

Description

Title of Invention: MILK-CONTAINING BEVERAGE PRODUCTION METHOD

Technical Field

[0001] The present invention relates to a method of producing a milk-containing beverage.

Background Art

[0002] As related art, there is known a method of improving flavor and quality of cow's milk by reducing its dissolved oxygen concentration. For example, in Patent Literature 1, there is described a method of producing a beverage having a flavor similar to that of raw milk or an unheated liquid containing milk, in which generation of dimethyl disulfide due to heating is suppressed, the method being characterized by substituting milk or an unheated liquid containing milk with an inert gas, such as a nitrogen gas, before heat treatment, and performing heat treatment under a state in which dissolved oxygen in the raw milk or the liquid is reduced to 5 ppm or less.

[0003] In Patent Literature 2, there is described a method for pasteurization where dissolved oxygen in cow's milk or the like is substituted with a nitrogen gas, the method being characterized in that means in which the nitrogen gas is directly mixed with and dispersed in cow's milk or the like, and means in which cow's milk or the like, which the nitrogen gas is not mixed with and dispersed

in, is sprayed from a nozzle to the top of cow's milk or the like, which the nitrogen gas has been mixed with and dispersed in, stored in a nitrogen gas substituting tank under a nitrogen gas atmosphere, are jointly used whereby the dissolved oxygen amount in the cow's milk or the like is reduced by means of substitution of the dissolved oxygen with the nitrogen gas, followed by pasteurization. In addition, in Patent Literature 2, there is described an apparatus for substituting the dissolved oxygen in cow's milk or the like with a nitrogen gas, which is characterized in that: a nitrogen gas substituting tank connected to a raw material tank by a liquid-sending pipe is installed; a nitrogen gas supply means is connected to the liquid-sending pipe at the side of the raw material tank while a nitrogen gas mixing/dispersing device is installed at the side of the nitrogen gas substituting tank of the liquid-sending pipe; a branched liquid-sending pipe, which leads from a raw material tank side with respect to the nitrogen gas supply means connected to the liquid-sending pipe into the nitrogen gas substituting tank, is placed; a spray nozzle is connected to a leading end of the branched liquid-sending pipe in the nitrogen gas substituting tank; and each of the liquid-sending pipes, the nitrogen gas supply means, and the branched liquid-sending pipe is equipped with a flow rate controlling apparatus.

[0004] In Patent Literature 3, there is described a method of keeping freshness of stored raw milk, characterized by feeding stored raw milk with a nitrogen gas while agitating the raw milk.

Specifically, it is described that, in the case of a storing tank of a 100-ton scale, the stored raw milk is fed with a nitrogen gas under standard conditions at a rate of from 100 liters to 300 liters per minute and a pressure of from about 2 kg/cm² to about 3 kg/cm² while agitating the stored raw milk.

Citation List

Patent Literature

[0005] [Patent Literature 1] JP 10-295341 A

[Patent Literature 2] JP 2001-078665 A

[Patent Literature 3] JP 05-049395 A

Summary of Invention

Technical Problem

[0006] When a milk-containing beverage having a fresh flavor is to be produced, in order to greatly reduce the dissolved oxygen concentration of the milk-containing beverage, for example, the supply amount of an inert gas, such as a nitrogen gas, to be mixed with the milk-containing beverage needs to be increased to substitute the dissolved oxygen in the milk-containing beverage with a large amount of the inert gas. However, in this case, because a large amount of the inert gas, which is a gas, is brought into contact with the milk-containing beverage, which is a liquid, excessive foaming is liable to occur in the milk-containing beverage. In addition, when the milk-containing beverage in which excessive

foaming has occurred is indirectly heat-pasteurized with a plate heat pasteurizer or the like, scorching due to the foaming is liable to occur, for example, on the inner surface of a plate. The scorching causes a decrease in thermal conductivity at the time of heating. Therefore, a higher temperature of a heating medium than in a normal case is required for heating to a certain temperature, and the plate is required to be washed or replaced more frequently than in a normal case. Accordingly, there arise problems, such as a decrease in overall production efficiency, and an increase in production cost entailed in the update of equipment.

[0007] An object of the present invention is to provide a method of producing a milk-containing beverage, in which, in the production of a milk-containing beverage having a fresh flavor, the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, and at the same time, foaming of the milk-containing beverage occurring in the production process is effectively suppressed to prevent a decrease in production efficiency.

Solution to Problem

[0008] The inventors of the present invention have made extensive investigations in order to achieve the above-mentioned object, and as a result, have found that the object can be achieved by a method of producing a milk-containing beverage, including:

(A) a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply

method (e.g., treatment using a proportional mixer) and supply conditions (e.g., the supply rate of the raw material milk and the supply amount of an inert gas) for the inert gas treatment being controlled so that the raw material milk has a foam ratio equal to or less than a specific numerical value at a time point before reservation and/or during reservation of the raw material milk, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step (i.e., the raw material milk that has finished the first oxygen concentration reduction step and been sent as a liquid) to inert gas treatment with a supply method (e.g., treatment using a proportional mixer) and supply conditions (e.g., the supply rate of the raw material milk and the supply amount of an inert gas) for the inert gas treatment being controlled so that the raw material milk has a foam ratio equal to or less than a specific numerical value; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step. Thus, the inventors have completed the present invention.

[0009] The present invention provides the following items [1] to [5].

[1] A method of producing a milk-containing beverage, including:

(A) a first oxygen concentration reduction step including

subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[2] A method of producing a milk-containing beverage according to the above-mentioned item [1], in which the raw material milk obtained in the first oxygen concentration reduction step has a dissolved oxygen concentration of 8 ppm or less.

[3] A method of producing a milk-containing beverage according to the above-mentioned item [1] or [2], in which the raw material milk obtained in the second oxygen concentration reduction step has a dissolved oxygen concentration of 1 ppm or less.

[4] A method of producing a milk-containing beverage according to any one of the above-mentioned items [1] to [3], in which the supply

method for the inert gas treatment of each of the first oxygen concentration reduction step and the second oxygen concentration reduction step is performed by one kind or a combination of two or more kinds selected from:

(a) mixing of the raw material milk and an inert gas using a proportional mixer;

(b) spraying of the raw material milk into an apparatus (e.g., a tank) having a space filled with an inert gas;

(c) mixing of the raw material milk and an inert gas using a centrifuge (i.e. separating disc-type centrifuge);

(d) mixing of the raw material milk and an inert gas using a pump; and

(e) blowing (i.e. bubbling) of an inert gas into the raw material milk accommodated in an apparatus (e.g., a tank).

[5] A method of producing a milk-containing beverage according to the above-mentioned item [4],

in which the supply method for the inert gas treatment in at least one of the first oxygen concentration reduction step or the second oxygen concentration reduction step is performed by a method including (a) the mixing of the raw material milk and an inert gas using a proportional mixer, and

in which in (a) the mixing of the raw material milk and an inert gas using a proportional mixer, a volume ratio of a supply rate (i.e. supply amount per unit time) of the inert gas to a supply rate (i.e. supply amount per unit time) of the raw material milk

(i.e. [supply amount (volume) of inert gas]/[supply amount (volume) of raw material milk]×100) is from 5% to 70%.

Advantageous Effects of Invention

[0010] According to the present invention, the milk-containing beverage having a greatly reduced dissolved oxygen concentration and having a fresh flavor can be obtained. In addition, according to the present invention, while the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, foaming of the milk-containing beverage occurring in the production process is also effectively suppressed to eliminate the need for a step such as foam removal treatment during production or after production, and hence a decrease in the production efficiency can be suppressed or prevented.

Description of Embodiments

[0011] The present invention is directed to a method of producing a milk-containing beverage, including:

(A) a first oxygen concentration reduction step (hereinafter referred to as "step (A)") including subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less at a time point before reservation and/or during reservation of the raw material milk, and then discharging the raw material milk to obtain raw material milk having

a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step (hereinafter "referred to as step (B)") of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step (hereinafter "referred to as step (C)") of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[0012] Each of the steps is described in detail below.

[0013] [Step (A): First Oxygen Concentration Reduction Step]

The step (A) is a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply method (e.g., treatment using a proportional mixer) and supply conditions (e.g., the supply rate of the raw material milk and the supply amount of an inert gas) for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less at a time point before reservation and/or during reservation of the raw material milk, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration.

[0014] The raw material milk of the present invention refers to a milk-containing beverage before heat treatment, such as unheated

rawmilk. In this step, the raw material milk of the present invention only needs to have a liquid form capable of being subjected to the inert gas treatment, and examples thereof include: animal milk, such as cow's milk, goat's milk, or sheep's milk (i.e. ovine milk) (raw milk milked from an animal); a processed product of animal milk (e.g., a liquid milk processed product, such as skimmed milk, partly skimmed milk, evaporated skimmed milk (i.e. skimmed condensed milk), evaporated partly skimmed milk, homogenized milk, cream, or buttermilk, and a milk processed product obtained by reconstituting skimmed milk powder, partly skimmed milk powder, butter, fermented milk, cheese, or the like into a liquid); plant milk, such as soybean milk or coconut milk; a processed product of plant milk (i.e. milk processed product reconstituted into a liquid); and a formula (an artificial milk; specifically, liquid milk processed product obtained by mixing an edible oil and fat, water, an emulsifier, and the like to form an oil-in-water emulsion). In addition, the raw material milk of the present invention may contain a raw material other than milk, and for example, may have a liquid form having added thereto coffee, black tea, green tea, powdered tea, mate, fruit juice, vegetable juice, a sweetener, an acidulant, a vitamin, a mineral, a functional material, or the like. Examples of the inert gas of the present invention include a nitrogen gas, an argon gas, and a helium gas.

