DESCRIPTION

TITLE OF INVENTION

THERMAL PROCESSING METHOD OF MICROORGANISM

TECHNICAL FIELD

[0001]

The present invention relates to a thermal processing method of a microorganism, and more particularly, to a thermal processing method of a microorganism available to food and drink, medicines or the like.

BACKGROUND ART

[0002]

Probiotic foods are foods containing a microorganism, such as bacteria that provide a human body with good benefits by taking them in the human body. Examples of probiotic foods include yogurt containing live lactic acid bacteria.

[0003]

Depending on the type of microorganisms, dead cells of the microorganisms available to probiotic foods contain active ingredients providing the human body with good benefits; thus the microorganisms contained in the probiotic foods may be dead cells of

the microorganisms. When the microorganisms contained in the probiotic foods are dead cells thereof, the microorganisms never act in the probiotic foods, thus allowing for maintaining stable quality of the probiotic foods.

[0004]

For example, JP 2008-245569 discloses a Lactobacillus paracasei KW311 stain, which is a type of lactic acid bacteria, as microorganisms available to the probiotic foods. JP 2008-245569 discloses that combining the dead cells of the heat sterilized Lactobacillus paracasei KW311 stain with drink and food allows for producing drink and food with antiallergic functions.

[0005]

The dead cells of the microorganisms available to probiotic foods are acquired by heat-sterilizing live bacteria, for example. However, in heat-sterilizing the live bacteria, the dead cells or the like aggregate in a liquid containing the live bacteria, thereby forming aggregates. When the aggregates formed through the heat sterilization are added to the probiotic foods, consumers feel roughness caused by the aggregates. This may deteriorate the food texture of the probiotic foods.

[0006]

To prevent the food texture of the probiotic foods from deteriorating, it is preferable to inhibit the aggregation of the live bacteria in heat sterilization from progressing and prevent large-sized aggregates from forming. The smaller sized aggregates cause consumers to feel less roughness; thus, the above-described prevention allows for preventing the food texture of the probiotic foods from deteriorating. To prevent the progression of aggregation, it is preferable to set a temperature in heat sterilization to 100°C or below. Lowering the temperature in heat sterilization prevents progression of the denaturation of protein forming microorganisms, which causes formation of aggregates.

[0007]

When a sterilization temperature is to be set to 100°C or below, hot water heating is used. The hot water heating is a method for heating an object to be heated by circulating hot water heated to a predetermined temperature (100°C or below) around the object to be heated. It is noted that examples of heat sterilization include steam heating in which water vapor with a temperature of 100°C or above is used; however, it is not appropriate to employ a

method using steam heating for preventing the progression of aggregation.

[0008]

The hot water heating needs a long time to heat an object to be heated to a predetermined temperature, and thus has bad efficiency in heat sterilization. Furthermore, in heat-sterilizing a liquid containing live bacteria using the hot water heating, the substantial time for heating the liquid containing live bacteria becomes long. This may cause the formation of aggregates containing dead cells or the like to progress.

[0009]

CITATION LIST

Patent Literature 1: Japanese Unexamined Patent Publication No 2008-245569

DISCLOSURE OF INVENTION

TECHNICAL PROBLEM

[0010]

It is an object of the present invention to provide a thermal processing method of a microorganism that prevents aggregates from forming.

SOLUTION TO PROBLEM

[0011]

A thermal processing method of a microorganism according to the present invention includes a step a) and a step b). The step a) includes heating a liquid containing the microorganism to a predetermined sterilization temperature using vacuum vapor. The step b) includes maintaining a temperature of the liquid containing the microorganism heated in the step a) at the sterilization temperature for a predetermined time using the vacuum vapor.

[0012]

Preferably, a thermal processing method of a microorganism according to the present invention may further include a step c). The step c) includes cultivating the microorganism. The step a) includes heating a liquid containing a microorganism cultivated in the step c).

[0013]

Preferably, in a thermal processing method of a microorganism according to the present invention, the step c) may include a step c-1) and a step c-2). The step c-1) includes inoculating the microorganism into a medium and cultivating the microorganism inoculated into the medium. The step c-2) includes generating a concentrate liquid of the microorganism from the

medium containing the microorganism cultivated in the step c-1). The step a) includes heating the concentrate liquid.

[0014]

Preferably, in a thermal processing method of a microorganism according to the present invention, the step a) may include a step a-1) and a step a-2). The step a-1) includes, when the temperature of a liquid containing the microorganism is an intermediate temperature lower than or equal to the sterilization temperature, heating the liquid containing the microorganism using vacuum vapor with a temperature that is higher than or equal to the intermediate temperature and is lower than or equal to the sterilization temperature. The step a-2) includes, when the temperature of the liquid containing the microorganism is a temperature that is higher than or equal to the intermediate temperature and is lower than or equal to the sterilization temperature, heating the liquid containing the microorganism using vacuum vapor with a temperature that is higher than or equal to the sterilization temperature.

