



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**06.06.2018 Bulletin 2018/23**

(51) Int Cl.:  
**C12G 3/08 (2006.01)**      **C12C 11/11 (2006.01)**  
**C12G 3/14 (2006.01)**      **C12G 3/12 (2006.01)**

(21) Application number: **16201524.2**

(22) Date of filing: **30.11.2016**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
 Designated Extension States:  
**BA ME**  
 Designated Validation States:  
**MA MD**

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(54) **BEER OR CIDER CONCENTRATE**

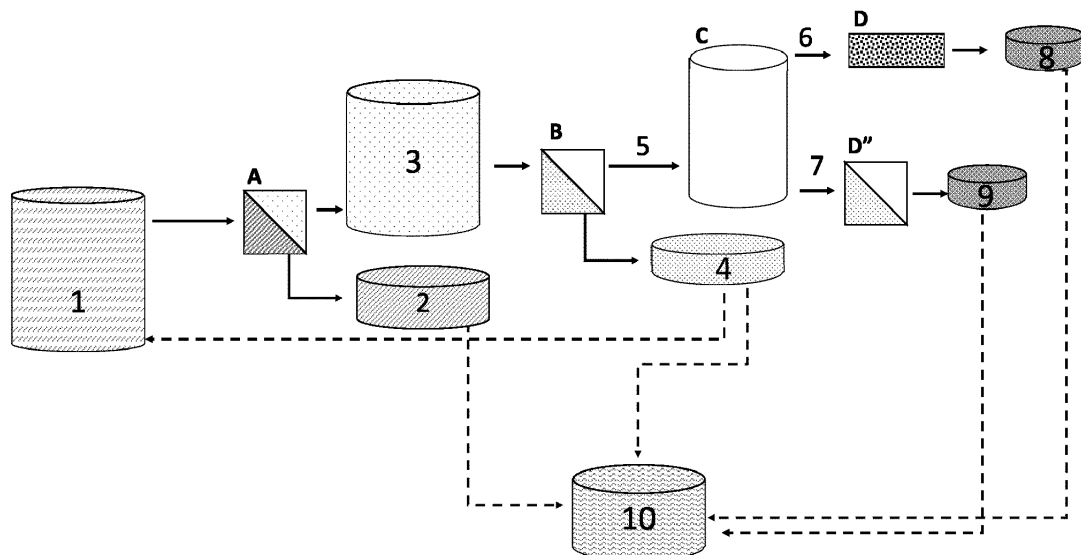
(57) A method for preparing beer concentrate, comprising the steps of:

- a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;
- b) Subjecting the fraction comprising alcohol and volatile

flavour components to a next concentration step (B) comprising freeze concentration, fractionation, preferably being distillation, or reverse osmosis, to obtain a concentrated fraction comprising alcohol and volatile flavour components (4), and a leftover fraction (5);

c) Subjecting the leftover fraction (5) of the next concentration step (B) to a fractionation, preferably being distillation, an adsorption or a freeze concentration to obtain a second fraction comprising alcohol and volatile flavour components and a second leftover fraction..

Figure 1



**Description****TECHNICAL FIELD**

[0001] The present invention concerns a method for preparing beer or cider concentrate comprising alcohol and flavour components, and further beer or cider, respectively prepared therefrom. In particular, the invention concerns a two-step concentration method wherein the first step involves a high-pressure nanofiltration that results in a highly concentrated retentate and an aqueous permeate fraction comprising alcohol and volatile flavour components, and wherein the second step involves removing water from said permeate fraction to obtain a highly concentrated alcohol solution comprising volatile flavour components.

**BACKGROUND OF THE INVENTION**

[0002] The major benefit of producing concentrates is the reduction in weight and volume which allows to save on storage and transportation costs, in addition to also often having favourable effect on improving shelf life of a product. Since beers and many other alcoholic beverages in general contain about 80 to 90% water, it has naturally been recognised that the most economical way to store or distribute them over considerable distances would be in the form of a concentrate.

[0003] In principle, a concentrate can be reconstituted to the initial product at any place at and time by the addition of the solvent, usually water. Nevertheless, it is not straightforward to produce an alcoholic beverage concentrate, the main difficulty lying in the fact that most concentration procedures lead to reduction in alcohol and losses in many flavour or aroma components. Beer in particular is a very challenging alcoholic beverage to produce a concentrate from because, unlike beverages produced from fruit juice fermentation such as wine, perry, or cider; the aromas present in beer are subtler and much less concentrated, which means that losing even a small portion of them at the concentration stage will have a profound effect on the organoleptic perception of the final rehydrated product. In addition, because of the great popularity of the drink and existence of a wide public of demanding beer aficionados, the reconstituted drink is expected to meet expectations with regard to its distinctive aroma, taste, mouthfeel, foaming properties, colour, and even haze perception. Reconstituted beer simply cannot taste like a diluted beer missing some characteristics; for gaining consumer acceptance it simply must have all the qualities of the "real" unprocessed beer.

[0004] Methods for producing beer concentrates and then rehydrating them into final beverages are known in the art. Various methods for concentrating alcoholic beverages that are known in the brewing industry include such processes as freeze-drying, reverse osmosis, and filtration. All of these methods start with a substantially finished beer and then remove the water. The resulting

concentrated beverages can then be transported more cost-effectively and then reconstituted at a final destination by addition of water, carbon dioxide, and alternatively also alcohol.

5 [0005] An example of one method for preparation of a reconstitutable beer concentrate can be found in GB2133418. The method is based on subjecting beer to reverse osmosis and results in a low alcohol concentrate which can be rehydrated to a low-alcohol beer.

