(54) Title: METHOD TO OBTAIN MILK WITH LOW SUGAR CONTENT

A method to obtain milk with low sugar content (LFM) starting from milk (M), comprises at least a first step in which the milk (M) is subjected to enzymatic hydrolysis (EH), in order to obtain hydrolyzed milk (HM), in which the lactose is converted at least partly into glucose and into galactose, and a second step in which the milk (HM) hydrolyzed in the first step is subjected to one or more membrane filtering operations, in order to reduce the content of glucose and the content of galactose.
METHOD TO OBTAIN MILK WITH LOW SUGAR CONTENT

A method to obtain milk with low sugar content (LFM) starting from milk (M), comprises at least a first step in which the milk (M) is subjected to enzymatic hydrolysis (EH), in order to obtain hydrolyzed milk (HM), in which the lactose is converted at least partly into glucose and into galactose, and a second step in which the milk (HM) hydrolyzed in the first step is subjected to one or more membrane filtering operations, in order to reduce the content of glucose and the content of galactose.
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments
"METHOD TO OBTAIN MILK WITH LOW SUGAR CONTENT"

FIELD OF THE INVENTION

The present invention concerns a method, and the relative plant, to obtain milk with low sugar content. In particular, the method according to the present invention reduces or eliminates the lactose naturally present in milk by means of enzymatic hydrolysis and, subsequently, reduces the content of the remaining sugars, particularly simple sugars, glucose and galactose, deriving from hydrolysis.

BACKGROUND OF THE INVENTION

It is known that lactose is a disaccharide naturally present in the composition of milk, to about 5% in weight.

Lactose may entail difficulties in digestion or other problems connected to its metabolism in some categories of prone consumers, for example people intolerant of lactose or following a course of antibiotics.

A method to reduce or eliminate lactose is known, by subjecting the milk to enzymatic hydrolysis by means of the enzyme β-galactosidase. The hydrolysis determines the conversion of more than 80% of the lactose into monosaccharides, or simple sugars, glucose and galactose. However, glucose and galactose, both individually and together, have a sweetening power much greater than that of the original lactose. The milk resulting from this method is thus impoverished or deprived of lactose but, for some categories of consumers, may taste too sweet.

Furthermore, the milk thus obtained in any case has a calorie content, due to the monosaccharides, which may be unadvisable in diets with low sugar consumption or for those suffering from disturbances in their sugar metabolism.

Another method to eliminate the lactose from milk is known, which provides first of all to subject the milk as it is to ultrafiltration.

Subsequently, the permeate from the ultrafiltration is subjected to nanofiltration in order to obtain a retentate of nanofiltration that mainly contains lactose and permeate of nanofiltration, mainly containing milk salts. The permeate of nanofiltration is subjected to inverse osmosis, from which a water-based permeate is obtained and a concentrate with a base of salts which is mixed with the retentate of the ultrafiltration. Salts obtained from milk whey are added
to this mixture, which is then subjected to enzymatic hydrolysis, then more water is added, then it is ultra-pasteurized and packed.

This known method, however, has technological limits in the membrane processes for separating-concentrating the lactose, due to the limited solubility of this sugar. Furthermore, the known method is complex from a management point of view, since it requires several operations with a dedicated plant engineering.

Another disadvantage of the known method is that the filtering operations with the membrane are traditionally performed at relatively high temperature, in order to obtain a better performance. This entails the risk of possible activation both of specific enzymes that degrade the milk, and also of bacteria that are normally present in milk.

Furthermore, the need to heat the milk also determines a considerable energy consumption, which increases the overall cost of the method.

One purpose of the present invention is to perfect a method and a relative plant to obtain milk with low sugar content, or substantially lactose-free, and with low sugar content, which overcomes the disadvantages of the state of the art, which does not taste too sweet and which has limited calorie content.

Another purpose of the present invention is to perfect a method and a relative plant which allows to operate within a greater temperature range, even at lower temperatures than those of the state of the art, so as to prevent the activation of bacteria and enzymes that degrade the milk and so as to reduce the overall cost.

The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

The present invention is set forth and characterized in the independent claim, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

In accordance with the above purpose, a method according to the present invention can be used to obtain milk with low sugar content.

According to a characteristic feature of the present invention, the method comprises at least a first step in which the milk is subjected to enzymatic hydrolysis, to obtain a hydrolyzed milk in which the lactose in the milk is at least
partly converted into glucose and into galactose, and a second step in which the milk hydrolyzed in the first step is subjected to one or more operations of membrane filtering, in order to reduce the content of glucose and galactose therein.

Advantageously, the first step of enzymatic hydrolysis reduces the content of lactose in the milk to a value lower than about 3% in weight.

The first step may be performed on the raw milk or on milk previously heat treated and possibly standardized to a content of fat comprised between the natural value and a substantially zero value.