[0015]

Preferably, the intermediate temperature may be a temperature for generating aggregates in the liquid

containing the microorganism.

[0016]

Preferably, in a thermal processing method of a microorganism according to the present invention, the step a) and the step b) each may include adjusting a temperature of the vacuum vapor by changing a pressure of the vacuum vapor.

[0017]

Preferably, in a thermal processing method of a microorganism according to the present invention, the step a) may include heating a liquid containing the microorganism using a jacket tank including a tank unit into which the liquid containing the microorganism is injected and a jacket unit having an inner space into which the vapor vacuum is supplied and reducing the pressure of the inner space to a pressure lower than an atmospheric pressure before feeding the vacuum vapor into the inner space.

Advantageous Effects

[0018]

The present invention allows for preventing aggregates from forming when heat processing for a microorganism is performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a flowchart showing a thermal processing method for a microorganism according to an embodiment of the present invention.

Fig. 2 is a schematic diagram showing the structure of a thermal processing device used in a heat process shown in Fig. 1.

Fig. 3 is a graph showing time-temperature characteristics for a concentrate liquid of bifidobacteria according to Working Example 2 of the present invention.

Fig. 4 is a graph showing time-temperature characteristics for a concentrate liquid of bifidobacteria according to Comparative Example 2 of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020]

An embodiment of the present invention will now be described in detail. Identical or corresponding parts in figures are denoted by the same reference numerals, and description thereof will not be repeated.

[0021]

A thermal processing method of a microorganism of

the present embodiment includes generating a culture solution by cultivating the microorganism, generating a concentrate liquid by concentrating the generated culture solution, and heating the microorganism contained in the concentrate liquid using vacuum vapor.

[0022]

Heating the concentrate liquid of the microorganism using the thermal processing method of the microorganism according to the present embodiment causes the microorganism contained in the concentrate liquid to be sterilized, thereby allowing for adding the thermal-processed concentrate liquid to drink and food or the like.

[0023]

In the present embodiment, a microorganism is one available to probiotic foods and medicines. In other words, the microorganism to be thermally processed in the present embodiment is a microorganism that are believed to provide a human body with good benefits by taking them in the human body.

[0024]

Examples of microorganisms that can be subjected to the thermal processing method of a microorganism of the present embodiment include microbes, such as lactic acid bacteria and bifidobacteria. Examples of

lactic acid bacteria include Lactobacillus, Streptococcus, and Lactococcus that are mainly used in producing yogurt. Also, Examples of lactic acid bacteria include Leuconostoc and Pediococcus that are used in producing meat products or dairy products other than yogurt. Bifidobacteria are bacteria belonging to the genus Bifidobacterium.

[0025]

Vacuum vapor is a kind of water vapor. More specifically, the vacuum vapor has a temperature below 100°C and a pressure lower than the atmospheric pressure. In the present embodiment, the atmospheric pressure means the standard atmospheric pressure (1 atm = 101325 Pa). The present embodiment employs heating the concentrate liquid under temperatures below 100°C, thus reducing the generation of aggregates in the concentrate liquid.

[0026]

Fig. 1 is a flowchart showing a thermal processing method for a microorganism according to the present embodiment. As shown in Fig. 1, the thermal processing method for the microorganism according to the present embodiment includes a culture process (step S1), a concentrating process (step S2), and a heating process (step S3).

[0027]

For example, in a case when the microorganism is bifidobacteria, each process shown in Fig. 1 will now be described in detail.

[0028]

{Culture Process (step S1)}

Frist, in the culture process (step S1), bifidobacteria are cultured. A culture medium used for culturing bifidobacteria needs to contain a nutrient source with which bifidobacteria can proliferate. The culture medium may contain at least one of a milk-derived component, yeast extract, a soybean essence, peptone, saccharides, and a mineral.

[0029]

Examples of the milk-derived component include whey, casein, skimmed milk powder, whey protein concentrate (WPC), whey protein isolate (WPI). For example, peptone is trypticase or the like. Examples of saccharides include monosaccharides such as glucose and disaccharides such as lactose. As the mineral, for example, a whey mineral may be used. The culture medium is completely sterilized at a temperature of 121°C or above for one to ten minutes. Subsequently, bifidobacteria are inoculated into the completely sterilized culture to perform the neutral culture of

bifidobacteria. In performing the neutral culture of bifidobacteria, a temperature of the culture medium and a pH of the culture medium are not limited to predetermined values and may be any values as long as they are suitable for proliferation of bifidobacteria.

[0030]

In the culture solution after cultivating in the culture process (step S1), a density of bifidobacteria is preferably a value within a range of 10^7 to 10^{11} cfu/mL.