10 [0006] Conversely, US4265920 and US4532140 teach two-step methods for obtaining a high-alcohol beer concentrate that can be reconstituted to beers of normal alcohol content. The method of US4265920 comprises a first distillation step to separate ethanol and volatile aroma components from the retentate comprising the rest of the beer components, which is followed by a second step comprising a rather costly freeze-concentration procedure to concentrate the retentate from the first step. Finally, the distilled ethanol from step 1 is combined with the freeze-concentrated retentate from step 2, resulting in the final ethanol-enriched beer concentrate. The method of US4532140, on the other hand, in the first step subjects beer to ultrafiltration to obtain a concentrated retentate and an aqueous permeate that is then, in the second step subjected to reverse osmosis to concentrate ethanol and volatile compounds; lastly, the alcohol fraction from step 2 is pulled with the retentate from step 1 to obtain the final beer concentrate.

20 [0007] Although at least some of the above described methods provide a general approach for concentrating beer including its alcohol content and, to some extent, volatile components, they achieve their goal at the cost of reaching high concentration factors and only provide final concentrates of a volume half or at most one third of the volume of the starting beer. Therefore, there clearly exists place for improvement and provision of more concentrated beer bases providing further reduction in transport and storage costs.

30 [0008] The present invention provides a method for producing a naturally alcohol-enriched beer concentrate of high density, said method providing an advantageous concentration factor potential of at least 5, 10, 15, up to 20 or more, while at the same time ensuring high and optionally selective retention of natural beer flavouring compounds, including the volatile ones. These and other advantages of the present invention are presented in continuation.

**SUMMARY OF THE INVENTION**

40 [0009] The present invention is defined in the appended independent claims. Preferred embodiments are defined in the dependent claims. In particular, the present invention concerns method for preparing beer or cider concentrate comprising the steps of:

- 55 a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to

obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;

b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising freeze concentration, fractionation, preferably being distillation, or reverse osmosis, to obtain a concentrated fraction comprising alcohol and volatile flavour components (4), and a leftover fraction (5);

c) Subjecting the leftover fraction (5) of the next concentration step (B) to a fractionation, preferably being distillation, an adsorption or a freeze concentration to obtain a second fraction comprising alcohol and volatile flavour components and a second leftover fraction.

**[0010]** The present invention also concerns a method comprising:

(a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;

(b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising an adsorption process wherein volatile flavour components are adsorbed on a column and subsequently eluted with a volume of water or alcohol to obtain a concentrated fraction of volatile flavour components (4') and a leftover fraction (5').

#### BRIEF DESCRIPTION OF THE FIGURES

**[0011]** For a fuller understanding of the nature of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawings in which:

**Figures 1 to 4:** shows a block diagram schematically illustrating key steps of four alternative methods according to the present invention.

**Figure 5:** shows a schematic diagram of a preferred embodiment of the method according to the invention, wherein the second concentration step (B), comprises distillation. Reference signs as in Figure

1.

#### DEFINITIONS

**[0012]** As used herein, the term "**concentrate**" is given the definition of Oxford dictionary: "A *substance made by removing or reducing the diluting agent; a concentrated form of something*" (cf. <http://www.oxforddictionaries.com/definition/english/concentrate>). In line with this, the term "*beer or cider concentrate*" or, alternatively "*(concentrated) beer or cider base*" or "*beer or cider syrup*", is meant to relate to beer or cider, respectively which had the majority of its solvent component - i.e. water - removed, while retaining most of the dissolved components conferring such features as taste, smell, colour, mouthfeel etc.

**[0013]** As used herein, the term "**beer**" is to be construed according to a rather broad definition:

*"the drink obtained by fermenting from a wort, prepared with starchy or sugary raw materials, including hop powder or hop extracts and drinkable water. Aside from barley malt and wheat malt, only the following may be considered for brewing, mixed with e.g. wheat malt, starchy or sugary raw materials in which the total quantity may not exceed 80%, preferably 40% of the total weight of the starchy or sugary raw materials:*

(a) *maize, rice, sugar, wheat, barley and the various forms of them.*

(b) *saccharose, converted sugar, dextrose and glucose syrup.*

Although according to certain national legislations, not all fermented malt-based beverages can be called beer, in the context of the present invention, the term "**beer**" and "*fermented malt based beverage*" are used herein as synonyms and can be interchanged. It follows, that as used herein the terms "*reconstituted beer*" and "*reconstituted fermented malt based beverage*" are to be understood as beverages composition-wise substantially identical to beer but obtained by addition of the solvent, i.e. water or carbonated water, to a previously prepared beer concentrate.

**[0014]** Next, as used herein, the term "**cider**" is to be understood as every alcoholic beverage resulting from the fermentation of apple juice or apple juice mixed with up to 10% pear juice. This term also encompasses the any product of this fermented apple juice further modified by adding such standard cider manufacturing additives as acids (citric or tartaric) and/or sugar, filtering, cooling, saturating with carbon dioxide, pasteurizing, etc., which is commercialized under the term cider.

**[0015]** As used herein, the term "**unfilterable compounds**" is to be understood as referring to all the diverse compounds comprised in any type of beer or cider, which cannot pass through a **nanofiltration** membrane, i.e.

beer compounds having the mean size greater than 150 Da, 180 Da, or 200 Da, which is the molecular weight retention size cut-off depending on a given nanofiltration membrane. As opposed to the "filterable compounds" comprising water, monovalent and some bivalent ions, low molecular alcohols such as ethanol, low molecular esters and a number of volatile flavour components, the unfilterable compounds mainly include sugars, mostly polysaccharides; sugar alcohols, polyphenols, pentosans, peptides and proteins, high molecular weight alcohols, high molecular weight esters, partially multivalent ions, and many other mainly organic and highly divergent compounds that vary depending on the beer or cider type. Due to the complexity and discrepancies between different beer or cider compositions, the collective concentration of the unfilterable compounds is often referred to (in great simplification and without being exact) as "concentration of sugars" or "concentration of solids" and can be easily calculated from mass balance considerations taking into account of parameters such as density, viscosity, beer rheology, original gravity or extract, real gravity or extract, degree of fermentation (RDF) and/or alcohol content. In brewing practice, the concentration of unfilterable compounds is routinely estimated from density (real extract) measurement corrected for the density of the measured ethanol amount, ethanol being the most prevalent compound of density  $< 1 \text{ g/cm}^3$  and therefore affecting the density measurement most substantially. Such measurements are well known in the art, are routinely performed using standard beer analysing systems like Anton Paar Alcolyzer device, and thus are readily and easily performable by any person skilled in beer brewing.