According to a variant of the present invention, the membrane filtering operations of the second step comprise at least an ultrafiltration of the hydrolyzed milk, so as to produce at the end an ultrafiltration permeate containing a portion of the sugars, and a retentate of ultrafiltration.

According to another variant of the present invention, the membrane filtering operations of the second step also comprise, downstream of the ultrafiltration, at least a nanofiltration of the ultrafiltration permeate, so as to produce at the end of the step a nanofiltration permeate and a nanofiltration concentrate rich in glucose and galactose.

According to another variant, the method also provides a third step in which the nanofiltration permeate is mixed with the ultrafiltration retentate.

According to another variant of the present invention, the method has a fourth step in which the mixture obtained in the third step is integrated with a suitable quantity of water, so as to return the mixture to the volume of milk used at the start.

The integration with water is performed with a quantity equal to that of the concentrated solution of sugars, nanofiltration concentrate, removed in the second step.

The present invention allows to obtain milk with low sugar content, or substantially lactose-free, with a percentage of lactose advantageously comprised between about 0.1% and 3% in weight, and with low content of sugars and limited calorie content.

Thanks to the hydrolysis performed before the membrane filtering operations and the conversion of a large part of the lactose into glucose and galactose, the
sugars in the milk are more soluble and therefore have a lesser tendency to crystallize, even in conditions of low temperature or high concentration. This allows, according to the process requirements, to perform the membrane filtering operations in a wide range of temperature, comprised between about 0°C and 50°C, advantageously even at relatively low temperature, comprised between about 5°C and 20°C, with a reduction of energy consumption in the process and the overall cost thereof.

Operating at such a low temperature also allows to prevent the activation of the bacteria normally present in milk, and the enzymes which, at high temperatures, degrade the milk. Therefore we have an increase in the quality and the organoleptic qualities of the final product.

The present invention also benefits from the fact that it allows to have an increased concentration of sugars in the nanofiltration retentate.

In this way we obtain a concentrated solution of simple sugars with a good sweetening power, to be used as a raw material in other productions.

The method according to the invention is also advantageous because it can be integrated into the existing production of "classic" lactose-free milk, that is, based on enzymatic hydrolysis only, with considerable management advantages and simplification of the process.

The milk obtained as final product can also be integrated, or not, with salts deriving from whey, or also possibly from milk, in order to balance the final taste and savor.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a method for processing milk.

DETAILED DESCRIPTION OF A PREFERENTIAL FORM OF EMBODIMENT

With reference to the attached drawing, a method according to the present invention is used to process milk, indicated by the reference M, having a typical initial composition of about 5% in weight of lactose, about 0.7% in weight of salts, milk proteins comprised between about 3% and 4% in weight, and also a fat content comprised between about 0% (skimmed milk) and 4% in weight.

The method according to the invention is performed discontinuously, in batches, and provides to feed a determinate quantity of milk M to an enzymatic hydrolysis unit, indicated by the block EH, and subsequently to perform membrane filtering operations on the hydrolyzed milk, to eliminate part of the
remaining sugars, including, particularly, glucose and galactose.

The present invention, as an optional passage, provides to standardize the content of fat upstream of the enzymatic hydrolysis, shown by block S, in order to take it to the desired percentage, by means of known techniques.

In particular, a first step of the method provides to subject the milk M, optionally standardized, to enzymatic hydrolysis by means of the enzyme β-galactosidase, in order to convert at least part of the lactose into monosaccharides, that is, glucose and galactose, preferably to a value of residual lactose of less than about 3% in weight.

Numerous types of β-galactosidase are available on the market, suitable for use in the present invention, for example produced from Kluyveromyces fragilis or Kluyveromyces lactis.

The hydrolysis preferably has a duration comprised between about 1 hour and 48 hours and is performed at a temperature comprised between about 2°C and 45°C, preferably between 4°C and 10°C.

However, it should be noted that enzyme producers indicate, for the various types of β-galactosidase, the optimum conditions for hydrolysis, that is, time and temperature.

At exit from the hydrolysis unit EH a hydrolyzed milk is obtained, indicated by HM, with a content of lactose of less than 3% in weight, for example comprised between 0.5% and 1%, that is, very low.

Subsequently, in a second step, the hydrolyzed milk HM is subjected to subsequent membrane filtering operations. In particular, the hydrolyzed milk HM is sent to an ultrafiltration unit with a membrane, indicated by the reference UF, where it is subjected to ultrafiltration.

The ultrafiltration UF produces a permeate, indicated by the reference UFP, typically containing water, a mixture of sugars (mainly glucose and galactose) at about 5% and salts, with a content of dry substance comprised between about 4.5% and 6.5%. Furthermore, we also obtain a retentate, indicated by the reference UFR, containing all the insoluble milk proteins, typically casein, and from which water, sugars and salts have been at least partly eliminated.

