Chemical analyses for quality control of worts and beers

Introduction

In recent years, the international brewing industry is evolving into a growing offer of craft beers, which arises from the demands of consumers, refining themselves to taste and quality.

We're talking about the so-called "craft beer revolution", which has oriented marketing strategies towards a recovery and a reinterpretation of traditional styles, as the use of raw materials, in order to enhance their autheticity. Even in Italy, the success of the craft beer industry has been overwhelming; sure enough, both a progressive spread of micro-breweries and a growing popularity of their beers have been noticed. Therefore, it is possible to discuss about a real "movement" made up of highly heterogeneous experts and companies [1], answering to the consumer's demand using the same standards, as a product of quality.

So clearly the quality of a product must be linked to objective parameters's analysis so as to perform a check on the brewing process.

Analysis parameters

Determination of pH: The pH value of wort is an important parameter during the mashing phase. In worts there are different types of enzymes (amylases) with their own specifications and they have an effect at different temperatures and pH. Then, every enzyme present in the wort has a "window of operation", which guarantees the perfect conversion of the starch into fermentable sugars and dextrins. An optimal pH in the phase of mashing is between 5.2 and 5.8, in fact the main enzymatic reactions of mashing take place in this range.

Determination of starch: Starch is converted into simple sugars thanks to the enzymes present in the malt, during the mashing. A check on the starch degradation can be made by measuring the residual starch in the wort, so as to be able to continue with the following operations. The measure of starch is the most representative parameter of mashing's end.

Determination of the FAN: Free amino nitrogen (FAN) is produced during the mashing. FAN is an important nutrient and it plays an essential role in keeping yeast cells alive during the fermentation. Its measurement allows brewers to decide to add additional nutrients into wort before the fermentation. The determination of FAN is significant for the fermentation process. In fact, low levels of FAN are indicative of a slow and incomplete fermentation process. In this way, it is possible to avoid product loss and save money. If needed nutrients are not added, the mash could not complete its fermentation, because of yeast cells death due to lack of free amino nitrogen. While, in the presence of an excessive amount of nutrients, the beer could be infected with microbes that would ruin the quality of the final product.

Determination of fermentable sugars: During the fermentation phase, the yeast converts fermentable sugars, produced throughout the mash, into ethanol and CO_2. Yeast is a single-celled organism and its work consists of three different steps: breathing, the yeast goes to draw on the reserves of oxygen of wort to store energy that will be used later; fermentation: yeast cells reproduce by converting sugars into alcohol and carbon dioxide; and finally, the sedimentation step: the yeast is deposited on the bottom of the fermenter, after having consumed almost all the sugars of the wort. The measurement of quantity of residual fermentable sugars attests the end of fermentation.

The fermentable sugars in beer's worts are: glucose and fructose (10-15%) (monosaccharides), maltose (50-60%) (disaccharide formed by two glucose molecules) and maltotriose (15-20%) (formed polysaccharide from three molecules of

glucose). They are called fermentable sugars because they can be digested by yeasts.

Maltotriose, unlike other sugars, is a partially fermentable sugar, because it is often not completely digested by yeasts, since not all yeast strains are able to completely ferment it.

Determination of bitter (IBU): The main contribution to the bitter taste of the beer comes from the iso-alpha-acids of the hop plant, belonging to the family of the Cannabaceae. In addition to stabilizing the foam and giving it a charming taste, the hops provides bitter flavor, which is necessary to counteract the cloying sweetness of the wort and thus balance its flavors and aromas. The alpha-acids of the hops, present in the resins, provide most of the bitter features. During the boiling phase, they endure a structural change called isomerization, which increases its solubility and creates bitter compounds that will remain until the moment of tasting of the finished beer.

The beer is therefore the result of the union of the sweet and full taste of the barley converted into malt, with the pleasant bitter aftertaste provided by the hops.

Determination of color: Taking a brief historical overview, in the last fifty years half a dozen techniques have been used to evaluate the color of beer and have provided different results. The original Lovibond method is still in use, and some methods for the determination of color refer to it, which was based on an optical comparison between a sample of beer or wort and a set of colored glass standards, corresponding to the Lovibond grades. Lovibond method attempted to capture the yellow / red balance and the color intensity using a single standard for each Lovibond grade. Obviously, this method was prior to reliable spectrophotometers's coming for estimating the amount of light absorbed by the beer, contained in a cuvette illuminated by a light at a precise wavelength [2]. In fact, the color characteristics of a beer are defined by its color through the absorbance reading at 420 nm.

