Alcohol-free beer, reverse osmosis process

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Abstract: Beer is the world most widely consumed alcoholic beverage. Non-alcoholic beer consume it is observed to have a significant increase due to people becoming more aware of problems that alcohol can bring regarding civil responsibilities. Also, there are countries where alcohol is forbidden by law and consumers are looking to buy products as close as possible to the conventional types.

Keywords: beer technology, free alcohol, reverse osmosis

INTRODUCTION

The sale of beers with low alcohol content is a fast growing segment of beer market and is the focus for a lot of innovation therefore beer industry is facing major challenges. A natural product – beer is the world´s oldest and most widely consumed alcoholic beverage and the third most popular drink overall after water and tea. So, beer is an alcoholic beverage made by the fermentation of cereals - traditionally barley, but also maize rice or sorghum. The first step in producing beer is the malting of barley but it is allowed to sprout, when the enzyme amylase hydrolyses some of the starch to dextrins and maltose. The sprouted (malted) barley is dried, then extracted with hot water (the process of mashing) to produce wort. After the addition of hops for flavor, the wort is allowed to ferment. Two types of yeast are used in brewing: top fermenting yeasts which float on the surface of the wort and bottom or deep fermenters (Bender and Bender, 1999). Therefore, brewer's yeast is a principal element in beer production. The normal beer usually comprises three types of beer from the alcohol content viewpoint; namely, low-strength (~ 2-3%), medium strength (~ 5%) and high-strength (~ 6-12%) (Sohrabvandi et al., 2010).

Lager is the traditional mainland European type of beer, sometimes called Pilsner lager or Pils, since the original lager was brewed in Pilsen in Bohemia. It is brewed by deep fermentation. These beer products have an original gravity that generally starts around 12 degrees Plato and the finished product usually has an alcohol level in the 4 to 5 percent range, by volume. Popularity of beer arises from its pleasant sensory attributes and favorable nutritional and medicinal (light-to-moderate consumption) characteristics as

well as its lower cost, compared to other types of western and European alcoholic beverages (e.g., wine) (Sohrabvandi et al., 2010). To be legally deemed “nonalcoholic", beer containing 5% ethanol by volume must be reduced to 0.5% ethanol. The primary options for this reduction are continuous distillation and batchwise reverse osmosis (RO) (Bertalan et al., 2012).

MATERIALS AND METHODS

The basic ingredients of non-alcoholic beer are malted barley (produced by soaking and germinating the grains), hops (witch add a characteristic bitter flavor), and possibly brewer's yeast (Sohrabvandi et al., 2012). The legal definition of non-alcoholic/alcoholic free non-alcoholic beer varies from one country to another. For instance, this type of non-alcoholic beer must contains maximum alcohol levels of 0.1% V/V (Arabic countries), 0.5% V/V (Iran, England, Germany and Holland), 1% beverage (Spain) (Sohrabvandi et al., 2012). Low alcohol beer may be made either by fermentation of a low carbohydrate wort, or by removal of much of the alcohol after fermentation (dealcoholised beer).

There are several methods for the production of low-alcohol and non-alcoholic beers. Alcohol removal or dealcoholization is a common practice used for industrial production of beers of these types - innovative membrane-based technologies such as the reverse osmosis (RO) are the most attractive option. The reverse osmosis is an inherent optimization when compared with distillation, which is the traditional method of beer dealcoholization. In previous decades, the only option for industrial scale dealcoholization was distillation, which, if done at elevated pressure, would denature the flavoring compounds of the beer, or, if done at low pressure using vacuum distillation, would require expensive compressors (Bertalan et al., 2012).

Reverse osmosis (hyper filtration) is the passage of liquid from a more concentrated to a less concentrated solution through a semipermeable membrane by the application of pressure. The membranes commonly used are cellulose acetate or polyamide of very small pore size, 10^{-4} - 10^{-3}µm.

