(57) Abrégé/Abstract:
A kind of lactose-removing milk is prepared with milk as material and through de-fatting (or not de-fatting), curding, precipitation, ultra-filtering, re-dissolving, mixing, recovering and other steps. The lactose-removing milk may be produced into liquid milk or milk powder, and may be also mixed with common milk to produce low lactose liquid milk or low lactose milk powder.
Abstract

A kind of lactose-removing milk is prepared with milk as material and through de-fattening (or not de-fattening), curding, precipitation, ultra-filtering, re-dissolving, mixing, recovering and other steps. The lactose-removing milk may be produced into liquid milk or milk powder, and may be also mixed with common milk to produce low lactose liquid milk or low lactose milk powder.
METHOD FOR MAKING LACTOSE-FREE MILK PRODUCTS OR LOW-LACTOSE MILK PRODUCTS

[0001] Field of the Invention

[0002] The invention relates to a method for making lactose-free milk products or low-lactose milk products with milk as raw material. The lactose-free milk products or low-lactose milk products can be lactose-free or low-lactose liquid milk, lactose-free or low-lactose solid milk powder.

[0003] Background of the Invention

[0004] Lactose is a unique disaccharide which exists in mammal breast milk and also a main carbohydrate in milk (more than 99.8% in sugar). The content of lactose in normal fresh milk is 4.8-5.2%, which accounts for about 52% of non-fat milk solid or about 70% of whey solid. Medical Encyclopedia (A service of the U.S. national library of medicine and the national institutes of health) discloses: unless lactose is decomposed by enough lactase, digested and assimilated in small intestine after entering the alimentary tract, symptoms which are medically called lactose intolerance such as abdominal distension, abdominal pain or diarrhea will occur. Lactose intolerance breaks out more in Asia, Africa, and Latin America. Lactose mainly comes from dairy 20 products. In order to avoid lactose intolerance, people usually choose to change their diet style and don't drink or drink a little milk or dairy products. However, Word journal of gastroenterology (2006, Vol12, NO.2, p187-191) discloses that escaping from milk or dairy product may cause diet structure absence and body nutrition imbalance. In order to solve the problem of lactose intolerance after drinking milk, U.S. Pat. 6881428, U.S. Pat. 20050170044 and European Food Tech Award to Valio lactose free milk technology (2006/5/4) disclose that based on current milk processing, lactase is added to milk and decomposes lactose to relieve uncomfortable symptoms. However, equal molar concentration of glucose and
galactose are produced by the above-mentioned method, which means the total sugar content is not reduced. Furthermore, drinking this kind of milk constantly or enormously is not beneficial to the blood sugar stability of diabetes patients. Therefore, removing lactose and reducing the sugar content of milk is significantly useful for consumer health. At present, there are methods about removing lactose disclosed in domestic or overseas publications, for example, U.S. Pat. 5429829 discloses a method for making flavorful de-lactose cheese products by chymosin with fermentation technique, the cheese products are nutritious and have low lactose, unfortunately they don’t have nutritional whey part. U.S. Pat. 20050214409 discloses a method for removing lactose from milk directly with membrane separation and column chromatography unfortunately the method exhibits a low efficiency and is difficult for industrial production.

[0005] Summary of the Invention

[0006] The invention provides a method for removing lactose from milk effectively. Firstly, milk is defatted to obtain low-fat milk and milk fat, and then milk coagulant and calcium salt are added with stirring to the low-fat milk to produce milk curd. The milk curd is heated, cut with stirring to give curd particles and whey. The curd particles are dissolved with milk solvent to obtain re-dissolved milk. De-lactose whey or de-lactose whey powder are obtained by removing lactose with membrane separation technique. The re-dissolved milk is mixed with the de-lactose whey or de-lactose whey powder with or without adding the original milk fat, emulsified with emulsifier to give lactose-free milk. Further, the lactose-free milk may be homogenized, disinfected to give liquid milk which may be dried to offer lactose-free milk powder. If milk is not defatted, low-lactose liquid milk or low-lactose milk powder can be obtained by producing milk curd from milk directly, obtaining re-dissolved milk, removing lactose from whey with membrane separation, and mixing, etc.

[0007] The key technique of the invention is to dissolve curd particles with milk solvent to produce re-dissolved milk, and then to mix the re-dissolved milk with de-lactose whey
to produce de-lactose liquid milk or de-lactose milk powder. This method can also be practicable in producing de-lactose goat milk or de-lactose goat milk powder with goat milk as raw material.