**[0016]** The amount of components dissolved in beer can also be expressed as so called specific gravity (relative density) or apparent specific gravity. The first one is measured as density (weight per unit volume) of beer divided by the density of water used as a reference substance, whereas the second one as the weight of a volume of beer to the weight of an equal volume of water. For example, a specific gravity of 1.050 ("50 points") indicates that the substance is 5% heavier than an equal volume of water. The densities of water, and consequently also beer, vary with temperature; therefore for both specific gravity and apparent specific gravity the measurement of the sample and the reference value is done under the same specified temperature and pressure conditions. Pressure is nearly always 1 atm equal to 101.325 kPa, while temperatures may differ depending on the choice of further systems for approximating beer density. Examples of such systems are two empirical scales, Plato and the Brix scale, that are commonly used in brewing and wine industries, respectively. Both scales represent the strength of the solution as percentage of sugar by mass; one degree Plato (abbreviated °P) or one degree Brix (symbol °Bx) is 1 gram of sucrose in 100 grams of water. There is a difference between these units mainly due to both scales being developed for solutions of sucrose at different temperatures, but it is so insignificant

that they may be used virtually interchangeably. For example, beer measured at 12° Plato at 15.5°C has the same density as a water-sucrose solution containing 12% sucrose by mass at 15.5°C, which is approximately equal to 12° Brix, being the same density as a water-sucrose solution containing 12% sucrose by mass at 20°C. The Plato and Brix scales have an advantage over specific gravity in that they express the density measurement in terms of the amount of fermentable materials, which is particularly useful at early stages of brewing. As, of course, both beer and wort are composed of more solids than just sucrose, it is not exact. The relationship between degrees Plato and specific gravity is not linear, but a good approximation is that 1°P equals 4 "brewer's points" ( $4 \times 0.001$ ); thus 12° Plato corresponds to specific gravity of 1.048 [ $1 + (12 \times 4 \times .001)$ ].

**[0017]** . The term "original gravity" or "original extract" refers to specific gravity as measured before fermentation, whereas the term "final gravity" or "final extract" relates to specific gravity measured at the completion of fermentation. In general, gravity refers to the specific gravity of the beer at various stages in its fermentation. Initially, before alcohol production by the yeast, the specific gravity of wort (i.e. the ground malt before beer fermentation) is mostly dependent on the amount of sucrose. Therefore, the original gravity reading at the beginning of the fermentation can be used to determine sugar content in Plato or Brix scales. As fermentation progresses, the yeast convert sugars to carbon dioxide, ethanol, yeast biomass, and flavour components. The lowering of the sugar amount and the increasing presence of ethanol, which has appreciably lesser density than water, both contribute to lowering of the specific gravity of the fermenting beer. Original gravity reading compared to final gravity reading can be used to estimate the amount of sugar consumed and thus the amount of ethanol produced. For example, for a regular beer, original gravity could be 1.050 and final gravity could be 1.010. Similarly, knowing original gravity of a beverage and its alcohol amount can be used to estimate the amount of sugars consumed during the fermentation. The degree to which sugar has been fermented into alcohol is expressed with the term "real degree of fermentation" or "RDF", and is often given as a fraction of original gravity transformed into ethanol and CO<sub>2</sub>. The RDF of beer is in theory indicative of its sweetness as beers usually have more residual sugar and thus lower RDF.

**[0018]** Concentration steps may involve any of the variety of techniques recognised in the art, which allow partial or substantial separation of water from the beer and thus retention of most of the dissolved therein components in a lower than initial volume. Many of the techniques currently used within the beverage industry rely on the so called membrane technologies, which provide a cheaper alternative to conventional heat-treatment processes and involve separation of substances into two fractions with the help of a semipermeable membrane. The fraction comprising particles smaller than the mem-

brane pore size passes through the membrane and, as used herein is referred to as "*permeate*" or "*filtrate*". Everything else retained on the feed side of the membrane as used herein is referred to as "*retentate*".

**[0019]** Typical membrane filtration systems include for example pressure-driven techniques microfiltration, ultrafiltration, nanofiltration and reverse osmosis. As used herein, the term "*microfiltration*" refers to a membrane filtration technique for the retention of particles having size of 0.1 to 10  $\mu\text{m}$  and larger. Usually, microfiltration is a low-pressure process, typically operating at pressures ranging from 0.34 - 3 bar<sup>1</sup>. Microfiltration allows separation of particles such as yeast, protozoa, large bacteria, organic and inorganic sediments etc. Then, as used herein, the term "*ultrafiltration*" designates a membrane filtration technique for the retention of particles having size of about 0.01  $\mu\text{m}$  and larger. Ultrafiltration usually retains particles having molecular weight greater than 1000 Dalton, such as most viruses, proteins of certain sizes, nucleic acids, dextrans, pentosan chains ect. Typical operating pressures for ultrafiltration range from 0.48 - 10 bar. Further, as used herein the term "*nanofiltration*" shall be understood as a membrane filtration technique for the retention of particles having size of 0.001  $\mu\text{m}$  to 0.01  $\mu\text{m}$  and larger. Nanofiltration is capable of retaining divalent or multivalent ions, such as divalent salts, and most organic compounds larger than approx. 180 Dalton, which include oligosaccharides and many flavour compounds; while allowing water, ethanol, monovalent ions, and some organic molecules such as many aromatic esters pass through. Operating pressures of 8 - 41 bar are typical for nanofiltration. Where nanofiltration is operated under inlet pressure within the upper end of this range, from 18 bar above, as used herein, it shall be termed "*high pressure nanofiltration*". Lastly, as used herein the term "*reverse osmosis*" shall be understood as referring to a high-pressure membrane process where the applied pressure is used to overcome osmotic pressure. Reverse osmosis usually allows to retain particles having size of 0.00005  $\mu\text{m}$  to 0.0001  $\mu\text{m}$  and larger, i.e. almost all particles and ionic species. Substances with molecular weight above 50 Dalton are retained almost without exception. Operating pressures are typically between 21 and 76 bar, but may reach up to 150 bar in specific applications.