[0031]

Note that in cultivating microorganisms other than bifidobacteria, it is preferable that a culture medium suitable for proliferation of microorganisms to be cultivated is used. For a temperature and a pH in cultivating microorganisms, it is preferable that conditions suitable for proliferation of microorganisms to be cultivated are maintained.

[0032]

{Concentrating Process (step S2)}

After the culture process (step S1), the culture solution of bifidobacteria is concentrated to generate the concentrate liquid bifidobacteria (step S2).

[0033]

In concentrating the culture solution of

bifidobacteria, the centrifugal separation method is used. For example, the centrifugal separation method includes cooling the culture solution of bifidobacteria to 10°C, subsequently exerting a centrifugal force within a range of 5,000 to 20,000×G on the culture solution of bifidobacteria, and setting a dwell time to a time period for two to ten minutes.

[0034]

A centrifugal separator used in the concentrating process (step S2) is preferable a continuous centrifugal separator to efficiently centrifugalize a large amount of culture solution of bifidobacteria. More specifically, the continuous centrifugal separator is able to perform, in parallel, supplying (supplying of the culture solution of bifidobacteria), deliquoring (acquisition of liquid included in the lower layer of the culture solution in which bifidobacteria are concentrated), and discharging (discharging the supernatant of the culture solution of bifidobacteria). Note that the present embodiment does not exclude the use of centrifugal separators other than the continuous centrifugal separator.

[0035]

Through the concentrating process (step S2), the culture solution of bifidobacteria is separated into

the lower layer of the culture solution, which contains bifidobacteria with a high density, and the upper layer (the supernatant) of the culture solution, which contains less bifidobacteria. Collecting the lower layer of the culture solution as the concentrate liquid allows for collecting bifidobacteria contained in the culture solution with high efficiency.

[0036]

The rate of collection of bifidobacteria in the concentrating process (step S2) is preferably greater than or equal to 95 percent. The density of bifidobacteria in the concentrating liquid generated in the concentrating process (step S2) is, for example, a value within a range of 10^8 to 10^{12} cfu/mL.

[0037]

Note that in centrifugalizing a culture solution of microorganisms other than bifidobacteria, the conditions for centrifugalizing may be changed as appropriate. More specifically, to concentrate microorganisms other than bifidobacteria at the collection rate of 95% or above, a centrifugal force to be exerted on the culture solution of microorganisms other than bifidobacteria and a dwell time may be changed as appropriate.

[0038]

{Heating Process (step S3)}

As shown in Fig. 1, the concentrate liquid of bifidobacteria generated in the concentrating process (step S2) is heated using vaccum vapor (step S3). The heating process (step S3) includes heating the concentrate liquid of bifidobacteria to a predetermined target temperature and then maintaining the concentrate liquid of bifidobacteria heated to the predetermined target temperature for a predetermined time period. The target temperature is a temperature at which bifidobacteria contained in the concentrate liquid can be sterilized, for example. This allows for sterilizing bifidobacteria contained in the concentrate liquid, thereby generating a concentrate liquid of dead cells of bifidobacteria. The concentrate liquid of dead cells of bifidobacteria is used as ingredients of probiotic foods and medicines.

[0039]

Fig. 2 is a schematic diagram showing the structure of a thermal processing device 100 used in a heating process (step S3) shown in Fig. 1. As shown in Fig. 2, the thermal processing device 100 includes a vacuum vapor generating device 1, a jacket tank 2, pipes 3 to 5, and a controlling device 6.

[0040]

The vacuum vapor generating device 1 is for generating vacuum vapor. The jacket tank 2 is a container for heating a concentrate liquid of bifidobacteria. The pipe 3 connects the vacuum vapor generating device 1 with an inner space 22A of a jacket unit 22 of the jacket tank 2. One end of the pipe 4 is connected to the bottom of the inner space 22A of the jacket unit 22. The other end of the pipe 4, not shown in Fig. 2, is an exhaust port for discharging water flocculated in the inner space 22A. One end of the pipe 5 is connected to a joint (not shown) in the pipe 4. The other end of pipe 5 is connected to the vacuum vapor generating device 1. The pipe 5 is used for causing the vacuum vapor generating device to collect vacuum vapor flown into the pipe 4. Based on a temperature of the concentrate liquid of bifidobacteria, which is measured by a temperature sensor 24, and a gas pressure of vacuum vapor, which is measured by a pressure sensor 25, the controlling unit 6 controls a supply amount of vacuum vapor supplied from the vacuum vapor generating device 1 into the inner space 22A. The temperature sensor 24 and the pressure sensor 25 will be described later.

[0041]

The jacket tank 2 includes a tank unit 21, the

jacket unit 22, a stirring device 23, the temperature sensor 24, and the pressure sensor 25.