In reverse osmosis process, the product - in this case beer - flows tangentially to the membrane surface and a portion of the feed flow rate (permeate) crosses selectively the membrane, while the other fraction (retentante) remains in the feed side (Catarino et al., 2006). It is used a semi-permeable ethanol membrane. Ethanol (and water) permeates the membrane against the osmotic pressure and is recovered in the permeate side. On the other

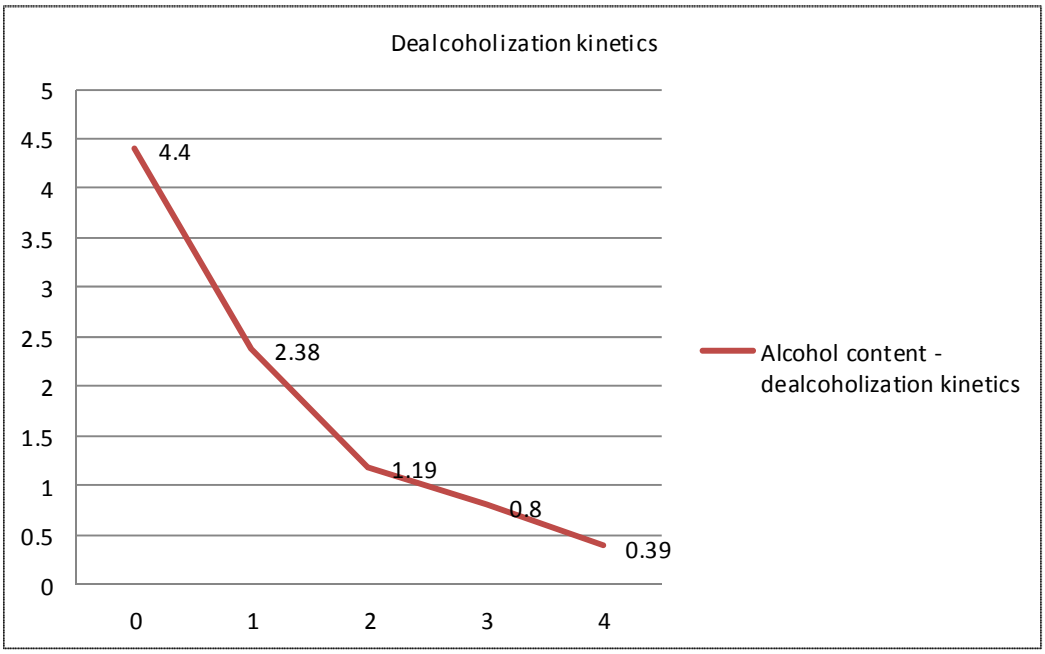
hand, larger molecules, such as beer aroma and flavor compounds, mostly remain at the side (concentrated beer).

The most used membrane in alcohol removal is made of cellulose acetate (CA), which has a high water and alcohol permeability and a high rejection to the compounds with high molecular weight such as proteins, polyphenols, sugars, bitter species, color substances and aroma compounds.

In order to produce a dealcoholized beer, which means less than 0,5 %vol alcohol, beer dealcoholization process was performed in 4 cycles stating from an alcohol content of 4,4 % vol. The results can be observed in table 1.

RESULTS AND DISCUSSION

Tabel 1



Alcohol content was almost reduced by half after one cycle from 4,4 % vol to 2,38 % vol, and it continued in the same way at the next tree cycles until it reached 0,39 % vol alcohol content.

The reverse osmosis process occurs to have some advantages compared to other dealcoholization processes. Reverse osmosis requires low energy consumption compared to distillation processes and the feed beer can be

processed at low temperatures (below room temperature). The low alcohol beer quality is similar to the standard beer because reverse osmosis semi-permeable membranes are specific to retain the larger beer flavor and aroma compounds.

These characteristics contrast with the ones assigned to the heat processes, where temperature sensitive compounds can suffer some damages (chemical alterations and physical losses), and with restricted alcohol processes, where the fermentation is stopped and the beer aroma does not develop such as in a regular alcoholic beer. Besides these advantages, reverse osmosis is a very versatile process since various beer types can be dealcoholized in a given unit and various alcohol contents can be obtained. In addition, it is a modular technology, easy of scaling- up.

CONCLUSION

Normally the reverse osmosis is applied to the beer in a batch or semi-batch way, where the retentate is recycled to the feed. The retentate loses important amounts of water in this process, besides alcohol, which should be added continuously to the feed or, at the end, to the retentate volume produced. The added water should be de-aerated and de-ionized.

Flavor is the most important quality criterion of non-alcoholic beer. Reverse osmosis of non-alcoholic beer is performed at low temperatures to ensure that the heat sensitive compounds of the non-alcoholic beer are not a ected. Higher temperatures increase throughput but have a negative impact on the flavorings and aromas of the beer. This process is run at 7.5°C to ensure that the beer is not negatively impacted. Also, at lower temperatures the flavoring rejection of the membrane is higher, which keeps more of the natural aromas and flavourings of the beer in the retentate stream (Bertalan et al., 2012).

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