**[0020]** Further, as used herein the term "*volatile flavour components*" shall be understood as any of the substances comprised in beer that contribute to its complex olfactory profile, said substances by their chemical nature having a boiling point lower than that of water. Examples of volatile beer flavour components include but are not limited to acetaldehyde, N-propanol, ethyl acetate, isobutyl alcohol, isoamyl alcohol, isoamyl acetate, ethyl hexanoate, ethyl octanoate, phenylethyl alcohol, 2-methyl-1-butanol and many more.

## DETAILED DESCRIPTION OF THE INVENTION

**[0021]** The present invention concerns method for preparing alcohol-enriched beer concentrate, said method comprising the steps of:

- a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;
- b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising freeze concentration, fractionation, preferably being distillation, or reverse osmosis, to obtain a concentrated fraction comprising alcohol and volatile flavour components (4), and a leftover fraction (5);
- c) Subjecting the leftover fraction (5) of the next concentration step (B) to a fractionation, preferably being distillation, an adsorption or a freeze concentration to obtain a second fraction comprising alcohol and volatile flavour components and a second leftover fraction.

**[0022]** In an alternative embodiment, the present invention concerns method for preparing alcohol-enriched beer concentrate, said method comprising the steps of:

- a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;
- b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising an adsorption process wherein volatile flavour components are adsorbed on a column and subsequently eluted with a volume of water or alcohol to obtain a concentrated fraction of volatile flavour components (4') and a leftover fraction (5').

**[0023]** Figure 1 schematically illustrates general scheme of the method for concentrating beer according to the present invention. As a first step, beer (1) is subjected to nanofiltration (A) through a semi-permeable membrane acting as physical barrier to passage of most beer components of mean molecular weight (MW) > 150-200 Da, but permeable to water, majority of ethanol,

monovalent salts and certain amount of beer flavour components. This first fraction retained on the membrane's inflow side is termed retentate (2) and is collected, whereas the fraction comprising alcohol and volatile flavour components is termed permeate (3) and is directed to a second concentration step (B). The second concentration step in this case involves reverse osmosis and results in separation of the permeate (3) from the previous nanofiltration step (A) into two fractions: first, a concentrated fraction comprising alcohol and flavour components (4), which is collected and blended with the collected retentate (2) from nanofiltration (A), resulting in final beer concentrate (10) or recirculated to the feed of the nanofiltration (A) or kept separately; and, secondly, a largely aqueous leftover fraction (5), that is subsequently processed by a fractionation such as distillation (C) to obtain a fraction (6) collected at the top of the distillation column that mainly comprises alcohol and volatile flavour components and a fraction (7) collected at the bottom of the distillation column and mainly comprising water and beer or cider extract. The fraction (6) can subsequently be fed to an adsorption column, selectively adsorbing volatile flavour compounds that can be eluted to obtain a concentrated volatile flavour component fraction (8) which can be added to the final beer concentrate (10) or kept apart. The fraction (7) is preferably fed to a freeze concentration process allowing removing pure water from this fraction at sub zero temperatures to obtain a concentrated extract fraction (9) that can either be added to the final beer concentrate or kept apart.

**[0024]** The final beer concentrate (10) can now be stored or transported over distances and readily rehydrated to a reconstituted beer having a taste profile from highly resembling to identical to that of a fermented beer.

**[0025]** In general, beer (1) subjected to nanofiltration (A) according to the invention is preferably clear beer that was treated using any regular beer clarification technique to remove yeast and most of the other particles above 0.2  $\mu\text{m}$  in diameter. Such techniques are standard and well known in the art of beer preparation. For example, they include centrifugation, filtration through e.g. kieselguhr (diatomaceous earth) optionally preceded by centrifugation, or other types of standard microfiltration techniques.

**[0026]** As can be appreciated from the present disclosure, the method of the invention is particularly advantageous for obtaining low-volume high-density beer or cider concentrates. The degree of concentration of the final product largely depends on the degree of concentration of the retentate obtained via nanofiltration in step a). Therefore, the present invention provides a method wherein the retentate not only comprises majority of beer (or cider) flavour components but also can potentially be characterised by a high concentration factor of 5, 10, 15, or even 20 or higher.

