelengths at a given angle from the source of the light. This is important, because the color of a beer sample is highly dependent upon the angle at which the sample is viewed in relationship to the source of light. In other words, if you view the beer sample at 90° from the light source, you would get a different set of L*a*b* values than if you view the sample from a 10° angle. The values for the measurement are also very dependent upon the level of carbonation and the degree of turbidity in the sample.

Turbidity, or cloudiness, in a beer sample has a significant amount of impact on many of the measurements made by the beer scientist. While some beer samples are naturally going to be turbid, such as a hefeweizen, the effect causes a lightening of the sample. Someone viewing the sample gets the impression that the beer is lighter in color than it actually is. Measuring the color using the tristimulus color method, then, requires that the beer is filtered.

CHECKPOINT 2.2
It is said that the amount of alcohol, as ABV, in a beer can be calculated using the equation (OG − FG) * 131. What is the ABV if the OG is 1.048 and the FG is 1.008? If the ABV is 6.5 % and the OG was 18 °P, what is the FG?

2.3 Common Beer Styles

There many different style definitions for beer, as we noted above. These include the Beer Judge Certification Program's 2015 guidelines that are periodically updated and/or retooled to account for new style classifications. They also include the Brewer's Association's guidelines that are annually updated to reflect changes in the classification details. While both are available online, they represent some significant details about beer styles that are beyond the scope of this textbook. However, with that said, we will explore some of the basic classification details that allow us to make some statements about beer styles. To aid this process, we will break the styles down into two main categories and each category into regional styles. A hybrid style breakdown will capture the majority of the rest of the styles.

2.3.1 Lagers

The lager style of beer was likely first started in the 1500 or 1600s in Germany. By 1860, the style had grown significantly in popularity. It is this "new" beer production process that caught on in the USA as German immigrants moved to the USA.

Lagers are characterized by the use of bottom-fermenting yeast (*Saccharomyces pastoranus*). This yeast strain requires the use of low temperatures during the fermentation step in brewing and followed by maturation or conditioning of the beer under very cool conditions. During the initial stages of the development of this major style classification, beer was fermented in caves or cellars where the temperature did not get very high. In fact, lagering may be part of the reason for statements in the Reinsheitgebot about different prices for beer were acceptable at different times of the year. During winter months, beer was less expensive because it was fermented and aged during the previous summer when the temperatures were warm. Beer fermented and aged at these higher temperatures often had many more flavors added from the yeast. The warmer temperatures ended up producing a beer that was not as crisp or clean. During the summer, the beer that was sold was fermented and aged over the previous winter (when the temperatures were colder). The colder temperatures produced fewer off-flavors and gave rise to a crisper, cleaner beer. But, this took longer to ferment and age, hence the slightly higher price.

> From Michaelmas (September 29) to Georgi (April 23), the price for one Mass or one Kopf, is not to exceed one Pfennig Munich value, and From Georgi to Michaelmas, the Mass shall not be sold for more than two Pfennig of the same value, the Kopf not more than three Heller.

The advent of refrigeration in the early 1800s meant that lagers were possible in locations that did not have access to year-round cool places. Because of the low temperatures during fermentation and conditioning, the yeast slowly converted sugars in the wort into beer. The process produced very few off-flavors. Therefore, lagers, in general, have a crisp clean flavor. They represent almost every color possible with other styles, but typically the head on the beer is white or off-white. Many lagers are very carbonated and bubbly, and many are relatively still.

2.3.1.1 European Lagers

European lagers are quite varied. While some accounts suggest that the lager style began as early as the mid-fifteenth century in Munich and its surroundings, the repeated brewing season over the winter months likely selected the lager strain of yeast. In the colder temperatures, the yeast that fell to the bottom of the fermenter had a better chance of surviving the cold. And thus, the style was born.

Many of the European lagers are represented in the traditional beers of Germany, France, and the Czech Republic. These lagers differ in the ingredients that traditionally are grown in the specific areas, but all have a fairly similar set of characteristics.

Pilsner The beer produced and consumed near the town of Plzen, Czech Republic, best represents the Pilsner style of lager. This style, first brewed in the early 1840s, is characterized by its golden color and slightly malty flavor. Noble hops tend to complement the flavor. Boiling portions of the mash as the beer is made (in a process known as decoction mashing) help to darken and flavor the beer. It is relatively lower in alcohol ($\sim$4 % ABV) and is very drinkable and refreshing.

Amber and Dark lagers A slightly darker style of lagers characterizes these styles. Anton Dreher (Vienna Lager) and Gabriel Sedlmayr (Oktoberfest) created two of the common members of this style after the lager yeast was identified and isolated. The style is characterized by a malt-forward profile with a slightly higher alcohol content than the pilsner style ($\sim$5 % ABV). The roasty malty flavor of the beer is coupled with crisp finish. Many of the examples of these styles are found served at festivals in October in Germany.