Preferably, the ultrafiltration is made with a concentration coefficient k, comprised between about 1 and 6, preferably between about 2 and 4.
By concentration coefficient $k$ we mean the ratio in weight, for example kilograms, between the liquid fed to the ultrafiltration unit UF, in this case the hydrolyzed milk HM, and the retentate UFR.

Furthermore, in the second step, the permeate UFP is subsequently sent to a membrane-type nanofiltration unit NF, downstream of the ultrafiltration UF, where it is subjected to nanofiltration.

At exit from the unit NF we have a concentrate, indicated by NFC, comprising water and sugars (mainly galactose and glucose) in a composition comprised between about 20% and 30% and a permeate, indicated by the reference NFP, containing salts originally present in the milk M and a reduced portion of simple sugars, in a quantity comprised between about 0% and 2% in weight.

The concentrate NFC obtained from the nanofiltration NF is a product rich in sugars which can be re-used in fields of application that require simple sugars.

Preferably, the nanofiltration is performed with a concentration coefficient $k$ comprised between about 1 and 6, preferably between about 4 and 6.

The working temperature of the ultrafiltration unit UF and the nanofiltration unit NF is comprised between about 0°C and 50°C.

Advantageously, the present invention allows to operate even at lower temperatures than those used in the state of the art, that is, between about 5°C and 20°C, since higher temperatures are not strictly necessary, inasmuch as the sugars in the hydrolyzed milk have a solubility compatible with the membrane filtering in a wide range of conditions.

The working pressure of the ultrafiltration unit UF and the nanofiltration unit NF is that advised by the membrane producers, that is, a few bar, for example comprised between 1 bar and 4 bar, for the ultrafiltration, and a few bar or tens of bar, for example between about 5 bar and 40 bar, for the nanofiltration.

According to requirements, the ultrafiltration UF and nanofiltration NF operations can be provided in a single stage or in several cascade stages, possibly recircling the currents, or a combination of said solutions.

In a third step, the permeate NFP is mixed with the retentate UFR in a mixer, indicated generically by the reference MIX in fig. 1.

In a fourth step, which can be performed at the same time as the third step and in the same mixer MIX, a quantity of water W is added to the mixture,
substantially equal to the quantity of concentrate NFC exiting from the nanofiltration unit NF, so as to return the milk to its original volume.

The finished product, milk with low sugar content, is indicated by the reference LFM.

The milk LFM is substantially lactose-free and has a content of residual sugars comprised between about 0.5% and 3%, preferably between about 1.5% and 2.5%.

According to production requirements, the sugar content can be varied and pushed towards one extreme or the other of the range, by acting selectively on the working pressure, on the concentration coefficient \( k \) and/or on the number of stages of the ultrafiltration and nanofiltration.

It is clear that modifications and/or additions of steps may be made to the method to obtain low sugar content milk as described heretofore, without departing from the field and scope of the present invention.

For example, as we said, the milk can be subjected to an operation to standardize the fat, block S, by means of centrifugal separation so as to separate the cream from the milk, in order to reduce the fat content and obtain skimmed or partly skimmed milk. This variant is advantageous since it implies a reduced deposit of fats, the so-called fouling effect, on the membranes used in filtering.

Advantageously, furthermore, in this way a milk is obtained that has reduced calorie content both in terms of sugar and also in terms of fat. This milk, with low sugar content and low fat content, is suitable for consumers following a diet that provides a limited quantity of these nutrients.

Moreover, the milk can also be subjected to heat treatment to guarantee conservation. The heat treatment can be performed on the milk LFM downstream of the membrane filtering operations, after the water W has been added, as indicated by block HT.

Furthermore, according to requirements, a heat treatment can also be carried out before the membrane filtering operations and/or enzymatic hydrolysis.

For example, the milk can be pasteurized, at a temperature comprised between about 60°C and 90°C, for example at about 72°C for 15 seconds, ultra-pasteurized using the ESL method for example at a temperature of about 130°C for about 1 – 2 seconds, or subjected to U.H.T. treatment (Ultra High
Temperature) at a temperature of about 145°C for about 2 – 4 seconds, and homogenized at a pressure comprised between about 100 and 300 bar.

In this way milk with low sugar content is obtained, and optionally also with low fat content, with the desired properties of hygiene and preservation.

A variant provides to apply the teachings of the international patent application WO-A-2004/110158, in the name of the present Applicant, so as to obtain milk both with a reduced sugar content and also of the ESL type, that is, long life, but which has not been subjected to too strong heat treatments or for too long a time, such as for example the U.H.T. treatment, which could denature the nutrients originally present in the milk and worsen the original organoleptic properties.