**[0027]** A used herein the term "*concentration factor*" shall be understood as the ratio of the beer or cider volume subjected to nanofiltration or reverse osmosis in

step a) to the volume of the obtained retentate at the end of the nanofiltration or reverse osmosis in step a), i.e. the ratio of the feed volume to the volume of the retentate obtained in the step a) of the method of the present invention. In an particularly preferred embodiment, a method in accordance with the previous embodiments is provided, wherein the retentate obtained in step a) is characterised by concentration factor of 5 or higher, preferably 10 or higher, more preferably 15 or higher, most preferably 20 or higher. A relationship between the concentration factor within the above-defined meaning, and the concentration of unfilterable compounds possible to be obtained in the retentate from step a) naturally depends on the type of beer or cider initially subjected to nanofiltration or reverse osmosis, which is shown and can be appreciated from in the graph presented in Figure 5, wherein each line represents a different beverage

(lines 1-4 were obtained for different beers, line 5 obtained for cider)

**[0028]** Concentration factors of 10 and above can advantageously, in terms of speed and performance, be obtained by, as used herein, a high-pressure nanofiltration, i.e. nanofiltration conducted under a pressure of minimum 18 bar. Thus, in preferred embodiments of the invention, a method is provided wherein the nanofiltration in step a) is a high-pressure nanofiltration, defined as nanofiltration conducted under a pressure in the range of about 18-41 bar, preferably in the range of about 20-35 bar, most preferably about 30 bar.

**[0029]** In case of cross-flow filtration we can always achieve the concentration one pass. But to make the operation more economical multi stages operation is done.

**[0030]** In line with the above, the present invention is based on the finding that nanofiltration of beer, high-pressure nanofiltration in particular, not only allows to retain majority of important beer flavour compounds in the retentate but also provides concentration potential substantially superior to the one of ultrafiltration or reverse osmosis, potentially allowing to obtain retentate of density comprised between 20-50 °P or higher even after a single filtration pass. In an advantageously economical embodiment, nanofiltration is performed as a multistage operation, wherein the retentate is progressing from one stage to the next one while becoming more and more concentrated. The preferred final density value of the retentate obtainable according to step a) of the present invention is comprised between 30-80 °P or higher, preferably between 50-70 °P, most preferably about 60 °P. Therefore, in one advantageous embodiment of the invention, the retentate from step a) is obtained in a single pass of nanofiltration, preferably being high-pressure nanofiltration, more preferably high-pressure nanofiltration conducted under a pressure range comprised between 18-35 bar, most preferably between about 20-30 bar.

**[0031]** It has been observed that such high concentration potential can particularly be achieved using polymer-

ic spiral membranes in range of 150-200 Daltons or similar. Examples of such membranes include thin film composite ATF (alternating tangential filtration, Refine Technology) membranes such as the ones currently available from DOW and Parker domnick hunter.

**[0032]** After the nanofiltration step, the highly concentrated retentate is collected while the aqueous permeate is fed to the second concentration step b) in order to selectively retrieve ethanol and volatile flavour components, said step either comprising freeze concentration, reverse osmosis or fractionation, preferably comprising distillation, and/or combination thereof.

**[0033]** Distillation is a classic example of a fractionation technique known to be particularly suited for separating alcohol and volatile component from water. The term "*distillation*" as used herein refers to the separation of the liquid mixture into the components thereof by utilising the difference in relative volatility and/or boiling point among the components by inducing their successive evaporation and condensation in the process of heating and cooling. Examples of the distillation may include simple distillation, fractional distillation, multistage distillation, azeotropic distillation, and steam distillation. In a preferred embodiment, a method of the invention is provided wherein the concentration in step b) comprises aromatic distillation, said distillation defined as distillation configured to ensure high retrieval of aromaproducing compounds. Figure 2 shows a specific embodiment of the general method according to the invention, wherein the second concentration (B) is performed by fractional distillation, as schematically illustrated by the presence of fractionating column.

**[0034]** Distillation forms part of a larger group of separation processes based on phase transition, collectively termed as "*fractionation*". Other examples of fractionation comprise column chromatography that is based on difference in affinity between stationary phase and the mobile phase, and fractional crystallization and fractional freezing both utilising the difference in crystallisation or melting points of different components of a mixture at a given temperature. In an advantageous arrangement of the present invention, method b) may comprise such fractionation, preferably distillation, arrangement, wherein different fractions are analysed for the presence of different components such as different volatile flavour component species and then selectively directed for pooling with the retentate from step a) or discarded, which would provide greater control over aroma profile of the final beer concentrate of the invention.

**[0035]** In a possible embodiment of the present invention, the step b) of the method of the invention first comprises reverse osmosis; and then further comprises at least one additional treatment of the fraction comprising ethanol, obtained following said reverse osmosis, said treatment comprising fractionation, preferably distillation, or reverse osmosis. In said embodiment the aqueous permeate being the fraction comprising alcohol and volatile flavour components is first subjected to a step

comprising reverse osmosis to obtain a fraction comprising alcohol and volatile flavour components at a higher concentration than before the step comprising reverse osmosis and leftover fraction, after which said fraction comprising alcohol and volatile flavour components is further subjected to at least one further concentration step comprising fractionation, preferably distillation, or reverse osmosis, to obtain a concentrated fraction comprising alcohol and volatile flavour components and a leftover fraction.

**[0036]** A in a further development of the embodiments of the present invention, a method is provided wherein the reverse osmosis is a high resolution reverse osmosis i.e. reverse osmosis conducted under operating pressure comprised within the range of 60-120 bar and at temperature of 0-12 °C.

**[0037]** According to an alternative method of the invention and as illustrated in figure 2 a method is provided wherein fractionation and preferably distillation is applied as further concentration step b). The distillation (B') results in obtaining a fraction (4') collected at the top of the distillation column that mainly comprises alcohol and volatile flavour components and a fraction (5') collected at the bottom of the distillation column and mainly comprising water and beer or cider extract. The fraction (5') can subsequently be fed to an adsorption column (D), selectively adsorbing volatile flavour compounds that can be eluted to obtain a concentrated volatile flavour component fraction (6') which can be added to the final beer concentrate (10) or kept apart. The fraction (5') is preferably fed to a freeze concentration process (D'') allowing removing pure water from this fraction at sub zero temperatures to obtain a concentrated extract fraction (7') that can either be added to the final beer concentrate or kept apart.