[0015] The dissolved oxygen concentration (upper limit value) of the raw material milk obtained in the first oxygen concentration

reduction step (i.e. the step (A)) is preferably 8 ppm or less, more preferably 6 ppm or less, still more preferably 4 ppm or less, still more preferably 3 ppm or less, still more preferably 2 ppm or less. A case in which the dissolved oxygen concentration of the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) is 8 ppm or less is preferred because, in the second oxygen concentration reduction step (i.e. the step (B)), while the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, foaming of the milk-containing beverage occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out.

[0016] The lower limit value of the dissolved oxygen concentration of the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) is preferably 0.1 ppm, more preferably 0.5 ppm, still more preferably 1.0 ppm, still more preferably 1.5 ppm. A case in which the dissolved oxygen concentration of the raw material milk is 0.1 ppm or more is preferred because, while the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, foaming of the milk-containing beverage occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out. In the case where the dissolved oxygen concentration of the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) is much

less than 0.1 ppm, a considerable amount of the inert gas may remain in the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) depending on a method for the inert gas treatment, and foaming of the raw material milk cannot be effectively suppressed owing to the remaining of the inert gas.

[0017] The method for the inert gas treatment in the step (A) is not particularly limited as long as the milk-containing beverage having a greatly reduced dissolved oxygen concentration and having a fresh flavor, which is a feature of the present invention, can be obtained, and for example, the inert gas treatment may be performed by one kind or a combination of two or more kinds selected from:

- (a) mixing of the raw material milk and an inert gas using a proportional mixer;

- (b) spraying of the raw material milk into an apparatus having a space filled with an inert gas;

- (c) mixing of the raw material milk and an inert gas using a centrifuge;

- (d) mixing of the raw material milk and an inert gas using a pump; and

- (e) blowing of an inert gas into the raw material milk accommodated in an apparatus. In addition, in the step (A), one kind of method selected from the methods (a) to (e) (e.g., the method (a)) may be performed once or two or more times.

[0018] Examples of the proportional mixer for mixing the raw material milk and an inert gas in the method (a) include an apparatus

(e.g., a shearing apparatus, such as a static mixer) configured to agitate the raw material milk and the inert gas in an in-line manner (i.e. continuously in piping) so that the inert gas is uniformly distributed in the raw material milk subjected to the inert gas treatment by continuously supplying the inert gas to the raw material milk that is continuously supplied into the proportional mixer at a specific ratio (i.e. supply amount of inert gas/supply amount of raw material milk). In addition, in the above-mentioned proportional mixer, as required, the supply conditions of the inert gas (i.e. the supply amount of the raw material milk and/or the supply amount of the inert gas) may be controlled at the supply portion (i.e. inlet portion) of the proportional mixer. Further, the mixing ratio of the raw material milk and the inert gas may be detected at the supply portion (i.e. inlet portion) and/or the discharge portion (i.e. outlet portion) of the above-mentioned proportional mixer, and the supply conditions of the raw material milk and the inert gas (i.e. the supply amount of the raw material milk and/or the supply amount of the inert gas) may be controlled at the supply portion of the proportional mixer on the basis of the result of the detection.

[0019] Examples of an apparatus for spraying the raw material milk into an apparatus having a space filled with an inert gas in the method (b) include an apparatus configured to inject and/or spray the raw material milk into a tank having its inside filled with an inert gas via a supply portion positioned at, for example,

an upper part of the tank. In this case, the injection of the raw material milk is not particularly limited, and may be performed, for example, through known piping or the like. The spraying of the raw material milk is not particularly limited, and may be performed, for example, through a known spray nozzle, a shower ball, or the like. The direction in which the raw material milk is injected and the direction in which the raw material milk is sprayed are not particularly limited, and examples thereof include a horizontal direction, an upward direction, and a downward direction. The supply portion positioned at, for example, the upper part of the tank is arranged at one site or two or more sites.

[0020] Examples of the centrifuge for mixing the raw material milk and an inert gas in the method (c) include separating disc-type centrifuges, such as: a clarifier intended to separate and remove fine dust and/or a component derived from an animal, such as a dairy cow (e.g., cytoplasm or white blood cells) through the utilization of a centrifugal force; a bactofuge intended to separate and remove microorganisms through the utilization of a centrifugal force; and a cream separator intended to separate skimmed milk and cream from the raw material milk. In addition, the inert gas treatment may be performed by continuously supplying the raw material milk and an inert gas into a rotary accommodating container arranged inside the centrifuge, to thereby mix the raw material milk and the inert gas with each other. It is known that, in general, in treatment with a centrifuge, when foam of a gas or the like remains in the

raw material milk, the efficiency of the treatment of the raw material milk is decreased. That is, hitherto, it has been common general technical knowledge that, in treatment with a centrifuge, the centrifuge is operated so as to prevent foam of a gas or the like from being trapped (i.e. remaining) in the raw material milk. On the other hand, in the present invention, despite the above-mentioned common general technical knowledge, daringly, the raw material milk and the inert gas are continuously supplied and the raw material milk is mixed with the inert gas while being treated in the same manner as above, and thus the dissolved oxygen concentration of the raw material milk can be effectively reduced.

[0021] Examples of a method for the mixing of the raw material milk and an inert gas using a centrifuge in the method (c) include: a method involving supplying raw material milk having part of its dissolved oxygen substituted with an inert gas by, for example, blowing of the inert gas, to a centrifuge having the inside of the device filled with an inert gas, to thereby reduce the dissolved oxygen concentration of the raw material milk while treating the raw material milk in the same manner as above; and a method involving supplying the raw material milk not having its dissolved oxygen substituted with an inert gas to a centrifuge having the inside of the device filled with an inert gas, to thereby reduce the dissolved oxygen concentration of the raw material milk while treating the raw material milk in the same manner as above.

[0022] Examples of a method for the mixing of the raw material

milk and an inert gas using a pump in the method (d) include a method involving continuously supplying the raw material milk and an inert gas, and agitating and mixing the raw material milk and the inert gas inside a pump while feeding the pump with the liquid, to thereby reduce the dissolved oxygen concentration of the raw material milk. In this case, examples of the pump for mixing the raw material milk and an inert gas in the method (d) include non-positive displacement pumps, such as a centrifugal pump, a mixed flow pump, and a friction pump. Examples of a specific method for the mixing of the raw material milk and an inert gas using a pump in the method (d) include a method involving agitating and mixing the raw material milk and an inert gas through the use of an agitation blade (i.e. bladed wheel) rotating inside a pump standing still like a centrifugal pump, to thereby reduce the dissolved oxygen concentration of the raw material milk.

[0023] In the mixing of the raw material milk and an inert gas using a proportional mixer in the method (a), the superficial velocity of the raw material milk to be supplied to the proportional mixer is preferably from 0.5 m/second to 2.5 m/second, more preferably from 0.7 m/second to 2.3 m/second, still more preferably from 0.8 m/second to 2.1 m/second, still more preferably from 1 m/second to 2 m/second. Here, a case in which the superficial velocity of the raw material milk to be supplied to the proportional mixer is 0.5 m/second or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. On the other hand, a case in which the superficial velocity of the

raw material milk to be supplied to the proportional mixer is 2.5 m/second or less is preferred because foaming of the raw material milk occurring in the production process can be effectively suppressed.

[0024] Herein, the superficial velocity is a linear velocity obtained by dividing the treatment flow rate of the liquid by the cross-sectional area of piping as shown in the following equation.

$$[\text{Superficial velocity (m/s)}] = [\text{treatment flow rate of liquid (m}^3\text{/s)}] \div [\text{cross-sectional area of piping (m}^2\text{)}]$$

In the equation, the cross-sectional area of the piping means the cross-sectional area of a space portion through which the liquid flows, and the cross-sectional area does not include the cross-sectional areas of the elements of the static mixer.

[0025] In the mixing of the raw material milk and an inert gas using a proportional mixer in the method (a), the volume ratio of the supply rate (i.e. supply amount per unit time) of the inert gas to the supply rate (i.e. supply amount per unit time) of the raw material milk (i.e. $[\text{supply amount (volume) of inert gas}] / [\text{supply amount (volume) of raw material milk}] \times 100$) is preferably from 5% to 70%, more preferably from 10% to 60%, still more preferably from 20% to 60%. Here, a case in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk is 5% or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. On the other hand, a case in which the volume ratio of the supply rate of the inert

gas to the supply rate of the raw material milk is 70% or less is preferred because foaming of the raw material milk occurring in the production process can be effectively suppressed.