[0007A] In one aspect, there is provided a method for making de-lactose milk products, characterized in that the de lactose milk products are prepared through the steps of A(1)-(6) or A(1)-(7): A. (1) defatting milk to obtain low-fat milk and milk fat; (2) heating the low-fat milk of A(1) and adding milk coagulant, calcium salt solution with stirring to obtain milk curd; (3) heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected; (4) dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0; (5) removing lactose from the whey of A(3) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder; (6) mixing the re-dissolved milk of A(4) with de-lactose whey or delactose whey powder of A(5), and adding the milk fat of A(1) or not, emulsifier to perform shear emulsification reaction and obtain lactose-free milk; and (7) homogenizing and disinfecting the lactose-free milk of A(6) to obtain lactose-free liquid milk which may be further dried to give lactose-free milk powder, or homogenizing and disinfecting the mixture of lactose-free milk of A(6) with common milk to obtain low-lactose liquid milk which may be further dried to give low-lactose milk powder.

[0007B] In another aspect, there is provided a method for making de-lactose milk products, characterized in that the de lactose milk products are prepared through the steps of B(1)-(5) or B(1)-(6): B. (1) heating milk and adding milk coagulant, calcium salt solution with stirring to obtain milk curd; (2) heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected; (3) dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0; (4) removing lactose from the whey of B(2) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder; (5) mixing the re-dissolved milk of B(3) with de-lactose whey or de lactose whey powder of B(4), and adding milk fat obtained by defatting milk or not, emulsifier to perform shear...
emulsification reaction and obtain lactose-free milk; and (6) homogenizing and disinfecting the low-lactose milk to obtain low lactose liquid milk which may be further dried to obtain low-lactose milk powder.

[0008] Purpose of the Invention

[0009] One of the purposes of this invention is to provide a method for removing lactose from milk effectively. Specifically, milk is used as raw 10 material, defatted or not, precipitated, ultrafiltrated, re-dissolved, mixed and restored to give de-lactose milk products. The products may be lactose-free liquid milk, lactose-free solid milk, low-lactose liquid milk or low-lactose solid milk. Another purpose of the invention is to provide the same method mentioned above to produce lactose-free goat liquid milk, low-lactose goat liquid milk, lactose-free goat milk powder or low-lactose goat milk powder with goat milk as raw material.

[0010] The following is the inventor’ research findings on milk and lactose in recent years:

[0011] 1. Milk structure can be modified by curding, and then milk is coagulated, fat, protein, vitamin and mineral are congregated in the curd. If the milk is defatted the concentration of the curd can be enhanced and further decrease the lactose content of curd particles. Since lactose mainly comes from whey, having low molecular weight and water-soluble, the effect of removing lactose can be doubled by whey membrane separation technique.

[0012] 2. People used to process milk with chymosin to get cheese or casein whose character, flavor and ingredients are different from the original milk. Milk solvent, emulsifier and homogenization combination scheme of the invention can restore the curd to obtain the re-dissolved milk.

[0013] 3. Mixing the above-mentioned de-lactose whey with the re-dissolved milk to produce stable de-lactose milk whose character is almost the same as the original milk.
[0014] 4. The invention shows that there is no occurrence of lactose intolerance and blood glucose abnormal reaction among people who are lack of lactase or suffer from diabetes after having the lactose-free dairy products.

[0015] National standard of People’s Republic of China GB13432-2004: General standard for the labeling of prepackaged foods for special dietary uses says the sugar content (including monosaccharide and disaccharide) ≤0.5% is defined as no sugar. Usually when the lactose content of dairy products is decreased by 20%-50%, lactose intolerance hardly happens. The lactose content of low-lactose liquid milk of the invention is ≤2.5 % (sugar decreased by 50%); the lactose content of full-fat low-lactose milk powder of the invention is ≤20 % (sugar decreased by 50%).

[0016] Therefore, the technique conception of the invention is:

[0017] To the defatted milk, add food-grade milk coagulant to precipitate and separate milk fat, protein and mineral from whey. The precipitates are collected and re-dissolved with curd solvent. The whey is operated to remove lactose by membrane separation technique, then mixed with fat and the re-dissolved milk. The mixed de-lactose milk is homogenized and disinfected to give lactose-free liquid milk which may be dried to offer lactose-free milk powder, or mixed with common milk to give low-lactose dairy products.

[0018] The preparation method of de-lactose milk products comprises the steps of:
A(1)-(6) to obtain lactose-free milk; A(1)-(7) to obtain lactose-free liquid milk which can be further dried to offer lactose-free milk powder, or low-lactose liquid milk which can be further dried to offer low-lactose milk powder; B(1)-(5) to obtain low-lactose milk; B(1)-(6) to obtain low-lactose liquid milk or low-lactose milk powder.