Bock This style of beer, which includes the dopplebock and eisbock, was historically made by brewers in the German town of Einbeck. When consumers in Munich first tasted this style of beer, it was an instant hit. They referred to the style as the beer made in "einbeck." Over time, the style became known as "ein bock."

Ein bock in german literally means “one goat.” The name stuck and is the reason beers of this style often have a goat on the label.

The main style of this category tends to be fairly malty with a relatively high alcohol content (~ 6.5 % ABV). The dopplebock (or double-bock) has typically the same amount of hops as the bock, but a little more alcohol (ranging from 7 to 10 % ABV). Partially freezing a bock and then removing the ice results in the eisbock version (eisbock literally translates to “ice bock”). The ice that is removed contains mostly water, but also contains a small amount of the off-flavors that are made during fermentation of the bock. Thus, the style becomes a little more malty with a greater alcohol content (ranging from 8 % ABV on up). Repeated partial freezing and removal of the ice can continue to “purify” the flavor and increase the alcohol content. Some commercial examples of the eisbock have greater than 30 % ABV.

2.3.1.2 English Lagers

Lagers in England are not the style that was originally preferred by consumers. However, in modern times, the lager style has become one of the best selling products. It is a bottom-fermented beer that is very crisp and clean in its flavors. Adjuncts, such as rice, are used to lighten the flavor of the beer, but most are made solely with lighter kilned malts. The lighter color and flavor of these beers compliments the lighter alcohol content (ranging from 3.5 to 4.5 % ABV). The low-alcohol content, light color, and crisp finish are likely the reason for their appeal.

2.3.1.3 American Lagers

The American Lager style is probably the best selling beer style worldwide (based on the amount of consumption of this style in North America alone). It is typically made with large amount of adjunct cereals (such as rice and corn). Both of these adjuncts ferment very cleanly and lend themselves well to the crisp, clean flavor of the beer. And in some cases, the beers mimic the flavors of the pilsners made in the Czech Republic. This particular style ranges on the lighter end of the ABV spectrum (from about 3.5–7.0 ABV) and on the lighter end of the SRM scale (from about SRM 2–6). The drinkability of the style also arises from the high levels of carbonation. Many, the authors included, have noted that there is nothing better to drink on a hot summer day after mowing the yard.

While some classifications make a distinction between the American Lager and the lower calorie versions of this style, we consider that they are in the same major classification. Similarly, rather than making a distinction between those made exclusively in the USA versus those made in Canada, Mexico, or other countries, the major style classification is somewhat identical across the entire set of examples from these countries.

CHECKPOINT 2.3
What is the relationship between *Saccharomyces pastoranus* and *Saccharomyces bayous*? (You may need to look this up on the Internet.)
Using the information in this section, propose a reason why the lager styles are more prevalent and diverse in Europe than they are in the UK.

2.3.2 Ales

The traditional method for the preparation of beer used yeast that fermented on the top of the wort. The top-fermenting yeast is *Saccharomyces cerevisiae*. This species of yeast prefers a slightly warmer temperature during fermentation, and with this warmer temperature, the yeast produces additional chemical compounds that give flavors to the beer. The flavors of ales tend not to be as crisp and clean as the lager, but contain some lingering flavors and mouthfeel that truly influence the experience of drinking. Because of this, a wider variety of ales exist.

Homebrewers often start their exploration of the craft by creating ales. This is an easier style of beer to make and is a great one in which to practice the craft of brewing. The style does not require the colder temperatures of fermentation and conditioning that the lager styles require. And, the ability to create malty, hoppy, sour, and other flavors easily is very accessible.

The microbrewer and startup brewery also tend to focus on the preparation of this style for the same reasons. Ales are easier to produce, and the variability of the ingredients and yeast varieties alone gives rise to a wide variety of flavors. Furthermore, the need for expensive refrigeration, decoction, and/or longer time from production to sale makes the ale the obvious choice.

As we noted, there are a very wide variety of ales. Many are simple modifications of the original. Basic groupings of these into three main style classifications are discussed here.

2.3.2.1 European Ales

Beers from Belgium, France, and to some extent Germany predominate this classification. The German version of this class of styles tends to be made with wheat or rye. In many cases, the wheat must occupy at least 50 % of the total amount of grains used to make the beer. Because of this, many of the styles are cloudy due to the high levels of wheat proteins. They tend not to be very bitter, but instead, showcase the flavors of clove and banana. Some of the German ales mimic the bock style, but are made using the top-fermenting yeast rather than being lagered.

The Belgian and French ales showcase rich, deep, and complex flavors. They can be divided into two main categories based on this.