[0026] In the mixing of the raw material milk and the inert gas using the proportional mixer in the method (a), when raw material milk having a large degree of foaming is mixed with raw material milk having a small degree of foaming, foaming of the raw material milk as a whole occurring in the production process can be suppressed as a result of the mixing, while the dissolved oxygen concentration of the raw material milk is greatly reduced. That is, even in the case where part of the raw material milk is subjected to the inert gas treatment under operation conditions in which the superficial velocity of the raw material milk to be supplied to the proportional mixer, and the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk do not fall within the above-mentioned preferred ranges, when two or more kinds of raw material milk having different degrees of foaming are mixed with each other, foaming of raw material milk as a whole occurring in the production process can be effectively suppressed as a result of the mixing, while the dissolved oxygen concentration of the raw material milk is greatly reduced.

[0027] Examples of a method of mixing the two or more kinds of raw material milk having different degrees of foaming include a method involving a sequence as described below. In the following, "L/h" means liter/hour, and "L/min" means liter/minute. First,

while a proportional mixer having arranged therein a static mixer (inner diameter: 11 mm, 30 elements) is fed with 280 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), bubbling with a nitrogen gas is performed to proportionally feed the proportional mixer with the gas (in other words, conduct mixing) at 3.5 L/min (volume ratio of nitrogen gas/raw milk: 75%). The raw milk after mixing with the nitrogen gas is reserved in a tank for milk storage (having a volume of 500 L). Next, while the proportional mixer is fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), bubbling with a nitrogen gas is performed to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 1.4 L/min (volume ratio of nitrogen gas/raw milk: 30%). The raw milk after mixing with the nitrogen gas is reserved in the tank for milk storage (having a volume of 500 L). After that, while the proportional mixer is fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), bubbling with a nitrogen gas is performed to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 0.7 L/min (volume ratio of nitrogen gas/raw milk: 15%). The raw milk after mixing with the nitrogen gas is reserved in the tank for milk

storage (having a volume of 500 L). Then, raw material milk having a small degree of foaming can be finally obtained by the method involving the above-mentioned sequence.

[0028] In the injection and/or spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), the oxygen concentration (upper limit value) in the tank having its inside filled with an inert gas is preferably 10% or less, more preferably 8% or less, still more preferably 7% or less. Here, a case in which the oxygen concentration in the tank having its inside filled with an inert gas is 10% or less is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. In the injection and/or spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), the lower limit value of the oxygen concentration in the tank having its inside filled with an inert gas is not particularly limited, but is preferably 0%, more preferably 0.1%, still more preferably 0.5%.

[0029] In the spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), the dissolved oxygen concentration of the raw material milk is preferably reduced by subjecting the raw material milk to inert gas treatment or the like in advance. Hitherto, it has been common general technical knowledge to consider that subjecting the raw material milk to inert gas treatment or the like in advance in the spraying of the raw material milk into an apparatus having a space filled with an inert

gas in the method (b) makes it difficult for foaming of the raw material milk itself to disappear, and hence foaming of raw material milk as a whole occurring in the production process cannot be effectively suppressed. On the other hand, in the present invention, despite the above-mentioned common general technical knowledge, daringly, the raw material milk is subjected to the inert gas treatment or the like to reduce the dissolved oxygen concentration of the raw material milk, and then the raw material milk is sprayed into the apparatus having a space filled with an inert gas in the method (b). Thus, while the dissolved oxygen concentration of the raw material milk is greatly reduced, foaming of the raw material milk as a whole occurring in the production process can be effectively suppressed.

[0030] In the spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), the dissolved oxygen concentration (upper limit value) of the raw material milk having its dissolved oxygen concentration reduced by being subjected to the inert gas treatment or the like in advance is preferably 10 ppm or less, more preferably 8 ppm or less, still more preferably 6 ppm or less, still more preferably 4 ppm or less, still more preferably 2 ppm or less. In the spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), a case in which the dissolved oxygen concentration of the raw material milk having its dissolved oxygen concentration reduced by being subjected to the inert gas treatment or the like

in advance is 10 ppm or less is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced, to thereby enable the present invention to be easily carried out. On the other hand, in the spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), the lower limit value of the dissolved oxygen concentration of the raw material milk having its dissolved oxygen concentration reduced by being subjected to the inert gas treatment or the like in advance is not particularly limited, but is preferably 0.1 ppm, more preferably 0.5 ppm, still more preferably 1.0 ppm, still more preferably 1.5 ppm. A case in which the dissolved oxygen concentration of the raw material milk is 0.1 ppm or more is preferred because, while the dissolved oxygen concentration of the raw material milk is greatly reduced, foaming of the raw material milk occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out.

[0031] In the spraying of the raw material milk into an apparatus having a space filled with an inert gas in the method (b), an apparatus for spraying the raw material milk having its dissolved oxygen concentration reduced by being subjected to the inert gas treatment or the like in advance is, for example, an apparatus obtained by modifying the nitrogen gas substituting apparatus described in JP 2001-078665 A (i.e. the above-mentioned Patent Literature 2), the apparatus being capable of subjecting the raw material milk, which is to be sprayed into the nitrogen gas substituting apparatus from

above, to inert gas treatment in advance by the proportional mixer for mixing the raw material milk and an inert gas in the method (a) for reducing the dissolved oxygen concentration of the raw material milk. Specifically, the apparatus is capable of: injecting and reserving (i.e. supplying) raw material milk, which has a nitrogen gas directly mixed therewith and dispersed therein in advance by directly mixing and dispersing the nitrogen gas with and in the raw material milk, in a tank having a nitrogen gas atmosphere; and, while spraying the raw material milk, which has a nitrogen gas directly mixed therewith and dispersed therein in advance, into the tank having a nitrogen gas atmosphere from above with a nozzle, mixing these raw material milks, to thereby reduce the dissolved oxygen amount (i.e. dissolved oxygen concentration) of the raw material milk through substitution of the dissolved oxygen of the raw material milk with the nitrogen gas.

[0032] Hitherto, it has been common general technical knowledge not to subject the raw material milk, which is to be sprayed into the nitrogen gas substituting apparatus from above, to the inert gas treatment in advance considering that, when the raw material milk, which is to be sprayed into the nitrogen gas substituting apparatus from above, is subjected to the inert gas treatment or the like in advance with the proportional mixer for mixing the raw material milk and an inert gas in the method (a) for reducing the dissolved oxygen concentration of the raw material milk with the nitrogen gas substituting apparatus described in JP 2001-078665

A (the above-mentioned Patent Literature 2), foam occurs in the raw material milk to be defoamed, which is injected and reserved (supplied) in the tank, and foaming of raw material milk as a whole occurring in the production process cannot be effectively suppressed. On the other hand, in the present invention, despite the above-mentioned common general technical knowledge, daringly, the raw material milk, which is to be sprayed into the nitrogen gas substituting apparatus from above, is subjected to the inert gas treatment in advance. Thus, while the dissolved oxygen concentration of the raw material milk is greatly reduced, foaming of raw material milk as a whole occurring in the production process can be effectively suppressed.

[0033] In the mixing of the raw material milk and an inert gas using a centrifuge in the method (c), the following methods may be used alone or in combination thereof: a method involving supplying raw material milk having part of its dissolved oxygen substituted with an inert gas by, for example, blowing of the inert gas, to a centrifuge having the inside of the device filled with an inert gas, to thereby reduce the dissolved oxygen concentration of the raw material milk; and a method involving supplying raw material milk not having its dissolved oxygen substituted with an inert gas to a centrifuge having the inside of the device filled with an inert gas, to thereby reduce the dissolved oxygen concentration of the raw material milk. In this case, in a method involving supplying raw material milk having part of its dissolved oxygen substituted

with an inert gas by, for example, blowing of the inert gas, to a centrifuge having the inside of the device filled with an inert gas, and performing treatment under conditions similar to those of a general operation, to thereby reduce the dissolved oxygen concentration of the raw material milk, the volume ratio of the supply rate (i.e. supply amount per unit time) of the inert gas (which means only the inert gas to be used before the treatment with the centrifuge) to the supply rate (i.e. supply amount per unit time) of the raw material milk (in other words, $[\text{supply amount of inert gas}] / [\text{supply amount of raw material milk}] \times 100$) is preferably from 10% to 200%, more preferably from 30% to 180%, still more preferably from 50% to 150%. Here, a case in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk is 10% or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. A case in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk is 200% or less is preferred because foaming of the raw material milk as a whole occurring in the production process can be effectively suppressed. On the other hand, in a method involving supplying raw material milk not having its dissolved oxygen substituted with an inert gas to a centrifuge having the inside of the device filled with an inert gas, and performing treatment under conditions similar to those of a general operation, to thereby reduce the dissolved oxygen concentration of the raw material milk, the oxygen concentration

(upper limit value) in the centrifuge is preferably 10% or less, more preferably 8% or less, still more preferably 7% or less. Here, a case in which the oxygen concentration in the centrifuge is 10% or less is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. The lower limit value of the oxygen concentration in the centrifuge is not particularly limited, but is preferably 0%, more preferably 0.1%, still more preferably 0.5%.

[0034] In the mixing of the raw material milk and an inert gas using a pump in the method (d), the volume ratio of the supply rate (supply amount per unit time) of the inert gas to the supply rate (supply amount per unit time) of the raw material milk (i.e. [supply amount of inert gas]/[supply amount of raw material milk]) is preferably from 3% to 50%, more preferably from 4% to 40%, still more preferably from 5% to 30%. Here, a case in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk is 3% or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. On the other hand, a case in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk is 50% or less is preferred because foaming of the raw material milk occurring in the production process can be effectively suppressed.