Another inquiring aspect is to research the causes of the color of a beer inside the Maillard reaction's products. The Maillard reaction means a series of phenomena that take place after the interaction of sugars (glucose, fructose, maltose, etc.) with amino acids, at high temperatures and in conditions of low water activity. These conditions occur during malting phase, exactly when the germinated kernels are first dried and then heated to the specific temperature to obtain the demanded malt. In other words, it is easily understood: dark beers are obtained from toasted malts, instead the clearest from malts subjected to mild thermal treatments.

Determination of alcohol by volume (% vol, ABV): the determination of the alcohol content in beer is not only an important process parameter for beer's production, it is useful to know the amount of duties, which weigh on the manufacturer (www.camera.it/leg17/522?theme=excise), depending on the percentage of wort's sugars before the fermentation. This percentage is called Plato scale Saccharometers (°P). In this regard, the Italian legislation classifies beer into the following categories:

- Non-alcoholic beer: 3 < °P > 8, ABV < 1.2% vol;
- Light beer: 5 < °P > 10.5, ABV > 1.2% vol;
- Normal beer: °P > 10.5, ABV > 4.5% vol;
- Special beer: °P > 12.5, ABV > 5.5% vol;
- Double malt beer: over 15 ° P, ABV > 6.5% vol.

It should be noted that the expression "double malt beer" has entered into common language, but it has no meaning other than a fiscal one.

Determination of lactic acid: Lactic acid is produced by mainly microbial activity, during the fermentation and its concentration is related to the total bacterial load. The lactic bacteria cause lactic acid as the main fermentation's product of carbohydrates, produce very small amounts of CO_2, survive in high acidity conditions (some species continue to grow up to about pH 3), ferment between 15 °C and 35 °C and they grow up even with low concentrations of oxygen. They are limited by abundant hops and high concentrations of alcohol. Although normally lactic bacteria are responsible for beer defects, they are able to contain or exclude the presence of other unwanted microorganisms, if they are used accurately. Therefore, a chemical analysis for determining the concentration of lactic acid in beer is a useful indicator of the good conservation of the beverage. To check lactic acid will be as useful as the analysis will be faster.

Determination of sulfure dioxide: Sulfure dioxide (SO2) is produced during the primary

fermentation process and during the refermentation phase. Its antioxidant action allows to prolong the shelf life of the beer.

Sulfites are widely used as additives in beverages to prevent bacterial growth and slow down the process of oxidation by inhibiting oxidative enzymes.

In particular, sulfure dioxide is considered to be the most important factor about the shelf life of beer, because it inhibits its oxidation. In fact, it is used by brewers in the form of potassium matabisulfite ($K_2S_2O_5$), commonly known as E224.

The analysis system CDR BeerLab®

CDR BeerLab® is an analysis system developed to control the brewing process during all its phases.

Thanks to CDR BeerLab® it is possible to perform a wide range of analyses on wort and beer, quickly and easily compared to traditional methods.

A versatile system which meets the needs of breweries of all sizes, without going to external laboratories, in complete autonomy.

CDR BeerLab® is a real laboratory of analysis: an analyzer based on photometric technology, 4 reading cells and 16 thermostated incubation cells, a kit of pre-vialed reagents, without the need to use special glassware, and finally the "Help" function which describes and lead you through the process step by step, which can also be performed by non-specialized employees.

CDR BeerLab® is a compact system, equipped with everything needed to test the quality of beer, highlighting its strengths in the brewing industry, such as:

1. Innovation: in the field of quality control of wort and beer, CDR introduces an innovative analysis system, which radically changes the way of performing the analyses;

2. Reliability: several comparative studies carried out by certified laboratories show the same accuracy of the results of traditional methods;

3. Simplicity: there is no need for specialized technicians because everyone can perform the wide analysis range;

4. Green: CDR BeerLab® system has a low environmental impact due to the minimum waste production and reduced reagent volumes.

Conclusion

CDR BeerLab® is able to perform the analyses independently, directly in the brewery, quickly, without turning to an external laboratory in order to achieve the brewing control. CDR BeerLab® allows constant monitoring of the production process, obtaining accurate results in a few minutes, without the support of specialized technical personnel.

Bibliografia

[1] R.Espositi, M.Fastigi, E.Viganò, Il movimento italiano delle birre artigianali:il caso dei birrifici agricoli, Agriregionieuropa, anno 11 n.43, Dic.2015

[2] R.Daniels Progettare grandi birre Edizioni LSWR