Sour Ales These range from slightly tart or barely perceivable sourness to the very sour. The base of the beers comes from the use of pale malt (and sometimes from the use of large amounts of wheat). As a class of beer, the malty flavors are complemented with complex fruity and/or spicy notes. The level of alcohol ranges dramatically based upon the specific style or region in which the beer is made. The most predominant flavor is that of the sourness due to the use of wild yeast, Lactobacillus (which produces lactic acid—a sour flavored compound), or Brettanomyces (a yeast strain that produces many off-flavors along with a mild sourness).

Sour ales in this category include styles known as Saison, Oud Bruin, Witbier, Berliner Weisse, Lambic, and Geuze (not to be confused with Gose—a beer made from salty water with added coriander spices). Many of the beer styles in this category originate from what is referred to as a “farmhouse” style. This refers to the early production of beers by residents making their own beers at their home. With limited equipment, the beers often were inoculated using spontaneous fermentation. The results of allowing spontaneous fermentation are the inclusion of some wild strains of yeast and bacteria. These strains become stable in the overall beer-making process as they inhabit the casks that are used. Mild and wild flavors (sourness, complex fruity, spicy) often result from this method.

Belgian Ales Ales made in Belgium are typically malt-forward with an alcohol content that is greater than the sour ales (ranging from 6 to 12 % ABV). These beers also have a very complex flavor and darker colors. Aromas and flavors of prunes, raisins, and other dried fruits can be found in the styles. While hops are used, these strong fruity flavors and malty background gives the drinker the impression of wine. The higher levels of alcohol in the beers give rise to their names: dubbel, tripel, quadrupel, etc.

Particularly noteworthy examples of this style are those made by Trappist Monks. The Trappist order is originated in France and throughout the Middle Ages, and this order produced beer for the local communities. Over the ages, the beers and style that were produced became quite desirable by those fortunate enough to sample them. Today, eleven Trappist breweries exist and are the only ones licensed to brew beer and call it a Trappist Ale (the oldest brewery with this designation is the Basserie du Rochefort that began in 1595). For a brewery to be allowed to use the Trappist designation, its beers must be made inside a Trappist monastery, not as the primary work of the monastery, and the proceeds from the sale of the beers must only go to cover the living expenses of those in the monastery. Any remaining profits are donated to charities.

Related examples of the Trappist Ales are known as Abbey Ales. When breweries are unable to be classified as Trappist, they can still produce beers that are similar in style, although they are not held to the same rigorous style guidelines. However, brewers are not just allowed to use the Trappist name to describe the flavors that they have created. So, they use the name “Abbey” to refer to their beers.

2.3.2.2 English, Scottish, and Irish Ales

The classification of the ales from England, Scotland, and Ireland includes a wide variety of relatively similar products. The similarities are not very obvious, but exist in the type of malt and hops that are used in the creation of these beers. While grouping the myriad of different styles into this one category eliminates many of the special styles that deserve individual mention, the general trends in the differences of the styles are the intent.

English Ales This class of styles is quite varied. With the exception of the barley wine, imperial stout, and robust porter styles, the entire class of ales typically has an alcohol content at the lower end of the spectrum (ranging from 3 to 6 % ABV, with many of the examples falling in the 4–5 % ABV range). Malt tends to predominate the main flavors with a noble hop aroma and flavor. Most are very well balanced between malty and hoppy.

As the demand for these ales outside of the country became high, the brewers began adding additional hops or increasing the alcohol levels in order to improve the shelf life of the beers. This was necessary as many of the ales had to be shipped overseas on long voyages. When the lighter colored pale ales were stored in kegs with additional hops added and then shipped to colonies in India, the beer style known as the India Pale Ale was born. When the darker more malty beers were brewed to contain higher levels of alcohol and shipped to Russia, the Imperial Stout and Robust Porter styles were produced. But for the exported beers, the majority of the styles in England were very drinkable throughout the day with lower alcohol contents.

One of the more interesting styles in this category is the Porter. This beer was initially produced in the 1700s as a drink for the workers in the shipyards (i.e., the porters who loaded and unloaded ships). It was first made around 1721, though historical records are somewhat confusing as to which brewery is likely the producer. Brewers noted that they could sell beer that was flavorful, but had a lower ABV, to these customers at lunch, dinner, or after a shift, if it were inexpensive to purchase and not inebriating. And the beers sold quite well as a thirst quencher. At the time, most of the inexpensive malt was kilned over wood fires and had a smoky aroma and flavor and a brown color. The beers, thus, also had these flavors and colors. The smoky flavors likely were reduced by relatively longer maturation times in wooden casks or kegs. As the industrial revolution brought about cheaper ways to make malt (without the smoky flavor or darker color), the brewers modified the recipes by adding chocolate malts and roasted barley to give back the darker colors to the finished product. The porter style almost died out entirely when customer preference for lighter ales became the trend, but has since found a resurgence in the craft beer drinker.