[0035] In the mixing of the raw material milk and an inert gas using a pump in the method (d), when raw material milk having a

large degree of foaming is mixed with raw material milk having a small degree of foaming, foaming of the raw material milk as a whole occurring in the production process can be suppressed as a result of the mixing, while the dissolved oxygen concentration of the raw material milk is greatly reduced. That is, even in the case where part of the raw material milk is subjected to the inert gas treatment under operation conditions in which the volume ratio of the supply rate of the inert gas to the supply rate of the raw material milk does not fall within the above-mentioned preferred range, when two or more kinds of raw material milk having different degrees of foaming are mixed with each other, foaming of raw material milk as a whole occurring in the production process can be effectively suppressed as a result of the mixing, while the dissolved oxygen concentration of the raw material milk is greatly reduced.

[0036] In the blowing (i.e. bubbling) of an inert gas into the raw material milk accommodated (i.e. stored) in a tank in the method (e), the volume ratio of the liquid-storage amount (in terms of volume) of the raw material milk to the volume of the space in the tank (i.e. whole volume in the tank at a time when the raw material milk is not accommodated in the space in the tank) (in other words, $[\text{liquid-storage amount of raw material milk}] / [\text{volume of space in tank}] \times 100$) is preferably from 20% to 90%, more preferably from 30% to 80%, still more preferably from 40% to 70%. Here, a case in which the volume ratio of the liquid-storage amount of the raw material milk to the volume of the space in the tank is 20% or more is preferred

because foaming of the raw material milk occurring in the production process can be effectively suppressed. On the other hand, a case in which the volume ratio of the liquid-storage amount of the raw material milk to the volume of the space in the tank is 90% or less is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. Besides, the case is preferred because, while the dissolved oxygen concentration of the raw material milk is greatly reduced by jetting the raw material milk, which has been subjected to the inert gas treatment or degassing treatment (i.e. pressure reduction treatment), toward the liquid surface of the raw material milk accommodated in the tank, foaming of the raw material milk as a whole occurring in the production process can be effectively suppressed. As an apparatus for the blowing of an inert gas into the raw material milk accommodated in a tank in the method (e), a known foam dispersing apparatus may be used, and for example, a sintered metal element, a filter, a sparger, or a nozzle having a narrow flow passage may be used.

[0037] In the blowing of an inert gas into the raw material milk accommodated in a tank in the method (e), the volume ratio of the supply rate (i.e. supply amount per unit time) of the inert gas to the supply rate (i.e. supply amount per unit time) of the raw material milk to the tank (in other words, $[\text{supply rate of inert gas}] / [\text{supply rate of raw material milk}] \times 100$) is preferably from 10% to 100%, more preferably from 20% to 90%, still more preferably from 30% to 80%. Here, a case in which the volume ratio of the supply

rate of the inert gas to the liquid-storage amount of the raw material milk is 20% or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. On the other hand, a case in which the volume ratio of the supply rate of the inert gas to the liquid-storage amount of the raw material milk is 100% or less is preferred because foaming of the raw material milk occurring in the production process can be effectively suppressed.

[0038] In the blowing of an inert gas into the raw material milk accommodated in a tank in the method (e), the blowing amount (supply amount per unit time: liter/minute) of the inert gas with respect to the liquid-storage amount (unit volume: 1 liter) of the raw material milk is preferably from 0.005 liter/minute to 0.1 liter/minute, more preferably from 0.006 liter/minute to 0.08 liter/minute, still more preferably from 0.008 liter/minute to 0.05 liter/minute, still more preferably from 0.01 liter/minute to 0.03 liter/minute, still more preferably from 0.015 liter/minute to 0.025 liter/minute. Here, a case in which the blowing amount of the inert gas with respect to the liquid-storage amount of the raw material milk is 0.005 liter/minute or more is preferred because the dissolved oxygen concentration of the raw material milk can be greatly reduced. On the other hand, a case in which the blowing amount of the inert gas with respect to the liquid-storage amount of the raw material milk is 0.1 liter/minute or less is preferred because foaming of the raw material milk occurring in the production process can be

effectively suppressed.

[0039] In the blowing of an inert gas into the raw material milk accommodated in a tank in the method (e), the raw material milk may be subjected to foam removal treatment in order to effectively suppress foaming of the raw material milk occurring in this case. In addition, in the first oxygen concentration reduction step (i.e. the step (A)), as required, the raw material milk may be subjected to foam removal treatment in order to effectively suppress foaming of the raw material milk occurring in this case. In this case, for example, the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) may be subjected to foam removal treatment by: injecting and reserving (supplying) the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) in a (small) tank arranged after the first oxygen concentration reduction step (i.e. the step (A)); and spraying and/or dropping part of the raw material milk discharged from the tank onto the liquid surface of part of the raw material milk reserved in the tank from above the tank. Also, the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) may be subjected to foam removal treatment by: supplying the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) to a (small) tank arranged after the first oxygen concentration reduction step (i.e. the step (A)); and spraying a gas (e.g., an inert gas, such as a nitrogen gas) onto the liquid surface of the raw material milk reserved in the

tank from above the tank. Further, for example, the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) may be subjected to foam removal treatment by: leaving the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) to stand still for a predetermined period of time; treating the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) with a hydrocyclone; treating the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) with a strainer; reducing the pressure on the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) with a known tank or piping; or blending (or adding) a defoaming agent or the like into the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)).

[0040] When the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) is subjected to foam removal treatment, even if foaming of the raw material milk occurs to a significant degree immediately after the first oxygen concentration reduction step (i.e. the step (A)), the foaming of the raw material milk has been efficiently suppressed before the second oxygen concentration reduction step (i.e. the step (B)).

[0041] In the first oxygen concentration reduction step (i.e. the step (A)), among the inert gas treatments of the methods (a) to (e), the inert gas treatment of the method (a) (i.e. mixing of the raw material milk and an inert gas using a proportional mixer)

is preferred from the viewpoints of facilitating the reduction of the dissolved oxygen concentration of the raw material milk, and facilitating the suppression of foaming of the raw material milk.

[0042] The degree of foaming of the raw material milk obtained in the first oxygen concentration reduction step (i.e. the step (A)) may be evaluated by using its foam ratio as an indicator. In this case, the foam ratio of the raw material milk is preferably 10% or less, more preferably 8% or less, still more preferably 6% or less, still more preferably 5% or less. Here, a case in which the foam ratio of the raw material milk is 10% or less is preferred because foaming of the raw material milk does not excessively occur and the foaming of the raw material milk is effectively suppressed, and hence subsequent foam removal treatment, defoaming treatment, or the like can be simplified or omitted. When raw material milk in which foaming has excessively occurred is indirectly heat-pasteurized with a plate heat pasteurizer or the like, sticking or scorching of a component derived from the raw material milk is liable to occur on the inner surface (e.g., the inner surface of plate, piping, or the like) of the plate heat pasteurizer or the like. In this case, owing to such sticking or scorching, thermal conductivity is decreased in the plate heat pasteurizer or the like, and the maintenance of the temperature of the heat pasteurization at a predetermined temperature requires a higher temperature of a medium (e.g., hot water, water vapor, or the like) for heating the raw material milk or an increased use amount of the medium for

heating the raw material milk. That is, a large amount of energy is used to heat the medium, resulting in a decrease in production efficiency and an increase in production cost or the like. In addition, owing to such sticking or scorching, in the plate heat pasteurizer or the like, a running time is shortened and the frequency of washing, the frequency of replacement of parts, or the like is increased, resulting in a decrease in production efficiency and an increase in production cost or the like.

[0043] Herein, the foam ratio of the raw material milk is a volume ratio obtained by dividing the volume of foam by the total volume of the raw material milk as shown in the following equation.

$$[\text{Foam ratio of raw material milk (unit: volume\%)}] = [\text{volume of foam (m}^3\text{)}] \times 100 \div [\text{total volume of raw material milk including foam (m}^3\text{)}]$$

The foam ratio of the raw material milk is, for example, calculated by the following equation after the following operation. Firstly, raw material milk, which is untreated or has been subjected to predetermined treatment (e.g., has been pasteurized), is injected into a transparent graduated cylinder made of glass, and kept for a predetermined period of time (5 minutes). After that, the height of a liquid phase in a lower layer in the raw material milk injected into the graduated cylinder and the height of a foam phase in an upper layer therein are measured with a ruler or the like.

$$[\text{Foam ratio of raw material milk (unit: volume\%)}] = [\text{height of foam phase (m)}] \times 100 \div ([\text{height of foam phase (m)}] + [\text{height of liquid}])$$

phase (m)])

[0044] The raw material milk obtained in the step (A) (first oxygen concentration reduction step) may be reserved. In this case, the raw material milk obtained in the step (A) (first oxygen concentration reduction step) may be reserved, for example, using a tank having its internal space filled (i.e. substituted) with an inert gas, or using a tank having an oxygen scavenger or the like applied or attached to its internal wall surface. In this connection, the step (B) (second oxygen concentration reduction step) is preferably performed immediately before the step (C) (heat pasteurization step), and hence, after the step (A) (first oxygen concentration reduction step) and until the step (B) (second oxygen concentration reduction step), the raw material milk obtained in the step (A) (first oxygen concentration reduction step) is held on standby and the raw material milk obtained in the step (A) (first oxygen concentration reduction step) is reserved for the purpose of, for example, adjusting the production time of the milk-containing beverage in accordance with the situation of the shipping of the milk-containing beverage serving as a final product. From the viewpoint of suppressing a rise in dissolved oxygen concentration of the raw material milk obtained in the step (A) (first oxygen concentration reduction step), the raw material milk obtained in the step (A) (first oxygen concentration reduction step) is preferably reserved under an inert gas atmosphere (e.g., under a nitrogen gas atmosphere). However, even if the raw material milk

obtained in the step (A) (first oxygen concentration reduction step) is reserved under the atmospheric atmosphere (ordinary conditions), the milk-containing beverage intended in the present invention can be obtained by appropriately deciding the conditions of the inert gas treatment and the like in the step (B) (second oxygen concentration reduction step).