**[0038]** According to another alternative method of the invention and as illustrated in figure 3 a method is provided wherein adsorption (B'') is applied as further concentration step b). The adsorption column selectively adsorbs volatile flavour compounds of the permeate (3) that can be eluted to obtain a concentrated volatile flavour component fraction (4'') which can be added to the final beer concentrate (10) or further concentrated by means of a freeze concentration process (C''), allowing removing pure water from this fraction at sub zero temperatures to obtain a concentrated volatile flavour component fraction (6'') that can either be added to the final beer concentrate or kept apart.

**[0039]** According to an alternative embodiment of the present invention and as illustrated in figure 4, a method is provided wherein freeze concentration (B\*) is applied as further concentration step b). Freeze concentration essentially concerns the removal of pure water in the form of ice crystals at sub zero temperatures. Freeze concentration has the advantage over eg. distillation that it does not remove ash or extract (ions, organic components, etc.) from the permeate obtained by nanofiltration in step a), which is the case in distillation. For this reason

it is believed that a beer or cider reconstituted by the addition of water after concentration by:

1) Subjecting beer or cider (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is characterised by the concentration of unfilterable compounds equal to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;

2) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step comprising freeze concentration to obtain a concentrated fraction comprising alcohol and volatile flavour components and a leftover fraction;

3) Subjecting the freeze concentrated fraction 4\* to an adsorption process to selectively remove flavour components from the concentrated fraction comprising alcohol and volatile flavour components.

**[0040]** In a preferred embodiment, beer subjected to the method of the invention is beer of gravity higher than 11 °P, preferably is high gravity beer defined as beer of original gravity of 14-25 °P or even higher. Concentration of high gravity beer is preferred for being applied to the method of the present invention as such arrangement provides synergistic approach resulting in final concentrates characterized by very high concentration factors, not obtainable by any method so far known in the art. As it will, however, be immediately appreciated by any skilled person, any commercial grade beer can be subjected to the provided herein method to obtain a beer concentrate of the present invention. In line with the above, in another preferred embodiment in accordance with the above embodiments, beer subjected to the method of the invention is any beer comprising alcohol concentration comprised between 2- 16 % ABV, preferably between 4-12 % ABV, most preferably between 6-10 % ABV.

**[0041]** Beer concentrates (10) according to the present invention can achieve final concentration of unfilterable compounds (following addition of the concentrated ethanol fraction (4) to the nanofiltration retentate(2)) equal to or higher than 8%, 10%, 15%, 20%, 25%, even up to 30% (w/w), which is equivalent to the final concentration factor (calculated as a ratio of starting volume of beer (1) to the volume of the final concentrate (6)) ranging from 4 to 6 or even 6.5.

**[0042]** In line with this, in a preferred embodiment, the present invention provides a beer concentrate (6) having extract density equal to or higher than at least 18 °P, preferably at least 20 °P, more preferably at least 25 °P or even higher.

**[0043]** Such obtained final beer concentrates (10) can

now be stored or transported at costs to a desired destination place, where they can be readily reconstituted to a final beverage of olfactory properties highly resembling or virtually identical to normally-brewed beer.

**[0044]** In some embodiments of the present invention, it may be advantageous to store and transport the highly concentrated retentate (2) obtained in the first concentration step a) on its own, without blending with the ethanol fraction. In such embodiment, the present invention also provides a liquid composition characterised by the concentration of unfilterable compounds obtained from beer or cider, said concentration equal to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount. In another similar embodiment, the present invention further provides a liquid composition characterised by the concentration of unfilterable compounds obtained from beer or cider, said concentration equal to or higher than 30% (w/w), preferably 35% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount.

**[0045]** The (concentrated) volatile flavour fractions and concentrated extract fractions obtained from processing the permeate of the nanofiltration process (A) can be used an ingredient for beer, as a component in beer reconstitution or as a flavour component to be added to a beer or cider. When used as a component in beer reconstitution starting from a beer concentrate, the beer concentrate can either be the beer concentrate obtained by the process of the present invention or another beer concentrate.

### 35 Claims

1. A method for preparing beer concentrate, comprising the steps of:

a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is **characterised by** the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;

b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising freeze concentration, fractionation, preferably being distillation, or reverse osmosis, to obtain a concentrated fraction comprising alcohol and volatile flavour components (4), and a leftover fraction (5);

c) Subjecting the leftover fraction (5) of the next concentration step (B) to a fractionation, prefer-



- ably being distillation, an adsorption or a freeze concentration to obtain a second fraction comprising alcohol and volatile flavour components and a second leftover fraction.
2. A method for preparing beer concentrate, comprising the steps of:
- a) Subjecting beer (1) to a first concentration step comprising nanofiltration (A) or reverse osmosis to obtain a retentate (2) and a fraction comprising alcohol and volatile flavour components (3), wherein the retentate (2) is **characterised by** the concentration of unfilterable compounds to or higher than 20% (w/w), preferably 30% (w/w), most preferably 40% (w/w), as calculated from density measurement corrected for the alcohol amount;
- b) Subjecting the fraction comprising alcohol and volatile flavour components to a next concentration step (B) comprising an adsorption process wherein volatile flavour components are adsorbed on a column and subsequently eluted with a volume of water or alcohol to obtain a concentrated fraction of volatile flavour components (4') and a leftover fraction (5').
3. The method according to claim 1, comprising subjecting the leftover fraction of the next concentration step to a fractionation, preferably being distillation, and subjecting the second leftover fraction (5) of the fractionation to a freeze concentration process to obtain a concentrated extract fraction.
4. The method according to claim 1, comprising subjecting the leftover fraction (5) of the next concentration step to a freeze concentration process, and subjecting the second leftover fraction of the freeze concentration process to an adsorption process, adsorbing at least part of the volatile flavour components from the second leftover fraction and subsequently eluting the adsorbed volatile flavour components in a volume of water or ethanol to obtain a concentrated fraction of volatile flavour components.
5. The method according to claim 1, comprising subjecting the leftover fraction (5) of the next concentration step to an adsorption process, adsorbing at least part of the volatile flavour components from the second leftover fraction and subsequently eluting the adsorbed volatile flavour components in a volume of water or ethanol to obtain a concentrated fraction of volatile flavour components.
6. The method according to any of the preceding claims, wherein the concentrated fraction comprising alcohol and volatile flavour components (4) of the first concentration step is recirculated to the feed
- of the first concentration step.
7. Use of a fraction comprising volatile flavour components or of a concentrated fraction comprising volatile flavour components obtained by a method as identified in any of claims 1 to 6 as an ingredient for beer or cider, as a component in beer or cider reconstitution or as a flavour component to be added to a beer or cider.