The porter style is a deep dark-colored beer that is very malt-forward. It typically has a lower alcohol content (ranging from 4 to 6 % ABV) with complex caramel, coffee, and/or chocolate notes. It has a light-colored, almost white, head that appears contrary to the dark color of the beer. And, it is very drinkable.

The porter is not to be confused with the stout, but is currently a very close cousin to the stout. The stout began as simply a stronger version of beer; a customer might ask for a "stout porter," meaning a stronger version of the porter. In fact, the first mention of a stout in 1677 likely predates the production of a beer known as a porter. The stout, as a current style, has a dark, almost black, appearance and a pronounced bitterness that complements the roasty, toasty, somewhat "darker" flavors of caramel. The head can be white, but also can be tan to brown in color. Alcohol concentrations range from 4 to 6 % typically, but can be much higher in the imperial or extra categories of stout.

Scottish Ales The more malty flavors of the Scottish Ales are obvious in this class. The limited use of hops is apparent with some earthy or estery flavors. The result is a malt-forward beer that has very little hoppiness or bitterness. While this is the case, the result is not an overly cloying or sweet flavor. The alcohol content tends to range from about 2–5 % ABV, and is often denoted in the number of shillings associated with the name of the beer. For example, a 90-shilling Scottish Ale would have a higher ABV than a 60-shilling version. The color of the ale also can be related to the number of shillings and ranges from a golden to copper color.

Irish Ale The most commonly thought of Irish ale is likely the stout. This style of beer is characterized by a very dark, almost black, color and a hop bitterness that is accentuated by the use of roasted and darker malts and barleys. The darker roasty flavors and astringency from the use of these grains is characteristic of the style. The creamy tan-colored head on the beer is a necessity. Increased alcohol contents are found in the export versions of the Irish Stout. Guinness makes one of the more recognized versions of the Irish Stout. Initially, the beer we know as Guinness Extra Stout was known as Extra Superior Porter, reflecting the appropriation of the word "stout" as a stronger version of the porter style.

Also in this class is the Irish red. This beer style is malty but has a strong bitterness from a hop addition early in the production of the beer. Often the grains used are such that the color of the beer is deep amber to red or copper. Very little, if any, hops are noted in the aroma or flavor of the beer. And the alcohol content tends to be in the 4–6 % ABV range. The result is a very drinkable beer with a dry finish that invites another sip.

2.3.2.3 American Ales

As expected with this classification, the sky is the limit for any of the ales produced. Many are mimics of the styles found elsewhere on the globe. However, in mimicking the style, many of the brewers exaggerate or downplay a characteristic or two (or more) for the original style. This does not mean that these are poor versions of the original style, but instead that they are examples of an American version of the style.

For example, many different breweries in the USA have produced mimics of the India Pale Ale style from England. The more successful IPAs, in terms of consumer preference, are extremely hop-forward. As we noted in Sect. 2.1.2, this particular style has been taken to the far extreme.

Another example lies in the American version of the Porter style. This style is often very flavor-forward with emphasis on the use of chocolate- or coffee-flavored malts. In some cases, the American Porter is flavored with the addition of cold coffee extract or chocolate nibs (cocoa beans) to emphasize those flavors in the finished beer.

CHECKPOINT 2.4

How is it possible that the same flavor of a farmhouse style ale from Belgium could be obtained from spontaneous fermentation?

The Gose style is mentioned in this section. Compare and contrast it to the Geuze style. (Use the Internet to find information on these two styles.)

2.4 Historical Beer Styles

Many beer styles have been lost to time, but were described or written about in historical documents. These styles either fell out of favor with the consumers, their ingredients became difficult to obtain, or laws and rules eliminated the options available to make these beers. The rapid growth in interest for craft beers has resulted in these styles being reintroduced.

For example, George Washington, one of the founders of the USA, was not only a statesman, but a wealthy plantation owner in the eighteenth century. As we uncovered in Chap. 1, almost every household brewed their own beer for consumption. In Washington's case, this meant the production of fairly large quantities of beer to supply everyone that lived at Mount Vernon. One such recipe for the construction of a table-strength or small beer (low alcohol for consumption any time of the day) survives from George Washington's personal notes:

> Take a large Sifter full of Bran Hops to your Taste – Boil these 3 h. Then strain out 30 Gall. into a Cooler put in 3 Gallons Molasses while the Beer is scalding hot or rather drain the molasses into the Cooler. Strain the Beer on it while boiling hot let this stand til it is little more than Blood warm. Then put in a quart of Yeast if the weather is very cold cover it over with a Blanket. Let it work in the Cooler 24 h then put it into the Cask. leave the Bung open til it is almost done working – Bottle it that day Week it was Brewed.
>
> —George Washington, personal papers, 1757

Attempts to reconstruct this beer have been made by both homebrewers and commercial operations. Similarly, many other beer recipes have been identified in the literature and have been converted into beers. Some of these have even become very well-known commercial products. For example, the kottbusser style was originally descriptive of the ale made from wheat, oats, malt, honey, and molasses. A couple of commercial breweries in the USA have revived the style.