[0045] [Step (B): Second Oxygen Concentration Reduction Step]

The step (B) is a second oxygen concentration reduction step of subjecting the raw material milk obtained in the step (A) (first oxygen concentration reduction step) to inert gas treatment with a supply method (e.g., treatment using a proportional mixer) and supply conditions (e.g., the supply rate of the raw material milk and the supply amount of an inert gas) for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration. In this step, from the viewpoint of maintaining the fresh flavor of the milk-containing beverage over a long period of time, the dissolved oxygen concentration of the raw material milk obtained in the step (B) is preferably 1 ppm or less, more preferably 0.8 ppm or less, still more preferably 0.6 ppm or less, still more preferably 0.5 ppm or less, still more preferably 0.4 ppm or less, still more preferably 0.3 ppm or less, still more preferably 0.2 ppm or less. The step (B) is generally performed by introducing the raw material milk obtained in the step (A) into the treatment means (i.e. oxygen concentration-reducing

apparatus) of the step (B) after the discharge of the raw material milk from the treatment means (i.e. treatment apparatus) of the step (A).

[0046] The lower limit value of the dissolved oxygen concentration of the raw material milk obtained in the step (B) is not particularly limited, but is preferably 0.01 ppm, more preferably 0.03 ppm, still more preferably 0.05 ppm. A case in which the dissolved oxygen concentration of the raw material milk is 0.01 ppm or more is preferred because, while the dissolved oxygen concentration of the raw material milk is greatly reduced, foaming of the raw material milk occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out. In the case where the dissolved oxygen concentration of the raw material milk is much less than 0.01 ppm, a considerable amount of the inert gas may remain in the raw material milk obtained in the step (B) depending on a method for the inert gas treatment, and foaming of the milk-containing beverage cannot be effectively suppressed owing to the remaining of the inert gas.

[0047] In the step (B), the inert gas treatment is performed so that the dissolved oxygen concentration of the raw material milk obtained in the step (B) becomes lower than the dissolved oxygen concentration of the raw material milk obtained in the step (A). This is preferred because, without the need for excessively increasing the supply amount of the inert gas, while the dissolved

oxygen concentration of the raw material milk to be supplied to the step (C) is greatly reduced, foaming of the raw material milk occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out. Here, the difference between the dissolved oxygen concentration of the raw material milk obtained in the step (A) and the dissolved oxygen concentration of the raw material milk obtained in the step (B) (i.e., the extent of reduction in dissolved oxygen concentration of the raw material milk) is preferably from 0.5 ppm to 7.8 ppm, more preferably from 0.6 ppm to 5.6 ppm, still more preferably from 0.8 ppm to 3.6 ppm, still more preferably from 1.0 ppm to 3.2 ppm. A case in which the difference between the dissolved oxygen concentrations of the raw material milk is 0.5 ppm or more is preferred because, while the dissolved oxygen concentration of the raw material milk is greatly reduced, foaming of the raw material milk occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out.

[0048] In the present invention, reasons why the method of reducing the dissolved oxygen concentration of the raw material milk through two-stage inert gas treatment including the step (A) and the step (B) is adopted include the following: while the dissolved oxygen concentration is greatly reduced, foaming of the milk-containing beverage occurring in the production process can also be effectively suppressed, to thereby enable the present

invention to be easily carried out (i.e. enable the effect of the present invention to be efficiently obtained); and besides, through the step (A) (first oxygen concentration reduction step), the raw material milk becomes more compatible with the inert gas, and can be subsequently treated stably and efficiently in the step (B) (i.e. second oxygen concentration reduction step), thus having a unique feature. Such feature cannot be expected from only the one-stage inert gas treatment described in Patent Literature 1, and has been found for the first time by the present invention as a remarkable effect. In particular, when the dissolved oxygen concentration of the raw material milk obtained in the step (A) (first oxygen concentration reduction step) is reduced to from 6 ppm to 8 ppm, and then the dissolved oxygen concentration of the raw material milk obtained in the step (B) (second oxygen concentration reduction step) is reduced to 1 ppm or less, the need to bring a large amount of the inert gas, which is a gas, into contact with the raw material milk, which is a liquid, in the step (A) (first oxygen concentration reduction step) and/or the step (B) (second oxygen concentration reduction step) is eliminated to eliminate the need to place or run (operate) large-scale equipment, and hence the equipment cost, production cost, and the like entailed therein can be reduced. Then, finally, the occurrence of excessive foaming in the milk-containing beverage obtained in the step (B) and/or the step (C) can be suppressed. Therefore, the two-stage inert gas treatment is preferred.

[0049] In the same way as in the step (A), the inert gas treatment

in the step (B) may be performed by one kind or a combination of two or more kinds selected from:

(a) mixing of the raw material milk and an inert gas using a proportional mixer;

(b) spraying of the raw material milk into an apparatus having a space filled with an inert gas;

(c) mixing of the raw material milk and an inert gas using a centrifuge;

(d) mixing of the raw material milk and an inert gas using a pump; and

(e) blowing of an inert gas into the raw material milk accommodated in an apparatus. In the step (B), one kind of method selected from the methods (a) to (e) (e.g., the method (a)) may be performed once or two or more times. In the present invention, the combination of the methods (a) to (e) in the step (A), and the methods (a) to (e) in the step (B) is not particularly limited. While any one kind or two or more kinds of the methods (a) to (e) are arbitrarily adopted in the step (A), any one kind or two or more kinds of the methods (a) to (e) may be arbitrarily adopted in the step (B).

[0050] The details of the methods (a) to (e) in the step (B) (e.g., an apparatus to be actually used, and a preferred superficial velocity of the raw material milk) are the same as the details of the methods (a) to (e) of the step (A) (e.g., an apparatus to be actually used, and a preferred superficial velocity of the raw

material milk). Among the methods (a) to (e) in the step (B), the method (e) (i.e. blowing of an inert gas into the raw material milk accommodated in an apparatus) is preferred because: the dissolved oxygen concentration of the milk-containing beverage can be easily reduced by adjusting the supply time of the inert gas and the supply amount of the inert gas; foaming can be sufficiently suppressed by adjusting the supply rate (i.e. supply amount per unit time) of the inert gas (e.g., from 0.005 liter/minute to 0.1 liter/minute per unit volume (1 liter) of the raw material milk); and the method can be realized by modifying only the liquid-storage tank (surge tank) after the pasteurization of the raw material milk and its surroundings, and can be realized by effectively modifying equipment in a space-saving manner. In addition, among the methods (a) to (e) in the step (B), the method (a) (i.e. mixing of the raw material milk and an inert gas using a proportional mixer) is preferred because the dissolved oxygen concentration of the milk-containing beverage can be easily reduced by adjusting the supply time of the inert gas and the supply amount of the inert gas, and foaming can be suppressed by adjusting the supply rate of the inert gas. A method for the step (C) and/or foam removal treatment after the step (C) and the details thereof are the same as the method for foam removal treatment in the step (A).

[0051] A foam ratio may be used as an indicator of the degree of foaming of the raw material milk obtained in the step (B) in the same way as a foam ratio used as an indicator of the degree

of foaming of the raw material milk obtained in the step (A). In this case, the foam ratio of the raw material milk obtained in the step (B) is preferably 10% or less, more preferably 8% or less, still more preferably 6% or less, still more preferably 5% or less. Here, a case in which the foam ratio of the raw material milk is 10% or less is preferred because, while foaming of the milk-containing beverage occurring in the production process is effectively suppressed, a decrease in the production efficiency can be suppressed. Meanwhile, in the case where the foam ratio of the raw material milk is more than 10%, foaming of the raw material milk excessively occurs, requiring subsequent foam removal or defoaming. Also, when the raw material milk in which foaming has excessively occurred is indirectly heat-pasteurized with a plate heat pasteurizer or the like, scorching due to the foaming is liable to occur, for example, on the inner surface of a plate, resulting in causing a decrease in thermal conductivity at the time of heating. Therefore, a heating medium needs to be set to a higher temperature than in a normal case in order to heat the raw material milk to a certain temperature, and the plate needs to be more frequently washed or replaced than in a normal case, resulting in problems, such as a decrease in production efficiency, and an increase in production cost entailed in the update of equipment, in some cases.