Figure 1

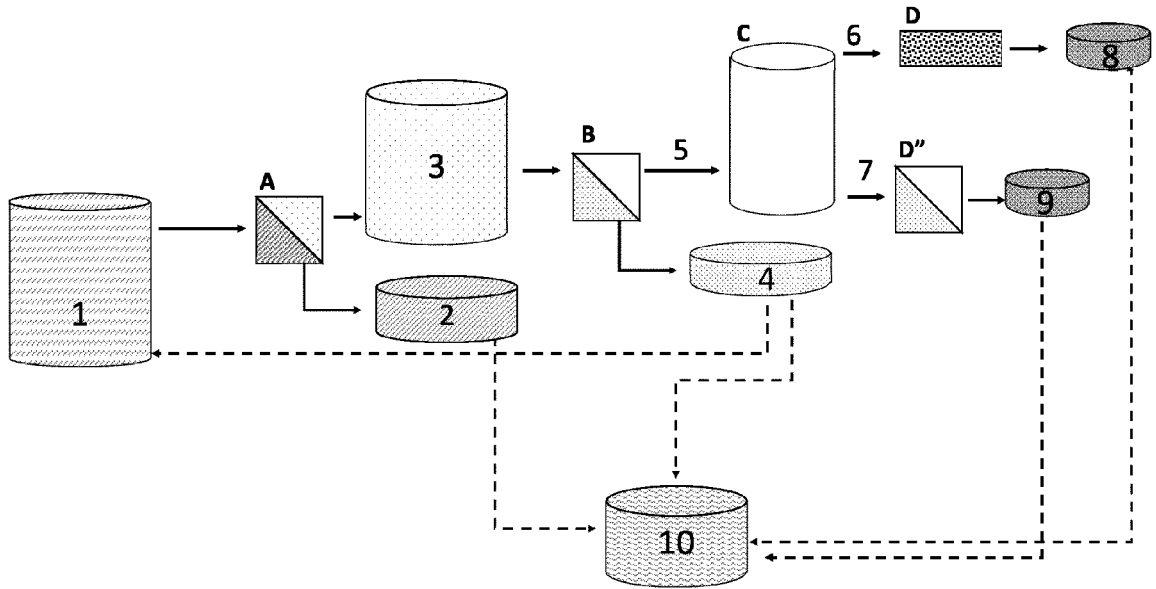


Figure 2

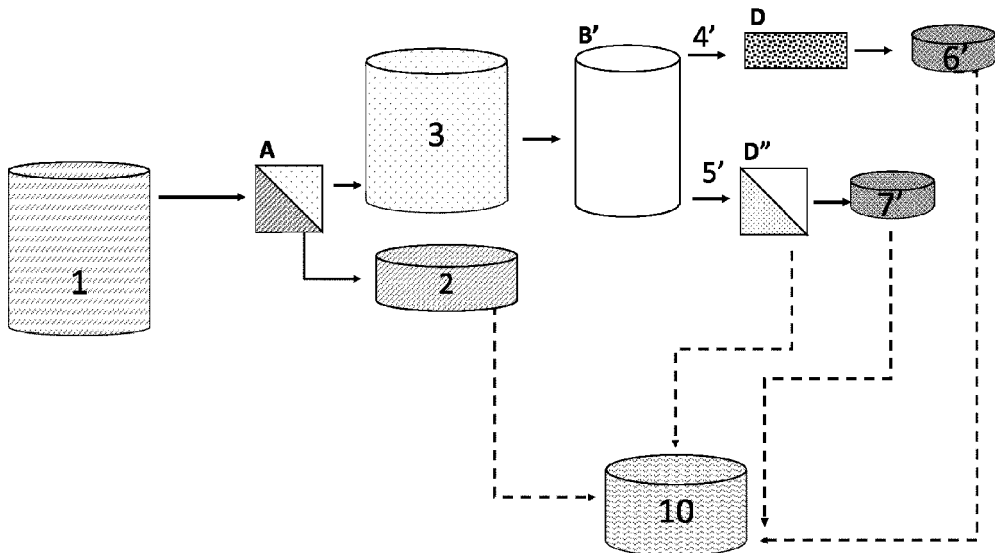


Figure 3

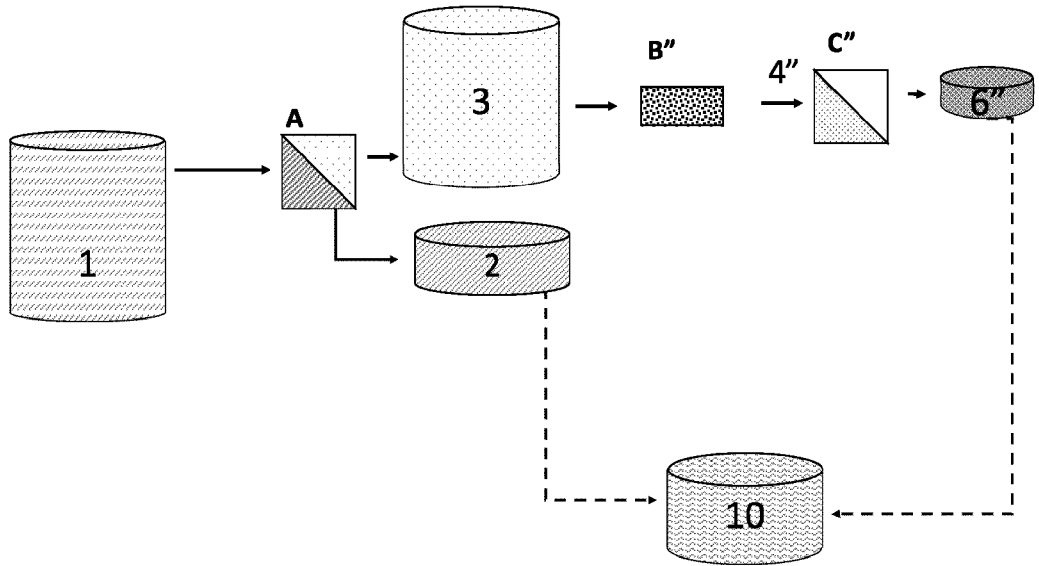