Some US brewers take specific steps to research and then produce a style of beer that has not been tried in the modern ages or is fairly rare on the US market. This includes the Kottbusser ale, the Kentucky Common ale (preprohibition ale common in Louisville), the Gose ale (made with salt water, coriander, and sour-producing bacteria), and Grodziskie (a Polish smoked-wheat ale). Additional styles and recipes continue to be located in the literature nearly every day. Its likely the better tasting ones will find their way to the commercial market.

One particular example of a little known style in North America is quite common in South America, chicha. Chicha is a drink that pre-dates the European migration to the New World. This beer style is entirely corn based (with flavorings added both pre- and post-fermentation). Since the corn is not malted prior to fermentation, masticating (chewing) the corn provided the enzymes needed to mash the corn. Spontaneous fermentation from wild yeast produced the finished cloudy beer. Yes, at least one commercial brewery produces chicha in the USA. And yes, the brewers take turns chewing on the corn and then spitting it into the mash tun. This definitely sounds like a beer everyone should try.

A search of old manuscripts, letters, and documents from the library (or digital library) may reveal a new beer recipe that has fallen into obscurity or even extinction. A little research and you may become the brewer that resurrects the style.

CHECKPOINT 2.5

The Reinheitsgebot outlawed styles such as the Kottbusser. Why?

Write down the recipe from George Washington and then "translate" it into masses and volumes that would be used today.

2.5 How to Sample and Taste Beer

Professional beer tasters have a specific set of steps that they follow as the drink a beer. Those specific steps allow them to examine every characteristic of the beer, from the flavor to the appearance and even beyond into the after-effects of the beer on the palate. Their method gives them the best chance to determine flavors that should not belong, evaluate the level of carbonation, or recognize the mouthfeel of the beer as it is consumed.

Every beer taster follows the steps in a slightly different way. Their individual modifications of the steps play to their strengths in analyzing beer. Some tasters have a very good eye for bubbles and gaze deeply into the beer. Others have a weaker sense of taste for certain off-flavors and spend considerable time slurping, swishing, and breathing while consuming a small sample. But all take their time to make sure that their evaluation is the best it can be.

For the non-professional, there are a few steps that can be taken to ensure that we are evaluating the beer in a way that allows us to appreciate every part of the brewer's invention. Of course, one could always rely on the use of laboratory analyses to give the impression of the beer, but this is not the best method. When it comes to determining if the beer tastes good, we have to rely on our senses. Thus, we have to taste it.

2.5.1 Beer Glasses

The best way to analyze the beer is to sit down and pour it into a glass. That does not mean "drink the beer from a glass bottle." That means we should open the beer container and pour it into a glass. The packaging is simply just that, packaging. While many of us grab a cold one and drink it right from the bottle or can, this is not how the brewer likely intended their hard work to be consumed. To honor the brewer's work, the glass should be used to truly enjoy the beer.

In fact, specific types of glasses go with specific styles of beers. It is the beer drinker's responsibility to make sure that the beer they are examining is consumed from the glass that works best. That is the glass the brewer envisioned as they constructed the recipe, and it is the glass that best accentuates the style of the beer. And with the myriad of styles that exist, there are an accompanying wide variety of glasses to choose from.

The basic styles of glasses are shown in Fig. 2.4. They include glasses that are tall and short, fat and skinny, and round and straight. The pilsner glass is intended for light clear bubbly beers, such as the pilsner style. The mug or tankard is for lower alcohol beers. Typically, when made of glass, this is the vessel chosen to serve light-colored beers, such as those of the Oktoberfest style, but even other low-alcohol beers can also be used. Related to the mug or tankard is the beer stein. The stein is often a ceramic vessel with a pewter lid (originally put there to keep out flies), but wooden, leather, and glass versions do exist.

The weizen glass is a tall glass with a protrusion in the wall that gives the top of the glass a globe-like shape. This glass is often used to serve wheat beers; the wheat beers tend to have fairly large heads; and the large area at the top of the glass allows it to hold the foam. In addition, the wide area at the top enables the drinker to really understand the aroma of the beer as they consume it. The pint, nonic, and the stang glasses are related to the weizen by shape, but have very different purposes. The pint glass is the standard ale glass used in pubs, taprooms, and bars everywhere to provide patrons with a pint of beer and a large area at the top to smell the aromas. It has straight sides. The nonic differs in that it has a bulge near the top that is wider

Fig. 2.4 Glasses used in drinking beer. From *left* to *right*: pewter mug, chalice, flared top stang, goblet, pilsner, pub glass (cross between a weizen and a pint), stein, and pint (from the author's own collection (MM))

than the glass is at the top. This bulge stops the glasses from getting chipped on their lips when they are stacked or clinked together. The stang is a straight-walled glass used for many German beer styles such as the kölsh, dunkel, and doppelbock.