[0052] Known oxygen concentration-reducing treatment other than the inert gas treatment may be applied to the oxygen concentration reduction steps corresponding to the step (A) and step (B) of the

present invention. For example, reduced-pressure degassing (i.e. vacuum degassing) treatment, membrane degassing treatment (e.g., a gas separation membrane, such as a hollow fiber membrane), or the like may be applied. Here, in the case where the reduced-pressure degassing treatment is applied to the oxygen concentration reduction steps, foaming of the raw material milk is less liable to occur than in the inert gas treatment, and even when the raw material milk is indirectly heat-pasteurized with a plate heat pasteurizer or the like, scorching due to the foaming of the raw material milk is less liable to occur, for example, on the inner surface of a plate. In this case, however, an aroma component derived from the raw material milk is liable to be dissipated, resulting in a problem, such as an influence on the flavor of the milk-containing beverage, in some cases. In the case where the membrane degassing treatment is applied to the oxygen concentration reduction steps, as compared to the inert gas treatment, on the basis of clogging of the separation membrane, treatment speed is decreased, and the separation membrane needs to be frequently washed or replaced, resulting in problems, such as a decrease in production efficiency, and an increase in production cost entailed in the update of equipment, in some cases.

[0053] [Step (C); Heat Pasteurization Step]

The step (C) is a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the step (B) (i.e. second oxygen concentration reduction step). A method for the heat pasteurization is not particularly limited as long as the method is a method for

heat pasteurization to be generally used in the production of cow's milk, and examples thereof include a low-temperature long-time pasteurization method involving treatment at from 61°C to 65°C for from 30 minutes to 60 minutes, a high-temperature short-time pasteurization method involving treatment at from 70°C to 75°C for from 15 seconds to 60 seconds, and an ultra-high temperature sterilization method involving treatment at from 130°C to 150°C for from 1 second to 5 seconds. In each of those methods for heat pasteurization, the temperature and time of the heat pasteurization may be appropriately adjusted as long as a predetermined degree of sanitation is kept and the quality of the milk-containing beverage is kept. In this step, from the viewpoint of keeping the fresh flavor of the milk-containing beverage over a long period of time, the dissolved oxygen concentration of the milk-containing beverage obtained in the step (C) is preferably 1 ppm or less, more preferably 0.8 ppm or less, still more preferably 0.6 ppm or less, still more preferably 0.5 ppm or less, still more preferably 0.4 ppm or less, still more preferably 0.3 ppm or less, particularly preferably 0.2 ppm or less. The step (C) is generally performed by introducing the raw material milk obtained in the step (B) into the treatment means (i.e. heat pasteurization apparatus) of the step (C) after the discharge of the raw material milk from the treatment means (i.e. treatment apparatus) of the step (B).

[0054] The lower limit value of the dissolved oxygen concentration of the milk-containing beverage obtained in the step

(C) is not particularly limited, but is preferably 0.01 ppm, more preferably 0.03 ppm, still more preferably 0.05 ppm, still more preferably 0.1 ppm. A case in which the dissolved oxygen concentration of the milk-containing beverage is 0.01 ppm or more is preferred because, while the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, foaming of the milk-containing beverage occurring in the production process can also be effectively suppressed, to thereby enable the present invention to be easily carried out.

[0055] Examples of the milk-containing beverage include: cow's milk; a dairy beverage including cow's milk; milk of an animal other than a cow; a dairy beverage including milk of an animal other than a cow; a plant beverage, such as soymilk; a formula (i.e. an artificial milk); and a beverage including an artificial milk. Before the heat pasteurization, during the heat pasteurization, or after the heat pasteurization, a raw material other than the raw material milk may be added.

[0056] After the step (C), as required, there may be performed: inert gas substitution of the internal space of a tank (e.g., surge tank, filler tank, or the like) before the milk-containing beverage is reserved in the tank; inert gas substitution of the internal space (i.e. headspace) of the tank after the milk-containing beverage is reserved in the tank; inert gas substitution of the internal space of a container before the milk-containing beverage is packed into the tank; inert gas substitution of the internal space

(headspace) of the container after the milk-containing beverage is packed into the container; application of an oxygen scavenger to the inner surface of the tank and/or the container; or the like.

[0057] In the present invention, any one kind or a combination of two or more kinds of the following treatments (i) to (iv) may be performed. In this case, the following treatments (i) to (iv) may be performed as the step (A) and/or the step (B), or the following treatments (i) to (iv) may be performed as new steps separate from the step (A) and/or the step (B).

(i) First treatment for micronizing the milk-containing beverage may be performed and followed by second treatment for placing the milk-containing beverage after the first treatment under a reduced-pressure atmosphere. Through the treatments, the dissolved oxygen concentration of the milk-containing beverage can be further reduced.

(ii) Treatment involving reserving the milk-containing beverage in a reservoir or the like, and then reducing the pressure inside the reservoir to release the dissolved oxygen included in the milk-containing beverage into the internal space of the reservoir may be performed. Through this treatment, the dissolved oxygen concentration of the milk-containing beverage can be further reduced.

(iii) After the dissolved oxygen concentration of the milk-containing beverage has been reduced by, for example, blowing of an inert gas into the milk-containing beverage, foam formed in

the milk-containing beverage may be broken using a vacuum pump or the like. Through this treatment, the dissolved oxygen concentration of the milk-containing beverage can be further reduced.

(iv) After the step (C), the milk-containing beverage reserved in a tank (e.g., surge tank, filler tank, or the like) may be subjected to, for example, blowing of an inert gas. Through this treatment, the dissolved oxygen concentration of the milk-containing beverage can be further reduced.

[0058] In the present invention, the milk-containing beverage may be packed (i.e. accommodated) in a container, and stored in a refrigerated state or stored at room temperature as a milk-containing beverage in a container. In the present invention, the dissolved oxygen concentration of the milk-containing beverage is greatly reduced, and hence the container to be used for the storage is preferably a container having low oxygen permeability, for example, a container using, as its material, a bottle, a steel can, an aluminum can, polyethylene terephthalate (PET), vinyl, nylon, or the like. This is because, when the milk-containing beverage in the container is stored in a refrigerated state or stored at room temperature, a state in which the dissolved oxygen concentration of the milk-containing beverage is reduced is easily maintained and the growth of psychrophiles present in the milk-containing beverage can be suppressed. In the present invention, when the milk-containing beverage is packed in a paper container, a paper

container having lower oxygen permeability, such as a container formed of a laminated sheet including a paper base layer and a nylon resin layer, than that of a general paper container for cow's milk, is preferably used. In the present invention, examples of the laminated sheet constituting the paper container include a laminated sheet in which a polyethylene layer, a paper base layer, a nylon resin layer, an adhesive layer, and a polyethylene layer are laminated in the stated order from the outer side of the container to its inner side. Further, as a resin for forming the nylon resin layer, there are given various nylons (i.e. polyamide resins), such as nylon MXD6, nylon 6, nylon 6,6, and nylon 4,6.

[0059] In the present invention, the dissolved oxygen concentration of the milk-containing beverage is reduced, and hence, for example, the generation of an abnormal flavor caused by heating and/or storage, which is generated in cow's milk whose flavor is liable to change due to oxygen and/or heating, can be reduced. The term "abnormal flavor" as used herein refers to, for example, a spontaneous oxidized odor called a beany flavor, a heating odor, or the like. As a causative substance of the spontaneous oxidized odor, there is known a carbonyl compound, such as hexanal, and as a causative substance of the heating odor, there is known a sulfur compound, such as dimethyl sulfide, dimethyl disulfide, or dimethyl trisulfide. In the milk-containing beverage of the present invention, the dissolved oxygen concentration is reduced, and hence the generation of the causative substance of the spontaneous oxidized

odor and/or the heating odor can be suppressed.

[0060] That is, the present invention is also directed to a method of producing a milk-containing beverage in which generation of an abnormal flavor caused by heating and/or storage is reduced, including:

(A) a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[0061] In the present invention, while the dissolved oxygen concentration of the milk-containing beverage can be efficiently reduced, the generation of an abnormal flavor caused by heating and/or storage of the milk-containing beverage can also be reduced.

That is, the present invention is also directed to a method of reducing an oxygen concentration of a milk-containing beverage, including:

(A) a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[0062] In addition, the present invention is also directed to a method of reducing generation of an abnormal flavor caused by heating and/or storage of a milk-containing beverage, including:

(A) a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being

controlled so that the raw material milk has a foam ratio of 10% or less, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[0063] In addition, the present invention is also directed to a method of reducing generation of a spontaneous oxidized odor and/or a heating odor of a milk-containing beverage, including:

(A) a first oxygen concentration reduction step of subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled;

(B) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the first oxygen concentration reduction step; and

(C) a second oxygen concentration reduction step of subjecting the raw material milk after heat pasteurization obtained in the heat pasteurization step to inert gas treatment with a supply method

and supply conditions for the inert gas treatment being controlled, to thereby obtain a milk-containing beverage having a dissolved oxygen concentration of 1 ppm or less.

