The “silent” importance of water in beer production

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Introduction

Although the influence of water with respect to the characteristics of the finished product may appear to be of little importance to an inexperienced consumer, from a production point of view, the choice and treatment of water are elements of primary importance in defining the organoleptic characteristics.

In fact, the chemical composition of the water not only directly affects the taste of the drink, as sweeter or bitterer taste, but also acts significantly on the series of biochemical reactions that take place during the manufacturing process, involving all the other ingredients used.

After all, it could not be otherwise considering that water constitutes the main matrix of beer, resulting in proportions from 80 to 90% of the production mix.

The past and the present

From a historical point of view, water has determined many of the characteristics that beer styles continue to have, if not also the possibility for a place to produce beer or not.

Every city and every village, in the past as today, has different waters, hard or soft, with a different concentration of calcium and other features. These characteristics forced the brewers of different places of the world to adapt the recipes and production processes to what the area could offer.

In other words, water is one of the main links that beer has had in the past with its territory. Unlike hops and malts that could travel in ancient times, water could not be transported, making it mandatory to manage its characteristics locally.

Nevertheless, if water could not travel, it could make travel, so the presence of important waterways near some beer sites allowed the rapid spread of many styles all over different countries.

Nowadays, water treatment technologies and improved control methods during the whole production process allow producers to always obtain water with an ideal composition. This is surely an advantage in particular for breweries that have more establishments and that are thus able to produce beer of the same quality everywhere.

From the cost effectiveness point of view also, an unsuitable brewing water quality not only affects the taste, but also interferes with the brewing process and thus increases the production costs.

Regulatory aspects

The mandatory prerogative for beer production is the use of drinkable water, microbiologically pure, as ingredient for making beer, according to the provisions of current regulation.

This does not oblige producers to use water from aqueducts and does not imply that it cannot be drawn from source water, as it happens for historical breweries, but it is necessary that the water is guaranteed as drinkable through periodic chemical - physical and microbiological analyses, or through the use of purification treatments.

Currently the most used method for water treatment is its demineralization by using

chemical filters, and then the gradually reintroduction of ions and salts in the desired proportion.

Main parameters of water directly involved in beer quality

Alkalinity of water is the most important parameter that beer producers have to consider, as directly involved in the mashing step and in all those final sensory qualities that feature a beer. From the chemical point of view, total alkalinity is defined as the concentration of strong acid, measured in milliequivalents per litre, needed to convert bicarbonate or carbonate in the sample in carbon dioxide at a pH of 4.3.

Generally speaking, the most common directives state that water alkalinity should be as low as possible.

Calcium ion is the other main parameter that needs to be considered for beer production. It acts as cofactor for the enzymes involved in the mashing phase, and its addiction may be necessary to assure the proper enzymatic activity for mashes in water that is naturally low in this ion, moreover it lowers the pH in order to obtain a solid trub at the end of the whirlpool phase and to allow the yeast flocculation at the end of fermentation process. Too high concentration of Calcium, over 250 ppm, can inhibit magnesium uptake by the yeast and may impair fermentation performance.

It is remarkably flavourless. It is widely approved that calcium level should be at least 50 ppm.

High quantity of **bicarbonate** can affect the pH, avoiding its decreasing, Moreover, as this ion interacts with iso- and alfa- acids obtained by the addiction of hop, its high concentration can be responsible of an undesired astringent tasting note.

Sulfate level contributes to bitter and dry taste of a beer. At concentration over 400 ppm the resulting bitterness can become astringent and unpleasant, also due to the development of sulfur dioxide and hydrogen sulfide can create unpleasant smells of the product.

Magnesium ion plays and important role in fermentation, especially favouring yeast reproduction, being an important yeast nutrient for yeast pyruvate decarboxylase metabolism, and it should be present in the worth at a minimum level of 5 ppm. On the other hand, too high quantities may be responsible of an acid and bitter unpleasant taste.

Zinc ion promotes yeast metabolism and it can be added as nutrient during the boiling phase of the wort, its recommended levels for optimum fermentation are 0.1-0.5 ppm. On the contrary, higher concentration can cause over-activity and off-flavours in beer.

Fullness and stability of a beer benefit from the presence of **chloride**, even if levels greater than 250 ppm in most beers tastes pasty or salty and levels greater than 300 ppm may affect yeast health.

Potassium is another important ion in the beer production process. Wort and beer have a relatively high natural concentration of potassium (300-500 ppm), contributed by the malt.

Some examples

As already said, the taste of some beers is unique and immediately recognizable, and one of the main responsible of them is just the water used for production.