Figure 4

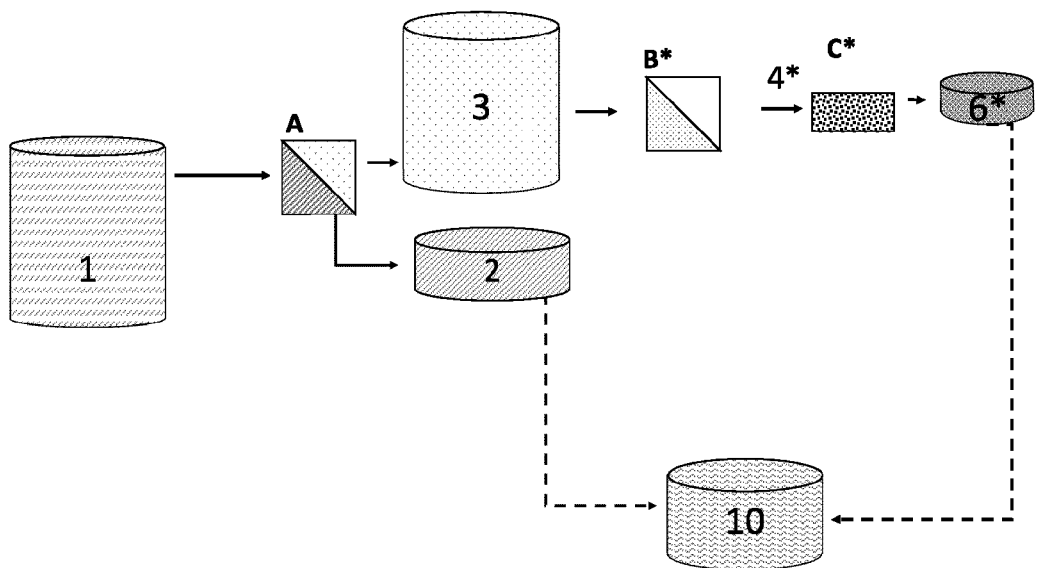
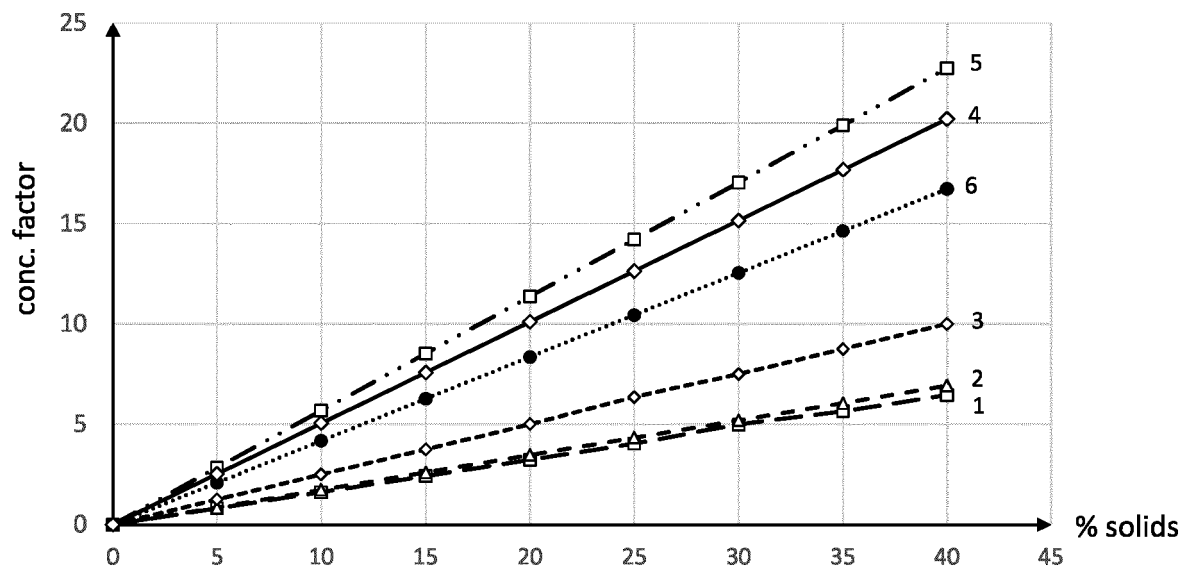


Figure 5





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