[0064] In addition, the present invention is also directed to a method of reducing generation of a carbonyl compound (e.g., hexanal) and/or a sulfur compound (e.g., dimethyl sulfide, dimethyl disulfide, or dimethyl trisulfide) in a milk-containing beverage, including:

(A) a first oxygen concentration reduction step of subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled;

(B) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the first oxygen concentration reduction step; and

(C) a second oxygen concentration reduction step of subjecting the raw material milk after heat pasteurization obtained in the heat pasteurization step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled, to thereby obtain a milk-containing beverage having a dissolved oxygen concentration of 1 ppm or less.

Examples

[0065] The present invention is hereinafter described by way of Examples. The present invention is not limited to Examples to be described below, and various embodiments may be adopted as long as the embodiments are encompassed in the scope of claims for a

patent.

[0066] In the present invention, "L/h" means liter/hour, and "L/min" means liter/minute. The foam ratio of raw material milk was calculated by the following equation after the following operation. Firstly, the raw material milk (or pasteurized milk) was poured into a transparent graduated cylinder made of glass (having a volume of 1 L), and kept for 5 minutes. After that, the height of a liquid phase in a lower layer in the raw material milk (or pasteurized milk) poured into the graduated cylinder and the height of a foam phase in an upper layer therein were measured with a ruler.

[Foam ratio of raw material milk] (unit: volume%)=[height of foam phase (m)] $\times$ 100÷([height of foam phase (m)]+[height of liquid phase (m)])

[0067] [Example 1]

While a nitrogen gas substituting apparatus (specifically, an apparatus having the static mixer as a proportional mixer for mixing and dispersing a nitrogen gas; abbreviated as "nitrogen gas substituting apparatus" in the following Examples and Comparative Examples) described in JP 2001-078665 A (i.e. the above-mentioned Patent Literature 2) having arranged therein a static mixer (inner diameter: 8 mm, 63 elements) was fed with 100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.7 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown (i.e. bubbling was performed) to proportionally feed (i.e. conduct mixing)

the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 1.5 ppm and a foam ratio of 5% or less. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 12.7 ppm.

[0068] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed again with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.1 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 1.5 ppm.

[0069] After that, a plate heat pasteurizer (abbreviated as "pasteurizer" in the following Examples and Comparative Examples) (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h. The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen

concentration of 0.3 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product) (immediately after the completion of the step (C)).

[0070] [Example 2]

While a proportional mixer having arranged therein a static mixer (inner diameter: 47.8 mm, 18 elements) was fed with 5,000 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 13.1 ppm, specific gravity: 1.03) at 5,000 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 37.5 L/min (volume ratio of nitrogen gas/raw milk: 45%). The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 12.7 ppm. After that, a tank for foam removal (having a volume of 200 L) was temporarily fed with the raw milk as a liquid. Specifically, a spray nozzle (Spraying Systems Co.; product name: Fulljet 22) was arranged in an upper part of the tank for foam removal, and part of the raw milk that had passed through the tank for foam removal was branched into the spray nozzle in the upper part of the tank for foam removal and sprayed onto the liquid surface at a back pressure of 0.07 MPa and a flow rate of 500 L/h to be fed as a liquid into a tank for milk storage (having a volume of 20,000 L) while eliminating foam (immediately after

the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.1 ppm and a foam ratio of 5% or less.

[0071] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 20,000 L), and then, while the nitrogen gas substituting apparatus was fed again with the raw milk as a liquid at 5,000 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 50 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.1 ppm.

[0072] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 10,000 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0073] [Example 3]

The inside of a tank for nitrogen substitution (having a volume of 50 L) having arranged in an upper part thereof a spray nozzle (Spraying Systems Co.; product name: Fulljet 1.5) was filled with a nitrogen gas. After that, while the tank for nitrogen substitution was fed with 20 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 11 ppm, specific gravity: 1.03) at 90 L/h, the whole amount was sprayed into the tank for nitrogen substitution through the spray nozzle (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.0 ppm and a foam ratio of 10% or less.

[0074] After that, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.1 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.0 ppm.

[0075] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The

cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0076] [Example 4]

The inside (bowl periphery) of a clarifier serving as a separating disc-type centrifuge (GEA Westfalia Separator, product name: SA-1) was supplied with a nitrogen gas at 10 L/min to adjust its oxygen concentration to 4%, and then the clarifier (back pressure: 0 MPa) was fed with 30 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 14.7 ppm, specific gravity: 1.03) at 100 L/h (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.8 ppm and a foam ratio of 10% or less.

[0077] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.3 ppm

and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.8 ppm.

[0078] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.6 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0079] [Example 5]

While the nitrogen gas substituting apparatus was fed with 30 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 14.7 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%). The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 14.7 ppm. After that, a clarifier serving as a separating disc-type centrifuge (GEA Westfalia Separator, product name: SA-1, back pressure: 0 MPa) was fed with raw milk as a liquid (immediately after the completion of the step (A)).

The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.1 ppm and a foam ratio of 10% or less.

[0080] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.1 ppm.

[0081] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.3 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0082] [Example 6]

While the nitrogen gas substituting apparatus was fed with

30 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 11.1 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.1 L/min (volume ratio of nitrogen gas/raw milk: 45%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.1 ppm and a foam ratio of 10% or less. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 11.1 ppm.

[0083] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L). Then, the inside (bowl periphery) of a clarifier serving as a separating disc-type centrifuge (GEA Westfalia Separator, product name: SA-1) was supplied with a nitrogen gas at 10 L/min to adjust its oxygen concentration to 4%, and then the clarifier (back pressure: 0 MPa) was fed with the raw milk as a liquid at 150 L/h (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk.

[0084] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The

cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0085] [Example 7]

While a vortex pump (manufactured by Nikuni Co., Ltd.) was fed with 30 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.3 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown in front of the vortex pump to proportionally feed (i.e. conduct mixing) the vortex pump with the gas at 0.33 L/min (volume ratio of nitrogen gas/raw milk: 10%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 3.0 ppm and a foam ratio of 10% or less.

[0086] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.3 ppm

and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 3.0 ppm.

[0087] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.6 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0088] [Example 8]

Two vortex pumps (manufactured by Nikuni Co., Ltd.) were arranged by being connected to each other in series. Of those, the vortex pump on the upstream side is referred to as first vortex pump, and the vortex pump on the downstream side is referred to as second vortex pump. While the first vortex pump was fed with 30 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.3 ppm, specific gravity: 1.03) at 200 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown in front of the first vortex pump to proportionally feed (i.e. conduct mixing) the first vortex pump with the gas at 0.15 L/min (volume ratio of nitrogen gas/raw milk: 5%). After that, while the second vortex pump was fed with raw milk as a liquid at

200 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown in front of the second vortex pump to proportionally feed (i.e. conduct mixing) the second vortex pump with the gas at 0.15 L/min (volume ratio of nitrogen gas/raw milk: 5%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.7 ppm and a foam ratio of 10% or less.

[0089] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.3 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.7 ppm.

[0090] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.6 ppm, a foam ratio of

5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0091] [Example 9]

While a proportional mixer having arranged therein a static mixer (inner diameter: 11 mm, 30 elements) was fed with 200 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 13.1 ppm, specific gravity: 1.03) at 703 L/h (superficial velocity: 2.1 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 1.25 L/min (volume ratio of nitrogen gas/raw milk: 11%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 3.4 ppm and a foam ratio of 10% or less.

[0092] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 200 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.4 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed

from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 3.4 ppm.

[0093] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.8 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0094] [Example 10]

While a proportional mixer having arranged therein a static mixer (inner diameter: 11 mm, 30 elements) was fed with 280 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 3.5 L/min (volume ratio of nitrogen gas/raw milk: 75%), and the raw milk after mixing with the nitrogen gas was reserved in a tank for milk storage (having a volume of 500 L). Next, while the proportional mixer was fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the

proportional mixer with the gas at 1.4 L/min (volume ratio of nitrogen gas/raw milk: 30%), and the raw milk after mixing with the nitrogen gas was reserved in the tank for milk storage (having a volume of 500 L).

[0095] Further, while the proportional mixer was fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 0.7 L/min (volume ratio of nitrogen gas/raw milk: 15%), and the raw milk after mixing with the nitrogen gas was reserved in the tank for milk storage (having a volume of 500 L) (immediately after the completion of the step (A)). The raw milk after mixing of those raw milks had a dissolved oxygen concentration of 2.2 ppm and a foam ratio of 10% or less.

[0096] After that, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting

apparatus had a dissolved oxygen concentration of 2.2 ppm.

[0097] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0098] [Example 11]

80 L of raw milk (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) was reserved in a tank for milk storage (having a volume of 100 L) having arranged in an upper part thereof a defoaming apparatus for breaking foam with a mechanical shearing force (manufactured by Toyooki Kogyo Co., Ltd., BABUKESU BK100). While a proportional mixer having arranged therein a static mixer (inner diameter: 23 mm, 38 elements) was fed with the raw milk as a liquid at 2,000 L/h (superficial velocity: 1.3 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 14.3 L/min (volume ratio of nitrogen gas/raw milk: 43%), and the raw milk after mixing with the nitrogen gas was reserved in the tank for milk storage to be circulated (immediately after the completion of the step (A)). The circulated raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.0

ppm and a foam ratio of 10% or less.

[0099] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 200 L), and then, while the nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.0 ppm.