[0042]

The tank unit 21 is a drum, into which the concentrate liquid of bifidobacteria is injected. The jacket unit 22 is a hollow container covering the outer side surface and the bottom of the tank unit 21. The hollow portion of the jacket unit 22 is the inner space 22A. In the inner space 22A, vacuum vapor supplied from the vacuum vapor generating device 1 is condensed into water. The tank unit 21 and the jacket unit 22 are formed, for example, using metal with high thermal conductivity; they are thermally connected with each other.

[0043]

The stirring device 23 is a stirring blade the concentrate liquid of bifidobacteria injected into the tank unit 21. The temperature sensor 24 measures a temperature of the concentrate liquid of bifidobacteria injected into the tank unit 21. The pressure sensor 25, which is disposed in the inner space 22A, measures a gas pressure of vacuum vapor supplied into the inner space 22A.

[0044]

As shown in Fig. 1, the heating process (step S3)

includes an injection process (step S31), a pressure reduction process (step S32), a temperature increasing process (step S33), and a temperature maintaining process (step S34). As an example, for a case in which the concentrate liquid of bifidobacteria is maintained at a temperature of 80°C for ten minutes, the heating process (step S3) will now be described in detail with reference to Figs. 1 and 2.

[0045]

{Injection Process (step S31) and Pressure Reduction Process (step S32)}

First, the concentrate liquid of bifidobacteria generated in the step S2 is injected into the tank unit 21 (step S31). Using a pressure reduction device not shown in figures or the vacuum vapor generating device 1, the pressure of the inner space 22A of the jacket unit 22 is reduced to a pressure lower than the atmospheric pressure (step S32).

[0046]

If the pressure of the inner space 22A is not reduced, the atmosphere exerts a significant influence on the pressure and temperature of the inner space 22A, thereby making it difficult to adjust the temperature of vacuum vapor in the inner space 22A. Reducing the pressure of the inner space 22A in advance allows the

temperature of vacuum vapor in the inner space 22A to be easily adjusted to a desired temperature.

[0047]

{Temperature Increasing Process (step S33)}

After the reducing the pressure of the inner space 22A of the jacket unit 22 in the step S32, vacuum vapor is fed into the inner space 22A to heat the concentrate liquid of bifidobacteria injected into the tank unit 21 (step S33). In the step S33, the temperature of the concentrate liquid of bifidobacteria is increased to the target temperature (80°C). Also, in the step S33, rotating the stirring blade of the stirring device 23 stirs the concentrate liquid of bifidobacteria. Stirring the concentrate liquid of bifidobacteria allows the concentrate liquid of bifidobacteria injected into the tank unit 21 to be heated almost uniformly.

[0048]

The temperature of the vacuum vapor in the inner space 22A of the jacket unit 22 is adjusted in accordance with the temperature of the concentrate liquid of bifidobacteria injected into the tank unit 21. More specifically, when the temperature of the concentrate liquid of bifidobacteria injected into the tank unit 21 is lower than or equal to an intermediate

temperature lower than the target temperature, the concentrate liquid of bifidobacteria is heated using vacuum vapor whose temperature is larger than or equal to the intermediate temperature and is lower than or equal to the target temperature. When the temperature of the concentrate liquid of bifidobacteria is larger than or equal to the intermediate temperature, the concentrate liquid of bifidobacteria is heated using vacuum vapor with a temperature larger than or equal to the target temperature. As described above, in this process, the concentrate liquid of bifidobacteria is heated using vacuum vapor, whose temperature is larger than or equal to the intermediate temperature and is lower than or equal to the target temperature, after heating the vacuum vapor with the intermediate temperature. This allows for rapidly heating the concentrate liquid of bifidobacteria and for easily maintaining the temperature of the concentrate liquid of bifidobacteria at the target temperature.

[0049]

The intermediate temperature is preferably a temperature for generating aggregates (e.g., 60°C). This prevents the temperature rising speed of bifidobacteria from decreasing around the temperature for generating aggregates in heating the concentrate

liquid of bifidobacteria. Shortening a heating time at around the temperature for generating aggregates in heating the concentrate liquid of bifidobacteria prevents aggregates to be formed in heating the concentrate liquid of bifidobacteria.

[0050]

In the present embodiment, at the beginning of heating the concentrate liquid of bifidobacteria, the target temperature is set to 80°C, and the intermediate temperature is set to 60°C. At the beginning of heating the concentrate liquid of bifidobacteria, the temperature of the concentrate liquid of bifidobacteria is lower than or equal to the intermediate temperature (60°C), and thus the temperature of vacuum vapor in the inner space 22A of the jacket unit 22 is adjusted to a temperature within a range from 60°C to 65°C inclusive. When the temperature of the concentrate liquid of bifidobacteria becomes larger than or equal to the intermediate temperature (60°C), the temperature of vacuum vapor in the inner space 22A is adjusted to a temperature within a range from 80°C to 85°C inclusive.