[0019] A.

[0020] (1) Defatting milk to obtain low-fat milk and milk fat;

[0021] (2) Heating the low-fat milk of (1) and adding milk coagulant, calcium salt solution with stirring to obtain milk curd;
[0022] (3) Heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected;

[0023] (4) Dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0;

[0024] (5) Removing lactose from the whey of A(3) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder;

[0025] (6) Mixing the re-dissolved milk of A(4) with de-lactose whey or de-lactose whey powder of A(5), and adding the milk fat of A(1) or not, emulsifier to perform shear emulsification reaction and obtain lactose-free milk;

[0026] (7) Homogenizing and disinfecting the lactose-free milk of A(6) to obtain lactose-free liquid milk which may be further dried to give lactose-free milk powder, or homogenizing and disinfecting the mixture of lactose-free milk of A(6) with common milk to obtain low-lactose liquid milk which may be further dried to give low-lactose milk powder.

[0027] B.

[0028] (1) Heating milk and adding milk coagulant, calcium salt solution with stirring to obtain milk curd;

[0029] (2) Heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected;

[0030] (3) Dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0;

[0031] (4) Removing lactose from the whey of B(2) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder;

[0032] (5) Mixing the re-dissolved milk of B(3) with de-lactose whey or de-lactose whey powder of B(4), and adding the milk fat of A(1) or not, emulsifier 5 to perform shear emulsification reaction and obtain low-lactose milk;
[0033] (6) Homogenizing and disinfecting the low-lactose milk to obtain low-lactose liquid milk which may be further dried to obtain low-lactose milk powder.

[0034] Lactose-free dairy products of the invention comprise lactose-free liquid milk and lactose-free milk powder. Low-lactose dairy products of the invention comprise low-lactose liquid milk and low-lactose milk powder.

[0035] The milk of the invention is fresh milk or food-grade milk powder dissolved with drinking water.

[0036] The milk coagulant of the invention comprises chymosin, acid supplements or a mixture thereof. The chymosin comprises animal chymosin such as calf chymosin or lamb chymosin, botanical chymosin such as chymopapain or microbial chymosin such as mucor chymosin. The acid supplements comprises hydrochloric acid, lactic acid, citric acid or carbon dioxide.

[0037] The milk solvent of the invention comprises carbonate-citric acid buffer, citrate-citric acid buffer or phosphate buffer. The phosphate buffer may be potassium phosphate dibasic-potassium dihydrogen phosphate buffer. The salt concentration of the re-dissolved milk is controlled between 0.005 M and 0.03 M. The pH value of the re-dissolved milk is controlled between 6.6 and 7.0.

[0038] The emulsifier of the invention comprises sucrose ester and lecithin.

[0039] The rotating speed of the shear emulsification reaction of the invention is between 1000 rpm and 4000 rpm, temperature between 25°C and 60°C for 10-60 min.

[0040] The membrane separation technique of the invention comprises ultrafiltration and nanofiltration. The type of ultrafiltration and nanofiltration is described by membrane material and molecular weight cutoff. Ultrafiltration specification: membrane material is polyethersulfone or ceramic, the membrane molecular weight cutoff is between 5000 and 20000; Nanofiltration specification: membrane material is composite membrane or ceramic membrane, the nanofiltration membrane molecular weight cutoff is between 100 and 350.
[0041] The invention further provides a method for making low-lactose liquid milk comprising mixing lactose-free liquid milk or lactose-free milk powder with common milk proportionally and thereafter homogenizing and disinfecting the mixture.

[0042] A method for making low-lactose milk powder comprises mixing lactose-free liquid milk or lactose-free milk powder with common milk proportionally and thereafter homogenizing, disinfecting and drying the mixture.

[0043] The method of making lactose-free or low-lactose milk can also be practicable in producing lactose-free goat milk or low-lactose goat milk powder with goat milk as raw material.

[0044] Advantages of the invention comprise:

[0045] 1. Precipitating milk curd increases the removal efficiency of the lactose from whey and saves the production cost;

[0046] 2. Mixing the curd with the de-lactose whey and fat maintains most nutrient components except lactose;

[0047] 3. De-lactose dairy products of the invention have less lactose and total sugar content, and meanwhile maintain the original flavor;

[0048] 4. The dairy products of the invention can also be further combined with other products to offer sugar-free or low-sugar healthy food.