The chalice, snifter, and goblet glasses are related in their shapes. They tend to be used for beers where the consumer can sink their nose into the glass and smell the aromas. The chalice is squat and wide at the top, the snifter is round and narrow at the top, and the goblet has the shape of a wine glass and is narrow at the top. These also tend to be used for higher alcohol more flavorful beers.

Many breweries have made their own versions of different glasses, and some have even created new glass styles. For example, some breweries serve their beers in mason jars, others in glasses that mimic the aluminum can, and still others in the shape of a boot, ball, or other object. In many cases, these are the glasses the brewer intends you to consume their hard work. Yet, some are simply unique glasses used as advertising for the brewery.

2.5.2 Serving Temperature

Serving temperature for a beer is more important than the glass that is used. Beer that is consumed at a temperature that is too high will accentuate the off-flavors in the beer. While that might be good for trying to determine those flavors, it is not appropriate for trying to get the best flavor out of the beer. Moreover, when the temperature of the beer gets too high, the sensations of carbonation and the bitterness from the hops decrease. This is not good for an IPA at all. Conversely, beer that is consumed at too low of a temperature will deaccentuate all of the flavors in the beer. In other words, too cold and you cannot really taste anything other than the carbonation and bitterness.

This leads to a common mistake in beer drinking, the “frosty mug.” This should never be done. In addition to freezing the beer as you pour it into the glass, it adds water to the brewer’s creation and dilutes the flavor. The beer becomes very cold and can eliminate the flavors that are intended in the product.

The best temperature for a particular beer style seems to mimic the SRM value or “richness of flavor” for the beer. Lighter beers, such as the American Lager and Pilsner styles, tend to favor the lowest temperatures. The darker beers, such as a barley wine or Belgian Tripel, prefer a much warmer temperature to allow the consumer to taste everything in the beer, as shown in Table 2.2.

Beers that are served directly from a cask (i.e., cask ales) are lightly carbonated, and the flavors of the beer should be the focus of the beer. This style of ales is seeing a strong resurgence in the UK and elsewhere in the world. Serving temperatures for these beers (no matter the specific style) should be around 12 °C. Contrary to popular opinion, they are not served at room temperature. In fact, no beer should be served that warm.

CHECKPOINT 2.6

Suggest a glass and serving temperature for a Märzen style beer. (Use the Internet to learn about this style.)

Assume a new glass has been invented that constantly forces bubbles to form at the bottom of the glass. Which styles of beer would benefit from use of this glass?

Table 2.2 Suggested serving temperatures

Style	Temperature (°C)	Style	Temperature (°C)
Amer. Lagers	2	Wiezen	7
Pilsner	4	IPA	9
Blonde Ale	4	Porter	10
Belgian Ales	7	Stouts	10
Sour Ales	7	Trappist/Abbey	12

2.5.3 Sampling and Tasting

There are four specific qualities in beer that need to be analyzed by the senses. They rely on our eyes, nose, and mouth to do the measurement and require that the beer be served at the appropriate temperature, and in the appropriate glass, in order to get the most from the sampling. Some judging takes place by pouring the beer samples into small taster glasses. While the judges understand how to adjust their analysis to account for the small glass, this is not even close to the appropriate method for maximum enjoyment of the brewer's project.

The key features of the sensory evaluation that are typically explored are as follows:

- Appearance,
- Aroma,
- Taste, and
- Mouthfeel.

The appearance of the beer is determined by evaluating the beer in two steps. First, as the beer is poured, special attention is paid to the quality of the "pour." Is the beer thick and syrupy, or is it thin and watery as it is poured. Second, the beer is examined in the glass like a fine gemstone. It is held up to the light to judge its color, which also gives the judge the opportunity to examine the bubbles and the head on the beer itself.

The amount or thickness of the head often results in the perceived quality of the beer. Is the head thick and rich with small beer-covered bubbles, or it is small and thin? Are the bubbles uniform in size and mostly small? Is the head similar throughout, or are there regions where the bubbles seem to clump into large "icebergs"?

Then, the next step in analyzing and enjoying the beer is to hold the glass close to the nose and allow the aroma to be sampled. The aroma can be based on the hops that are added near the end of the boil, but can also come from other sources. Does the malt shine through into the aroma? Can you smell the off-flavors of diacetyl (butter), apple (acetaldehyde), vinegar (acetic acid), or creamed corn (dimethyl sulfide). While some of the off-flavor aromas are needed and required as part of the style, many are not and should not be found in beer.