[0100] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0101] [Example 12]

While a nitrogen gas substituting apparatus modified so as to allow raw material milk subjected to nitrogen gas substitution

to be used also for raw material milk to be sprayed from above the nitrogen gas substituting apparatus (abbreviated as "modified nitrogen gas substituting apparatus" in the following Examples) was fed with 100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.7 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 1.5 ppm and a foam ratio of 5% or less. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had a dissolved oxygen concentration of 1.5 ppm.

[0102] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the nitrogen gas substituting apparatus was fed again with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.1 ppm and a foam ratio of 5% or less. At this time, foaming was hardly

observed in the raw material milk. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had a dissolved oxygen concentration of 0.1 ppm.

[0103] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.3 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0104] [Example 13]

While a modified nitrogen gas substituting apparatus having arranged therein a static mixer (inner diameter: 47.8 mm, 18 elements) in place of the static mixer (inner diameter: 8 mm, 63 elements) was fed with 5,000 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 13.1 ppm, specific gravity: 1.03) at 5,000 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 37.5 L/min (volume ratio of nitrogen gas/raw milk: 45%). The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 2.1 ppm. After that, a tank for foam removal (having a volume of 200 L) was temporarily fed with the raw milk as a liquid. Specifically,

a spray nozzle (Spraying Systems Co.; product name: Fulljet 22) was arranged in an upper part of the tank for foam removal, and part of the raw milk that had passed through the tank for foam removal was branched into the spray nozzle in the upper part of the tank for foam removal and sprayed onto the liquid surface at a back pressure of 0.07 MPa and a flow rate of 500 L/h to be fed as a liquid into a tank for milk storage while eliminating foam (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 2.1 ppm and a foam ratio of 5% or less.

[0105] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 20,000 L), and then, while the modified nitrogen gas substituting apparatus was fed again with the raw milk as a liquid at 5,000 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 50 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 0.2 ppm.

[0106] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid

at 10,000 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0107] [Example 14]

While a proportional mixer having arranged therein a static mixer (inner diameter: 11 mm, 30 elements) was fed with 200 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 13.1 ppm, specific gravity: 1.03) at 703 L/h (superficial velocity: 2.1 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 1.25 L/min (volume ratio of nitrogen gas/raw milk: 11%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 3.4 ppm and a foam ratio of 10% or less.

[0108] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 200 L), and then, while the modified nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing

again with the nitrogen gas had a dissolved oxygen concentration of 0.4 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had a dissolved oxygen concentration of 0.4 ppm.

[0109] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.8 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0110] [Example 15]

While a proportional mixer having arranged therein a static mixer (inner diameter: 11 mm, 30 elements) was fed with 280 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 3.5 L/min (volume ratio of nitrogen gas/raw milk: 75%), and the raw milk after mixing with the nitrogen gas was reserved in a tank for milk storage (having a volume of 500 L). Next, while the proportional mixer was fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less,

dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 1.4 L/min (volume ratio of nitrogen gas/raw milk: 30%), and the raw milk after mixing with the nitrogen gas was reserved in the tank for milk storage (having a volume of 500 L).

[0111] Further, while the proportional mixer was fed with 105 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.0 ppm, specific gravity: 1.03) at 280 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the proportional mixer with the gas at 0.7 L/min (volume ratio of nitrogen gas/raw milk: 15%), and the raw milk after mixing with the nitrogen gas was reserved in the tank for milk storage (having a volume of 500 L) (immediately after the completion of the step (A)). The raw milk after mixing of those raw milks had a dissolved oxygen concentration of 2.2 ppm and a foam ratio of 10% or less.

[0112] After that, while the modified nitrogen gas substituting apparatus was fed with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved

oxygen concentration of 0.2 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had a dissolved oxygen concentration of 0.2 ppm.

[0113] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.4 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0114] [Example 16]

While a modified nitrogen gas substituting apparatus was fed with 100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.7 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 0.75 L/min (volume ratio of nitrogen gas/raw milk: 30%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 7.1 ppm and a foam ratio of 5% or less. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had

a dissolved oxygen concentration of 7.1 ppm.

[0115] After that, the raw milk was temporarily reserved in a tank for milk storage (having a volume of 100 L), and then, while the modified nitrogen gas substituting apparatus was fed again with the raw milk as a liquid at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the modified nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%) (immediately after the completion of the step (B)). The raw milk after mixing again with the nitrogen gas had a dissolved oxygen concentration of 0.8 ppm and a foam ratio of 5% or less. At this time, foaming was hardly observed in the raw material milk. The raw material milk sprayed from above the modified nitrogen gas substituting apparatus had a dissolved oxygen concentration of 0.8 ppm.

[0116] After that, a pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.3 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product).

[0117] [Comparative Example 1]

While the nitrogen gas substituting apparatus was fed with

100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.7 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 1.5 L/min (volume ratio of nitrogen gas/raw milk: 60%). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 1.7 ppm and a foam ratio of 5% or less. The raw material milk sprayed from above the nitrogen gas substituting apparatus had a dissolved oxygen concentration of 12.7 ppm. After that, the pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with the raw milk as a liquid at 150 L/h. The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 1.7 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product). However, the cow's milk of Comparative Example 1 did not have a fresh flavor as compared to the cow's milk of Example 1 and the like owing to the dissolved oxygen concentration of more than 1 ppm.

[0118] [Comparative Example 2]

The pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with 100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 12.7 ppm, specific gravity: 1.03) at 150 L/h. The cow's milk (i.e.

pasteurized milk) after the heat pasteurization (immediately after the completion of the step (C)) had a dissolved oxygen concentration of 7.1 ppm, a foam ratio of 5% or less, and a liquid temperature of 10°C or less. At this time, foaming was hardly observed in the cow's milk (i.e. milk-containing beverage serving as a final product). However, the cow's milk of Comparative Example 2 did not have a fresh flavor as compared to the cow's milk of Example 1 and the like owing to the dissolved oxygen concentration of more than 1 ppm.

[0119] [Comparative Example 3]

While the nitrogen gas substituting apparatus was fed with 100 L of raw milk as a liquid (raw material milk, temperature: 10°C or less, dissolved oxygen concentration: 11.0 ppm, specific gravity: 1.03) at 150 L/h (superficial velocity: 0.8 m/second), a nitrogen gas was blown to proportionally feed (i.e. conduct mixing) the nitrogen gas substituting apparatus with the gas at 7.5 L/min (volume ratio of nitrogen gas/raw milk: 300%) (immediately after the completion of the step (A)). The raw milk after mixing with the nitrogen gas had a dissolved oxygen concentration of 0.8 ppm and a foam ratio of more than 10%.

[0120] After that, the pasteurizer (heat pasteurization conditions: 130°C, 2 seconds) was fed with the raw milk as a liquid at 150 L/h (immediately after the completion of the step (C)). The cow's milk after the heat pasteurization (i.e. pasteurized milk) had a dissolved oxygen concentration of 0.9 ppm, a foam ratio of

more than 10%, and a liquid temperature of 10°C or less. At this time, intense foaming was found in the cow's milk (i.e. milk-containing beverage serving as a final product), and hence the production efficiency was decreased.

Claims

[Claim 1] A method of producing a milk-containing beverage, comprising:

(A) a first oxygen concentration reduction step including subjecting raw material milk to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, and then discharging the raw material milk to obtain raw material milk having a reduced dissolved oxygen concentration;

(B) a second oxygen concentration reduction step of subjecting the raw material milk obtained in the first oxygen concentration reduction step to inert gas treatment with a supply method and supply conditions for the inert gas treatment being controlled so that the raw material milk has a foam ratio of 10% or less, to thereby obtain raw material milk having a reduced dissolved oxygen concentration; and

(C) a heat pasteurization step of heat-pasteurizing the raw material milk obtained in the second oxygen concentration reduction step.

[Claim 2] A method of producing a milk-containing beverage according to claim 1, wherein the raw material milk obtained in the first oxygen concentration reduction step has a dissolved oxygen concentration of 8 ppm or less.

[Claim 3] A method of producing a milk-containing beverage according to claim 1 or 2, wherein the raw material milk obtained in the second oxygen concentration reduction step has a dissolved oxygen concentration of 1 ppm or less.

[Claim 4] A method of producing a milk-containing beverage according to any one of claims 1 to 3, wherein the supply method for the inert gas treatment of each of the first oxygen concentration reduction step and the second oxygen concentration reduction step is performed by one kind or a combination of two or more kinds selected from:

- (a) mixing of the raw material milk and an inert gas using a proportional mixer;

- (b) spraying of the raw material milk into an apparatus having a space filled with an inert gas;

- (c) mixing of the raw material milk and an inert gas using a centrifuge;

- (d) mixing of the raw material milk and an inert gas using a pump; and

- (e) blowing of an inert gas into the raw material milk accommodated in a tank.

[Claim 5] A method of producing a milk-containing beverage according to claim 4,

wherein the inert gas treatment is performed in at least one of the first oxygen concentration reduction step or the second oxygen

concentration reduction step is performed by a method including (a) the mixing of the raw material milk and an inert gas using a proportional mixer, and

wherein in (a) the mixing of the raw material milk and an inert gas using a proportional mixer, a volume ratio of a supply rate (supply amount per unit time) of the inert gas to a supply rate (supply amount per unit time) of the raw material milk ($[\text{volume of inert gas}]/[\text{volume of raw material milk}]$) is from 5% to 70%.