[0051]

Note that setting of the target temperature (80°C) and the intermediate temperature (60°C) in

heating the concentrate liquid of bifidobacteria is merely one example; the target temperature and the intermediate temperature may be set to other temperatures other than the above-described temperatures.

[0052]

The temperature adjustment of vacuum vapor in the inner space 22A of the jacket unit 22 will now be described in detail. A pressure reduction device not shown in figures or the vacuum vapor generating device 1 performs control processing such that the pressure of the inner space 22A of the jacket unit 22 becomes a pressure lower than or equal to the atmospheric pressure. The condensing temperature of vacuum vapor is uniquely determined, by a pressure, and thus injecting vacuum vapor in a space whose pressure has been controlled causes the temperature of the vacuum vapor to become a condensing temperature at that pressure.

[0053]

Thus, controlling the pressure in the inner space 22A of the jacket unit 22 allows for adjusting the temperature of vacuum vapor in the inner space 22A. Controlling the pressure in the inner space 22A is performed by adjusting a flow rate of vacuum vapor

supplied into the inner space 22A.

[0054]

Next, the principle of heating the concentrate liquid of bifidobacteria by vacuum vapor will be described in detail. The concentrate liquid of bifidobacteria injected into the tank unit 21 is heated by latent heat emitted when vacuum vapor is condensed into water (liquid) in the inner space 22A of the jacket unit 22.

[0055]

The temperature of the concentrate liquid of bifidobacteria injected into the tank unit 21 is, for example, 4°C at the beginning of heating (immediately after centrifugal separation). The tank unit 21 and the jacket unit 22 are thermally connected with each other, and thus vacuum vapor in the inner space 22A of the jacket unit 22 is cooled by the concentrate liquid of bifidobacteria injected into the tank unit 21. With cooling the vacuum vapor, the vacuum vapor emits latent heat and then is condensed into water. The latent heat emitted when the vacuum vapor is condensed into water transmitted to the tank unit 21, thereby heating the concentrate liquid of bifidobacteria.

[0056]

The water (liquid) generated by condensing the

vacuum vapor moves to the bottom of the inner space 22A of the jacket unit 22, and then is discharged from the pipe 5. Condensing the vacuum vapor lowers the pressure of the inner space 22A, thereby lowering the temperature of the inner space 22A. However, as described above, adjusting the flow rate of the vacuum vapor controls the pressure of the inner space 22A. Thus, the vacuum vapor continues to be supplied into the inner space 22A; accordingly, the concentrate liquid of bifidobacteria continues to be heated by the latent heat emitted from the vacuum vapor.

[0057]

Though the concentrate liquid of bifidobacteria is heated by the latent heat emitted from the vacuum vapor, the temperature of the vacuum vapor is lower than 100°C. Thus, the concentrate liquid of bifidobacteria is not heated to a temperature higher than or equal to 100°C. Besides heating methods using vacuum vapor, hot water heating is known as a method for heating the concentrate liquid of bifidobacteria to a temperature lower than or equal to 100°C. However, heating the concentrate liquid of bifidobacteria using the latent heat emitted from the vacuum vapor reduces a time required to heat the concentrate liquid of bifidobacteria as compared with the hot water heating.

The reason will now be described.

[0058]

Latent heat is thermal energy released or absorbed when a substance changes from one state (e.g., gas) to another state (e.g., liquid). In phase transition of vacuum vapor to water (liquid), the latent heat is emitted from the vacuum vapor. The latent heat emitted from the vacuum vapor changes depending on a pressure of the vacuum vapor; it is greater than the sensible heat of water (liquid) and is greater than or equal to approximately five times the sensible heat of water (liquid). The sensible heat of water (liquid) is heat emitted when the temperature of water (liquid) decreases or heat absorbed when the temperature of water (liquid) increases.

[0059]

The hot water heating is a heating method using the sensible heat of water (liquid); more specifically, it is a method of heating the concentrate liquid of bifidobacteria by filling the inner space 22A of the jacket unit 22 with hot water having a predetermined temperature. As described above, the latent heat of the vacuum vapor is significantly greater than the sensible heat of hot water. Thus, the heating method

using the latent heat emitted from the vacuum vapor shortens the time required to heat the concentrate liquid of bifidobacteria as compared with the heating method using the sensible heat (the hot water heating).

[0060]

Furthermore, heating using the vacuum vapor lowers a load of stirring. The reason will now be described.