Multiple ways to pull a sample of the aroma of the beer into the nose exist. One such way is to rapidly pull small amounts of the beer into the nose with miniature exhales. In this method, approximately 4–5 small puffs of the aroma are brought into the nose within as many seconds. The beer should then be removed from under the nose immediately after the puffs are sampled. In another method, the beer is placed near the nose and the sampler then pulls a long deep draw into the lungs. Again, the beer is removed away from the nose as quickly as possible after the sample. If the glass is small enough, such as the sampling glasses found at a judging competition, the hands can be cupped around the mouth of the glass and then around the nose. In this way, only the aromas from the beer are pulled into the nose.

Of course, with any of these methods, it is imperative that the sampler not be wearing heavy cologne or perfume. The use of hand creams should be avoided (even the unscented ones can have an impact on the aroma of the beer). Other distractions, such as loud music, talking, and overly bright lights, can have a negative impact on the sampler's ability to judge the aromas of the beer.

The beer taster then puts a small sample in their mouth (about 10–15 mL or 0.5 oz) and swishes it around. There are many ways to do this. One of the easier ways is to pretend that you are eating a bit of food and chewing the beer. In other words, the consumer moves their jaw up and down while sampling the beer. The effect is to add oxygen into the beer and allowing the vapors from the beer to mix as they go to the back of the throat. Those vapors are the aroma of the beer and must hit the palate fully oxygenated in order to give the appropriate result.

Sometimes, the beer is spit out of the mouth. For a judging process or for those beer aficionados visiting a beer festival, this is not a bad thing. With the shear volume of samples, it is not required that the beer be swallowed in order to determine the appearance, aroma, flavor, and mouthfeel. As Anton Ego, a food critic in the movie *Ratatouille* said:

> "I don't like food - I love it! And if I don't love it, I don't swallow."

There is nothing wrong with that approach to tasting and drinking beer.

The final sensory experience that assists in determining the overall characteristics of a beer is known as the "mouthfeel." To use a tautology, mouthfeel is how the beer feels when it is in your mouth. The sensations that the beer causes when it is in the mouth (not the flavor or taste, although there is some overlap) are referred to as the mouthfeel. This characteristic covers three main areas of sensations: after effects, carbonation, and thickness. Some descriptors (words that describe the sensation) that are related to the mouthfeel of a beer include warming (from alcohol), astringent (tea-like dryness), flat (no bubbles), gassy (opposite of flat), creamy (coats the mouth like milk), and thin (like water).

Judges often record their notes in each of the four categories to assist in their grading of the beer sample. In some cases, this is very helpful to the brewer (whether they win first place or not), because the notes can provide information about another person's perception of the beer. When the information is detailed, the data can be used to adjust a recipe or a process.

But that is not the only place information about a beer should be obtained. One of the major and most important analyses to perform is the sensory analysis. In fact, even if a microbrewer or nanobrewer lacks a laboratory to calculate the key aspects of a brew, they should still have access to a panel of tasters. By giving samples to the tasters, the brewer can learn about off-flavors, consistency, and other aspects of the beers that they make. These results should be obtained constantly to determine the quality and customer satisfaction with the beers the brewer makes. We will uncover this in much greater detail in Chap. 12.

Chapter Summary

Section 2.1

Beer styles represent a classification system that groups beers with similar characteristics together.
There is no requirement that a beer must be made to fall within a style category.

Section 2.2

Physical characteristics that can be measured for a beer include OG, FG, IBU, ABV, and SRM.

Section 2.3

Ales and lagers are the main categories of beer, classified based on whether the yeast is top-fermenting or bottom-fermenting.
Most styles can be classified into European, English, or American categories.

Section 2.4

Historical styles are on the rise as brewers and consumers look for new tastes in beer.

Section 2.5

Beer glasses come in many different shapes and are based on the style of beer that should occupy the glass.
Beer should always be served at the appropriate temperature to ensure the best experience.
Tasting and evaluating a beer is very important in determining the flavor characteristics.

Questions to Consider

1. Describe the key differences between an American Pale Ale and a European Pale Ale.
2. Use a Web site that describes beer-style information. Use that site to compare and contrast the ABV and SRM for the bock and doppelbock styles.
3. Repeat question #2 to determine the flavor characteristics of the helles and kölsch styles.
4. Describe how the alcohol content could be determined for an American Lager style beer. Would your description change if the beer style was an Irish Red Ale?
5. Use the Internet to lookup and report the style characteristics for the California Common style. What is unique about this beer style?