[0049] Example 1

[0050] 100 Kg of milk from healthy cow were collected, defatted by centrifugation, heated at 61°C and disinfected for 30 min. After the temperature was cooled down to 41°C, 100 ml of 10% CaCl₂ and 0.2% calf chymosin were added to the milk slowly with stirring. Stand the solution for 45 min. After the reaction, the solution was heated quickly to 45°C and the milk curd was smashed with stirring to give curd particles and whey. The whey were filtered, collected, and added to 100 Kg of 45°C purified water, stirred, filtered and collected again. Meanwhile, the residue of the washed curd particles were
also collected, dissolved with 0.01 mol potassium citrate-citric acid buffer to produce the re-dissolved milk whose pH value was 6.7. The lactose of the collected whey was removed by ultrafiltration and nanofiltration to give de-lactose whey which contained minerals and vitamin. The re-dissolved milk, the de-lactose whey were mixed with fat, heated, homogenized at 20 Mpa, and disinfected to give lactose-free liquid milk. Tests showed the de-lactose milk contained lactose ≤5%, total sugar ≤0.5%, fat ≥3.0%, and protein ≥2.9%. The liquid milk can be further dried to give lactose-free milk powder. Tests showed the de-lactose milk powder contained lactose ≤5%, total sugar ≤5%, and proteins ≥30%.

[0051] Example 2

[0052] 10 Kg of food-grade skim milk powder (fat content ≤2.0%) was dissolved with 90 Kg of water, and then 3000 ml of 10% calcium lactate and 1000 ml of 0.2% chymopapain solution were added with stirring, heated to 39°C for 20 min. After the reaction, the solution was heated quickly to 55°C and the milk curd was smashed with stirring to give curd particles and whey. The whey were filtered, collected, and added to 100 kg of 45°C purified water, stirred, filtered and collected again. Meanwhile, the residue of the washed curd particles were also collected, dissolved with 0.01 mol potassium carbonate-citric acid buffer and 0.2% sucrose ester to produce the re-dissolved milk whose pH value was 7.0. The lactose of the collected whey was removed by ultrafiltration and nanofiltration to give de-lactose whey which contained minerals. The re-dissolved milk were mixed with the de-lactose whey, homogenized, heated and disinfected to give lactose-free liquid milk. Tests showed the lactose-free milk contained lactose ≤5%, total sugar ≤0.5%, fat ≤1.5%, and proteins ≥2.9%.

[0053] Example 3

[0054] 100 Kg of milk from healthy cow were collected, defatted by centrifugation, and 1000 ml of 10% CaCl₂ was added with stirring slowly, then 2N hydrochloric acid was
also added to the milk. The solution was heated to 41°C, the pH value was decreased to 5.0. Stand the solution for 45 min. After the reaction, the milk curd was smashed with stirring to give curd particles and whey. The whey were filtered, collected, and added to 100 Kg of purified water, stirred, filtered and collected again. Repeat the filtering until the pH value of the whey reached 6.5. Meanwhile, the residue of the washed curd particles were also collected, dissolved with K₂HPO₄ - KH₂PO₄ to produce the re-dissolved milk whose pH value was 6.8. The lactose of the collected whey was removed by membrane filtration to give de-lactose whey which contained minerals. The re-dissolved milk was mixed with the de-lactose whey to give 80 Kg of lactose-free milk which was mixed with 80 Kg common fresh milk, homogenized, heated, and disinfected to give low-lactose liquid milk. Tests showed the low-lactose milk contained lactose ≤2.5%, total sugar ≤2.5%, fat ≥1.5%, and proteins ≥2.9%.

[0055] Example 4

[0056] 10 Kg of defatted milk powder (fat content s; 2.0%) was dissolved with 90 Kg of water to obtain low-fat milk. The milk was coagulated with lactic acid, dissolved with citric acid buffer to give the re-dissolved milk. The re-dissolved milk was mixed with 1 Kg of high-protein de-lactose whey powder, 1 Kg of milk fat and 0.02 Kg of lecithin, homogenized and disinfected to give lactose-free liquid milk. Tests showed the lactose-free milk that contained lactose ≤0.5%, total sugar ≤0.5%, fat ≥1.5%, and proteins ≥2.9%.

[0057] Example 5

[0058] 100 ml of 10% CaCl₂, 0.2% mucor chymosin solution, and 1 N hydrochloric acid were added to 100 Kg of milk from healthy cow slowly with stirring. The temperature was up to 390°C, the pH value was decreased to 6.5 and standing for 45 min. After the reaction, the milk curd was smashed with stirring to give curd particles and whey. The whey were filtered, collected, and added to 100 Kg of purified water, stirred, filtered and
collected again. Meanwhile, the residue of the washed curd particles were also collected, dissolved with sodium citrate-citric acid buffer to produce the re-dissolved milk whose pH value was 6.8. The lactose of the collected whey was removed by membrane filtration to give de-lactose whey which contained minerals. The re-dissolved milk was mixed with the de-lactose whey to give 80 Kg of lactose-free milk, homogenized, heated, and disinfected to give low-lactose liquid milk. Tests showed the low-lactose milk contained lactose ≤2.5%, total sugar ≤2.5%, fat ≥3.0%, and proteins ≥2.9%.