[0061]

As described above, the hot water heating requires a longer time to reach the target temperature than heating using the vacuum vapor. When the hot water heating is used, it takes a long time for the temperature of the concentrate liquid of bifidobacteria to stay a temperature around the temperature for generating aggregates, thereby progressing to form aggregates. In other words, using the hot water heating prompts forming large-sized aggregates in the concentrate liquid of bifidobacteria. To destroy the formed large-sized aggregates, it is needed to raise the load of stirring. In other words, when the hot water heating is used, it is needed to set the tip speed of the stirring blade to a speed at which aggregates are destroyed.

[0062]

Conversely, when bifidobacteria are heated by using the vacuum vapor, the time required to stay a temperature around the temperature for generating aggregates shortens as described above, thereby prevent aggregates from forming. It is not needed to destroy aggregates by stirring, thus lowering the load of stirring (lowering the tip speed of the stirring blade). For example, heating using the vacuum vapor makes it possible to heat the concentrate liquid with a high viscosity, which is unable to be stirred with a high load.

[0063]

{Temperature Maintaining Process (step S34)}

When the temperature of the concentrate liquid of bifidobacteria injected into the tank unit 21 increases and then reaches the target temperature through the temperature increasing process (step S33), the concentrate liquid of the bifidobacteria is maintained at the target temperature for a predetermined time with the stirring blade continuously rotated (step S34). In the present embodiment, the pressure of the vacuum vapor in the inner space 22A of the jacket unit 22 is controlled such that the temperature of the concentrate liquid of bifidobacteria is maintained at the target temperature

of 80°C for ten minutes.

[0064]

As described above, the vacuum vapor is used in the temperature maintaining process (step S34). This makes it easy to maintain the temperature of the concentrate liquid of bifidobacteria at the temperature of 80°C as compared with the hot water heating. The reason will now be described using an exemplary case when the target temperature is set to 80°C.

[0065]

When the temperature of the concentrate liquid of bifidobacteria is heated above the target temperature (80°C) in the hot water heating, it is needed to lower the temperature of the inner space 22A by supplying hot water at a temperature lower than or equal to 80°C into the jacket unit 22. However, the temperature of the hot water in the inner space 22A changes due to convection of the hot water, and thus it takes a time until the temperature of the hot water in the whole of the inner space 22A becomes to a temperature lower than or equal to 80°C.

[0066]

Conversely, when the vacuum vapor is used, controlling the pressure of the vacuum vapor in the

inner space 22A controls the temperature of the vacuum vapor in the inner space 22A. The vacuum vapor is a gas, and thus the pressure of the vacuum vapor in the inner space 22A changes much faster than the temperature of the hot water changes when the inner space 22A is filled with hot water. It is possible to promptly adjust the temperature of the vacuum vapor in the inner space 22A in accordance with the temperature of the concentrate liquid of bifidobacteria. Thus, using the vacuum vapor makes it easy to maintain the temperature of the concentrate liquid of bifidobacteria to the target temperature (80°C) as compared with a case when the hot water heating is used.

[0067]

In the temperature maintaining process (step S34), maintaining the temperature of the concentrate liquid of bifidobacteria at the target temperature for a predetermined time terminates the heating process (step S3). The concentrate liquid of bifidobacteria after the heating process (step S3) is used as ingredients for probiotic foods or medicines.

[0068]

Note that when the concentrate liquid of microorganisms other than bifidobacteria is heated in

the heating process (step S3), a heating temperature of the concentrate liquid of microorganisms other than bifidobacteria and a time for maintaining the concentrate liquid at the heating temperature may be changed depending on the type of microorganism contained in the concentrate liquid. For example, when the concentrate liquid of a microorganism is completely sterilized in the heating process (step S3), a condition under which the microorganism is completely sterilized by heating differs depending on the type of microorganism.

[0069]

As described above, the thermal processing method of microorganisms according to the present embodiment includes heating the concentrate liquid of microorganisms using the vacuum vapor, and maintaining the temperature of the concentrate liquid of the microorganism at a predetermined temperature for a predetermined time using the vacuum vapor.

[0070]

The vacuum vapor supplied into the inner space 22A of the jacket unit 22 has a temperature lower than or equal to 100°C, and thus the concentrate liquid of microorganisms is not heated to a temperature higher than or equal to 100°C in the heating process (step

S3). Accordingly, progression of the denaturation, caused by heat, of protein forming microorganisms or protein originated from a medium is prevented, thus preventing the progression of forming aggregates in the concentrate liquid of microorganisms.

[0071]

In addition, using latent heat emitted in condensing the vacuum vapor allows for promptly heating the concentrate liquid of bifidobacteria to the target temperature as compared with a case when the hot water heating is used. This shortens the substantial heating time for the concentrate liquid of bifidobacteria, thus preventing aggregates from forming more efficiently.

[0072]

{Modification}

In the above embodiment, a case in which microorganisms contained in the concentrate liquid is sterilized by heat is described; using the heat processing method of microorganisms according to the above embodiment, microorganisms contained in the concentrate liquid may be inactivated.