In this variant, the initial milk is subjected to skimming and centrifugal clarification in order to separate the fat and to kill about 70% - 90% of bacterial content and reduce the content of other microbes and pathogenic substances.

The milk is sent to the enzymatic hydrolysis EH, and then follows the main method according to the invention to reduce the sugars.

Subsequently, the skimmed milk, with its reduced sugar content, as obtained by the steps of the method according to the main solution, is optionally subjected to heating to 50°C – 60°C, and then subjected to micro-filtering, in one or more stages, in order to obtain milk with a low bacterial and microbe content.

This milk is finally standardized to the desired fat content and subjected to low-temperature pasteurization. In this way, milk is obtained with a long shelf life.

It is also clear that, although the present invention has been described with reference to specific examples, a person of skill in the art shall certainly be able to achieve other equivalent forms of method to obtain milk with low sugar content, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.
CLAIMS:

1. A method to obtain milk with low sugar content starting from milk, comprising at least the following steps:
   - a first step in which the milk is subjected to enzymatic hydrolysis, in order to obtain hydrolyzed milk, in which the lactose is converted at least partly into glucose and into galactose;
   - a second step in which the milk hydrolyzed in the first step is subjected to a plurality of membrane filtering operations, in order to reduce the content of glucose and the content of galactose, wherein the membrane filtering operations of the second step comprise at least an ultrafiltration of the hydrolyzed milk, so as to produce, at exit, an ultrafiltration permeate and an ultrafiltration retentate and at least a nanofiltration of the ultrafiltration permeate, so as to produce, at exit, a nanofiltration permeate and a nanofiltration concentrate rich in glucose and galactose.

2. The method according to claim 1, wherein the membrane filtering operations are performed at a temperature between 0°C and 50°C.

3. The method according to claim 1 or 2, wherein the membrane filtering operations are performed at a temperature between 5°C and 20°C.

4. The method according to any one of claims 1 to 3, further comprising a third step in which the nanofiltration permeate is mixed with the ultrafiltration retentate.

5. The method according to claim 4, further comprising a fourth step in which water is added to the mixture obtained in the third step, so as to regulate the content of sugar and obtain the milk with low sugar content.
6. The method according to claim 5, wherein the quantity of water added in the fourth step is equal to the quantity of nanofiltration concentrate obtained in the second step.

7. The method according to any one of claims 1 to 6, wherein the duration of the enzymatic hydrolysis in the first step is between 1 hour and 48 hours and the temperature of the hydrolysis is between 2°C and 45°C.

8. The method according to any one of claims 1 to 7, wherein a concentration coefficient of the ultrafiltration is between 1 and 6.

9. The method according to any one of claims 1 to 7, wherein a concentration coefficient of the nanofiltration is between 1 and 6.

10. The method according to claim 5, wherein the sugar content in the milk with low sugar content obtained in the fourth step is between 0.5% and 3% in weight.

11. The method according to claim 5, wherein the sugar content in the milk with low sugar content obtained in the fourth step is between 1.5% and 2.5% in weight.

12. The method according to any one of claims 1 to 11, further comprising a step of heat treatment guaranteeing the preservation of the milk with low sugar content.

13. The method according to any one of claims 1 to 12, further comprising an operation to reduce the content of fat in the milk.

14. The method according to any one of claims 1 to 13, further comprising a step of centrifuge clarification of the milk.
15. The method according to any one of claims 1 to 14, further comprising a step of micro-filtering of the milk with low sugar content.

16. A plant to obtain milk with low sugar content starting from milk, comprising at least:
- enzymatic hydrolysis means, able to subject the milk to enzymatic hydrolysis, in order to obtain hydrolyzed milk, in which the lactose is at least partly converted into glucose and galactose;
- membrane filtering means, downstream of the enzymatic hydrolysis means, able to subject the milk hydrolyzed in the first step to a plurality of membrane filtering operations, in order to reduce the content of glucose and the content of galactose, wherein the membrane filtering means comprise at least a membrane ultrafiltration unit for ultrafiltration of the hydrolyzed milk, so as to produce, at exit, an ultrafiltration permeate and an ultrafiltration retentate and at least a membrane nanofiltration unit for nanofiltration of the ultrafiltration permeate, so as to produce, at exit, a nanofiltration permeate and a nanofiltration concentrate rich in glucose and galactose.

17. The plant according to claim 16, further comprising a mixer for mixing the nanofiltration permeate with the ultrafiltration retentate.

18. The plant according to claim 17, further comprising a means for adding water to the mixture obtained from the mixer, so as to regulate the content of sugar and obtain the milk with low sugar content.

19. The plant according to claim 18, wherein said means for adding water are configured to add a quantity of water equal to the quantity of nanofiltration concentrate.