[0059] Example 6

[0060] Fig chymopapain, CaCl₂ solution were added to 1 Kg of goat milk to produce milk curd and whey. The curd was dissolved with citric acid buffer whose pH value was 7.0 to obtain re-dissolved milk. Afterward, lactose was removed from the whey by membrane filtration. The re-dissolved milk was mixed with de-lactose whey, homogenized to obtain lactose-free goat milk. Tests showed the lactose-free goat milk contained lactose ≤0.5%, total sugar ≤0.5%, fat ≥1.5%, and proteins ≥2.9%.
Claims

1. A method for making de-lactose milk products, characterized in that the de-lactose milk products are prepared through the steps of A(1)-(6) or A(1)-(7):

   A.

   (1) defatting milk to obtain low-fat milk and milk fat;

   (2) heating the low-fat milk of A(1) and adding milk coagulant, calcium salt solution with stirring to obtain milk curd;

   (3) heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected;

   (4) dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0;

   (5) removing lactose from the whey of A(3) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder;

   (6) mixing the re-dissolved milk of A(4) with de-lactose whey or delactose whey powder of A(5), and adding the milk fat of A(1) or not, emulsifier to perform shear emulsification reaction and obtain lactose-free milk; and

   (7) homogenizing and disinfecting the lactose-free milk of A(6) to obtain lactose-free liquid milk which may be further dried to give lactose-free milk powder, or homogenizing and disinfecting the mixture of lactose-free milk of A(6) with common milk to obtain low-lactose liquid milk which may be further dried to give low-lactose milk powder.

2. The method of claim 1 characterized in that the milk of A(1) comprises fresh milk or food-grade milk powder dissolved with drinking water.
3. The method of claim 1 characterized in that the milk coagulant of A(2) comprises chymosin, acid supplements or a mixture thereof.

4. The method of claim 1 characterized in that the calcium salt of A(2) comprises calcium chloride or calcium lactate.

5. The method of claim 4 characterized in that the chymosin comprises animal chymosin, botanical chymosin, or microbial chymosin; the acid supplements comprise hydrochloric acid, lactic acid, citric acid or carbon dioxide.

6. The method of claim 1 characterized in that the membrane separation technique of A(5) is ultrafiltration whose molecular weight cutoff is between 1000 and 10000 and nanofiltration whose molecular weight cutoff is between 100 and 350.

7. The method of claim 1, characterized in that the milk solvent of A(4) comprises carbonate-citric acid buffer, citrate-citric acid buffer or phosphate buffer; the salt concentration of the re-dissolved milk is controlled between 0.005M and 0.03M.

8. The method of claim 1, characterized in that the rotating speed of the shear emulsion of A (6) is between 1000rpm and 4000rpm, temperature between 25°C and 60°C for 10-60 min.

9. The method of claim 1, characterized in that the lactose-free liquid milk or the lactose-free milk powder of A(7) can be mixed with common milk or milk powder to give low-lactose liquid milk or low-lactose milk powder.

10. The method of claim 1, characterized in that the method is practicable in producing lactose-free goat liquid milk, lactose-free goat milk powder,
low-lactose goat liquid milk or low-lactose goat milk powder with goat milk as raw material.

11. A method for making de-lactose milk products, characterized in that the de-lactose milk products are prepared through the steps of B(1)-(5) or B(1)-(6):

B.

(1) heating milk and adding milk coagulant, calcium salt solution with stirring to obtain milk curd;

(2) heating the milk curd, cutting with stirring to obtain curd particles and whey which are separately collected;

(3) dissolving the curd particles with milk solvent to obtain re-dissolved milk whose pH value is controlled between 6.6 and 7.0;

(4) removing lactose from the whey of B(2) with membrane separation technique to obtain de-lactose whey or de-lactose whey powder;

(5) mixing the re-dissolved milk of B(3) with de-lactose whey or de-lactose whey powder of B(4), and adding milk fat obtained by defatting milk or not, emulsifier to perform shear emulsification reaction and obtain lactose-free milk; and

(6) homogenizing and disinfecting the low-lactose milk to obtain low-lactose liquid milk which may be further dried to obtain low-lactose milk powder.