[0073]

In the above embodiment, a case in which the concentrate liquid of microorganisms is heated using

the vacuum vapor is described; however, the present invention should not be limited to this case. In the heating process (step S3), the culture solution of microorganisms may be heated using the vacuum vapor without centrifugalizing the culture solution of microorganisms. In other words, the liquid containing the cultivated microorganisms may be heated. Alternatively, the liquid in which food and drink containing microorganisms is dispersed in water with a predetermined density may be heated using the vacuum vapor. In other words, the liquid to be heated in the heating processing (step S3) is required to be a liquid containing a microorganism.

[0074]

The above embodiment describes a case in which the temperature of the vacuum vapor is adjusted in two stages in the temperature increasing process (step S33); that is, in one stage, the vacuum vapor is adjusted to a temperature that is higher than or equal to the intermediate temperature and is lower than or equal to the target temperature, and in the other stage, the vacuum vapor is adjusted to a temperature higher than or equal to the target temperature. However, in the temperature increasing process (step S33), the temperature of the vacuum vapor may be

adjusted in three or more stages. Alternatively, the temperature of the vacuum vapor may be adjusted directly to the target temperature.

[0075]

In the above embodiment, a case for microorganisms (e.g., lactic acid bacteria or bifidobacteria) available to ingredients for probiotic foods or medicines is described; however, the present invention should not be limited to this case. A liquid containing another microorganism such as bacteria may be heated in the heating process (step S3).

[0076]

In the concentrating process (step S2) of the above embodiment, a case in which the centrifugal method is used to generate the concentrate liquid of bifidobacteria from the culture solution of bifidobacteria after cultivation is described; however, the present invention should not be limited to this case. Any method, other than the centrifugal method, which generates the concentrate liquid of bifidobacteria from the culture solution of the bifidobacteria after cultivation, may be used (e.g., membrane separation method).

[0077]

In the above embodiment, a case in which the concentrate liquid of bifidobacteria is sterilized by heat is described. However, when the concentrate liquid containing a microorganism other than bifidobacteria is heated, the target temperature (sterilization temperature) may be changed depending on the type of microorganism contained in the concentrate liquid. When the intermediate temperature is set to the temperature for generating aggregates, the intermediate temperature may be changed depending on the type of microorganism contained in the concentrate liquid and/or a component contained in the concentrate liquid.

[0078]

The above embodiment describes a case in which, in the culture process (step S1) and the concentrating process (step S2), the concentrate liquid containing only bifidobacteria is prepared, and in the heating process (step S3), the target temperature of the concentrate liquid is set to a temperature for sterilization. However, the concentrate liquid may contain two or more types of microorganisms. In this case, in the heating process (step S3), the target temperature of the concentrate liquid may be a temperature at which at least one of the

microorganisms contained in the concentrate liquid is sterilized. The target temperature may be a temperature at which at least one of the microorganisms contained in the concentrate liquid is inactivated.

[0079]

Working Example

The present invention will now be described in more detail using a working example. Note that the present invention should not be limited to the working example below.

[0080]

[Evaluation Test 1]

The size of aggregates in heating the concentrate liquid of the microorganism using the vacuum vapor is verified. More specifically, a result of a working example 1 in which the concentrate liquid of bifidobacteria is heated using the vacuum vapor with a temperature lower than 100°C is compared with a result of a comparative example 1 in which the concentrate liquid of bifidobacteria is heated using the normal vapor with a temperature higher than or equal to 100°C.

[0081]

{Working Example 1}

In accordance with procedures below, a

concentrate liquid of bifidobacteria after the heat processing is produced.

[0082]

1) A culture solution of bifidobacteria is acquired by performing the neutral culture on a bifidobacterium OLB6378 stain, which is a type of bifidobacteria, using a casein decomposition medium. The casein decomposition medium is a medium that uses casein undergone enzymatic decomposition as a protein source. The bifidobacterium OLB6378 stain is a bifidobacterium bifidum OLB6378 stain, and is deposited in National Institute of Technology and Evaluation NITE Patent Microorganisms Depositary as a deposit number "NITE BP-31".

[0083]

2) 1500 kg of the culture solution of bifidobacteria is centrifugalized (at a temperature of 4°C, by a force of 10,000G, for three minutes) using a centrifugal separator manufactured by GEA Westfalia Separator Group Gmbh (model name: CFD 130). Through this process, 1457 kg of the supernatant of the culture solution is eliminated from 1500 kg of the culture solution of bifidobacteria, thereby acquiring a bacterial cell concentrate fraction (43 kg).