6. What would you say to a brewer that wanted to make a beer that had some of the flavor characteristics of a weizen and some of the characteristics of a porter?
7. Why would the German ales likely not conform to the Reinheitsgebot?
8. Describe the best glass to use to drink a porter.
9. Use the Internet to provide the history of the porter style. Be sure to include a discussion of "three-threads."
10. Given the information in this chapter, how would you arrange a sampling room to obtain the best results of a sensory analysis of a single beer?
11. Is there a relationship between OG and FG?
12. Is there a relationship between OG and SRM?
13. The alcohol content of a beer can be reported in ABV and ABM (alcohol by mass). Given that the density of pure alcohol is 0.789 g/mL and water is 1.000 g/mL, which measurement (ABV or ABM) would provide the larger number?
14. Using the information in question #13, calculate the ABM for a beer that is 4.0 % ABV.
15. Why is the SRM difficult to report above 40?
16. If a brewer wished to report the SRM of a beer that was a 60, how could this be done using only the beer and water?
17. Use the Internet to look up information on how chicha, umqombothi, and chibuku are made.
18. Look up a flavor wheel on the Internet and describe the flavors for at least two different key descriptors.
19. What is the density of a 10 °P wort? …16 °P? What is the °P for a wort with a density of 1.069 g/mL? …1036 kg/m^3? …52 GU?
20. What is the ABV of a beer that had an OG of 14 °P and an FG of 1 °P?
21. Explain how two nearby towns could be responsible for two completely different beer styles.
22. Throughout South America, the native population produced chicha long before the arrival of the European settlers. Explain why this style was found across this wide region.
23. Use the Internet to determine how a refractometer works.

Laboratory Exercises

Density measurements

This "experiment" is designed to provide the student with a clear understanding of the term density and when and where it makes sense to use it. When coupled with use of refractometry, the information in this experiment gives excellent background on determining alcohol levels in beer.

Equipment Needed

Laboratory scale to 2 decimal places
Graduated cylinder, 10 mL and 100 mL

Erlenmeyer flasks (3), 125 mL or 250 mL
Beaker, 50 mL and 250 mL
Hydrometer and hydrometer tube
Refractometer, handheld, or Abbé style.
Bag of cane sugar.
Ethanol, 100 %, denatured or punctilious

Experiment

Prepare three solutions. The first solution should be 10 gm of sugar dissolved in enough water to make 100 mL. The second solution should be 10 mL of ethanol and 90 mL of water. The third solution should be 5 gm of sugar and 5 mL of ethanol dissolved in enough water to make 100 mL.
Measure the density of the solutions using the hydrometer by pouring the solution into the hydrometer tube and using the hydrometer. Then, the density of the solution is measured using the 10 mL graduated cylinder. To do so, mass the cylinder empty and then add at least 5 mL of the solution to the cylinder. The density is recorded by dividing the mass of the solution in the cylinder by the exact volume that is in the cylinder. Compare the hydrometer and the density numbers to determine the accuracy of the two methods.
The refractive index for each solution is then determined by placing a drop of each solution on the refractometer and reading to at least 4 decimal places.
The density and refractive index for pure water and pure ethanol should be determined as well.
Finally, a plot of the density as a function of the percent sugar in the solution should be made. Is this plot linear or is there some other relationship?
A plot of the refractive index as a function of the percent sugar should also be made. Also, make a plot of the refractive index as a function of the percent alcohol. Are either of these two plots linear or is there some other relationship?
What conclusions about the use of density and refractive index can be made?

SRM Determination

This “experiment” is designed to provide a rapid evaluation of the color of a beer using a spectrometer to determine the actual value for the SRM.

Equipment Needed

Visible spectrometer capable of reading 430 nm and 700 nm
Graduated cylinder, 10 mL
Test Tubes (6), 20 mL and a test tube rack
One bottle of a clear “dark” beer such as a porter
One bottle of a clear “medium” beer such as an amber ale
One bottle of a clear “light” beer such as an American lager
One bottle of a cloudy “light” beer such as a hefeweizen

Experiment

Obtaining a 10 mL sample of the “dark” beer. Swirl the beer and mix it until it is fully decarbonated. Then, dilute 5 mL of the beer with 5 mL of water (50 %). Dilute 5 mL of the 50 % beer with 5 mL water (25 %). Repeat this two more times to create a 12.5 and 6.75 % dilution. Then, obtain the absorbance at 430 nm of each sample, 100, 50, 25, 12.5, and 6.75 %. For each value, if the absorbance at 700 nm is more than 0.039 times the value of the absorbance at 430 nm, the value should not be used. If the absorbance at 700 nm is less than 0.039 times the value of the absorbance at 430 nm, multiply the absorbance at 430 nm by 12.7. The result is the SRM value for that sample.
Make a plot of the value of SRM versus the dilution factor for the dark beer. Is there a linear relationship? If not, what is the relationship and why is not it linear?
Then, repeat the experiment and create the plot with the “medium” colored beer. Is there a linear relationship in this case?
Finally, measure the SRM value for the two “light”-colored beers.
Then, draw some conclusions about the beer analysis and what it means in terms of measurement of the color.

http://www.springer.com/978-3-319-46393-3

Brewing Science: A Multidisciplinary Approach
Mosher, M.; Trantham, K.
2017, XIII, 408 p. 176 illus., 104 illus. in color.,
Hardcover
ISBN: 978-3-319-46393-3