If Pilsner beer has to thank PIzen water for its famous sweetness, Stout beers are the result of Dublin hard water, as Pale Ale are definitely linked to Burton-on-Trent water, rich of calcium and sulfate.

In this table, the different ions content of some of the most famous locations for beer production in Europe are briefly summarized.

Data in mg/L	Calcium	Magnesium	Sulfate	Bicarbonate	Chloride
Burton	295	45	725	300	25
Dublino	115	4	55	200	19
Londra	90	5	40	125	20
Monaco	75	20	10	200	2

How the brewery can monitor water parameters during beer production process

Conventional methods

Conventionally analyses on water parameters have to be managed by specialized technicians, responsible of using, calibrating and maintaining on a series of instrumentation and tools dedicated to them.

If quite only big establishments can have internal labs, the most of the breweries rely on external labs, that is easier for what the internal organization is concerned, but usually analysis cost is expensive and mostly, results are forcedly delayed, when brewer should has immediate answers in order to take the best decision during a specific step of the production.

Considering the total alkalinity of water, the importance of which has been already discussed, it is conventionally determined by potentiometric titration.

This method needs to be carried out by specialized personnel, with the employment of lab tools as glassware, weight scales and personal protective equipment.

Sample is typically titrated using methyl orange indicator, which has a color range of 3.2-4.4 pH, although its color change that determines the 4.3 pH endpoint is said to be subtle and difficult to observe accurately.

That's why the current ISO standard specifies the use of bromocresol green-methyl red indicator solution with the endpoint defined as 4.5 pH.

In case of metallic ions their detection is usually performed by using complex techniques as AAS (Atomic Absorption Spectroscopy), ICP-MS (Inductively Coupled Plasma Emission Mass Spectroscopy) or IPC-OES (Optical Emission Spectroscopy) and the only option for brewery is to refer to a specialized laboratory.

Briefly, AAS is cheaper and more accurate in comparison with ICP techniques that are less accurate, more expensive but faster and able to detect more parameters at the same time, anyway both methods remain very time consuming, need specialized personnel for being carried out and their application real time during the different phases of beer production is quite impossible.

CDR BeerLab® method and main advantages

By comparing the detection of the same parameters with **CDR BeerLab®**, it is evidently easier and faster, although guarantying the same accuracy because perfectly correlated to respective reference methods and optimized to be applied on this system.

CDR BeerLab® is a complete system, composed of analyzer and dedicated reagents.

Instrument reading principle is the photometric technology, based on LED emitters, that does not

require periodical calibration, is a longer-life optical system and has a detection range 3 times wide, the whole if compared with standard photometry.

Moreover, both incubation and reading cells of the analyzer are thermostated at 37°C, allowing to shorten the reactions time.

All the dedicated reagents are provided as complete kits and in pre-filled cuvettes, thus allowing to reduce possible errors during their preparation and to speed up the whole operative procedure.

In case of alkalinity of water, the detection on CDR BeerLab® is based on the alkaline components of water that react with a specific reagent, leading to the formation of an adduct which absorbs at the wavelength of 366nm. The absorbance of the sample is directly proportional to the alkalinity value, and its reading is realized by a photometer that uses LED emitters. In terms of time, just 10 minutes for a determination.

The wide panel of analyses of CDR BeerLab® foresees the other overviewed parameters, but also in case of metallic ions, their detection does not require any additional instrumentation or tool and takes just few minutes in all the cases.

Furthermore, CDR BeerLab® enables you to determine a wide panel of parameters on beer and wort in every stage of the brewing process, even if you don't have chemical laboratory or fume hood. Its use does not require laboratory background. So, with CDR BeerLab®, you can perform a complete in-house quality control of your brewing process getting results in real time.

Main advantages of our system are:

- **reliability** – CDR BeerLab® method is compared to the reference method;
- **reduced test times** - just few minutes for a determination;
- **easiness** - reagents are pre-filled and instrument does not need calibration, maintenance or cleaning procedures at the beginning or at the end of the working session, no technical skill is requested;
- **reproducibility** - the possibility to introduce manual errors by working with CDR close-system is reduced to the minimum, if not excluded;
- **flexibility** – instrument has been thought to be used real time in the processing plant.
- **versatility** – CDR laboratories are the exclusive producers of both instrumentation and reagents, we are always researching for new applications, that once released, they will be available on CDR BeerLab® just upgrading instrument software.

Bibliografy

John Palmer and Colin Kaminski (2013). Water A Comprehensive Guide for Brewers.