[0084]

The bacterial cell concentrate fraction acquired through the centrifugal separation corresponds to the concentrate liquid of bifidobacteria before the heating process of the working example 1. In the concentrate liquid of bifidobacteria before the heat processing of the working example 1, the bacteria cell concentration of bifidobacteria is 2×10^{11} cfu/mL. Note that the bacteria cell concentration of bifidobacteria is measured by using a method described in "Standard Methods of Analysis in Food Safety Regulation, Microorganism edition (1990)" issued by Japan Food Hygiene Association.

[0085]

3) The concentrate liquid of bifidobacteria before the heat processing of the working example 1 is injected into a 100L tank manufactured by Osaka sanitary Co., Ltd. The temperature of the concentrate liquid of bifidobacteria of the working example 1 is 6.2°C before the beginning of the heat processing.

[0086]

Subsequently, the vacuum vapor is injected into the jacket unit of a 100L tank; and then the concentrate liquid of bifidobacteria of the working example 1 is heated to 80°C while the concentrate liquid of bifidobacteria injected into the 100L tank

is being stirred. The above-described stirring process is performed under the conditions in which the rotation speed of a stirring blade is set to 120 rpm and the tip speed of the stirring blade is set to 0.88 m/sec. In heating the concentrate liquid of bifidobacteria according to the working example 1, the temperature of the vacuum vapor of the jacket unit is adjusted to a temperature which is higher than or equal to 60°C and is lower than or equal to 65°C until the temperature of the concentrate liquid reaches 60°C. When the temperature of the concentrate liquid of bifidobacteria is within a range from 60°C to 80°C inclusive, the temperature of the vacuum vapor of the jacket unit is adjusted to a temperature within a range from 80°C to 85°C inclusive.

[0087]

4) After heating the concentrate liquid of bifidobacteria to 80°C, the concentrate liquid of bifidobacteria is maintained at 80°C for ten minutes. Through this process, the concentrate liquid of bifidobacteria after the heat process of the working example 1 is acquired.

[0088]

{Comparative Example 1}

As a comparative example 1, the concentrate

liquid of bifidobacteria is heated using normal vapor with 100°C or higher.

[0089]

1) A bifidobacterium OLB6378 stain, which is a type of bifidobacteria and is identical to one used in the working example 1, is cultivated by using the cultivation method described in the above working example 1, thereby acquiring the culture solution of bifidobacteria of the comparative example 1.

[0090]

2) Using the centrifugal separation method described in the working example 1, a bacterial cell concentrate fraction (43 kg) of the comparative example 1 is acquired from the culture solution of bifidobacteria of the comparative example 1. The bacterial cell concentrate fraction of the comparative example 1 corresponds to the concentrate liquid of bifidobacteria before the heating process of the comparative example 1. In the concentrate liquid of bifidobacteria before a comparative process of the comparative example 1, the bacteria cell concentration is 2×10^{11} cfu/mL. The method of measuring the bacteria cell concentration is the same as the method of measuring the bacteria cell concentration used in the working example 1.

[0091]

The concentrate liquid of bifidobacteria before the heat process of the comparative example 1 is injected into a 50L tank manufactured by Iwai Kikai Kogyo Co., Ltd. The temperature of the concentrate liquid of bifidobacteria of the comparative example 1 is 6.2°C before the beginning of the heat process.

[0092]

Vapor with a temperature within a range from 110°C to 130°C inclusive is injected into the jacket unit of the 50L tank; and then the concentrate liquid of bifidobacteria of the comparative example 1 is heated to 80°C while the concentrate liquid of bifidobacteria injected into the 50L tank is being stirred. The above-described stirring process is performed under the conditions in which the rotation speed of a stirring blade is set to 250 rpm, the tip speed of the stirring blade is set to 1.31 m/sec.

[0093]

After heating the concentrate liquid of bifidobacteria of the comparative example to 80°C, the concentrate liquid of bifidobacteria of the comparative example 1 is maintained at 80°C for ten minutes. Through this process, the concentrate liquid of bifidobacteria after the heat process of the

comparative example 1 is acquired.

[0094]

{Evaluation}

The size of aggregates of the concentrate liquid of bifidobacteria before the heat process of the working example 1, the size of aggregates of the concentrate liquid of bifidobacteria after the heat process of the working example 1, and the size of aggregates of the concentrate liquid of bifidobacteria after the heat process of the comparative example 1 are measured.

[0095]

For example, in a case of the concentrate liquid of bifidobacteria after heat process of the working example 1, the method of measuring aggregates will be described. Dispersion is acquired by dispersing the concentrate liquid of bifidobacteria after heat process of the working example 1 in water. Using a laser diffraction particle size analyzer (SALD-2000, manufactured by Shimadzu Corporation), the mean diameter, medium diameter, and most frequent diameter of aggregates contained in the dispersion are measured.

[0096]

Table 1 shows the sizes of aggregates of the concentrate liquid of bifidobacteria before the heat

process of the working example 1, the sizes of aggregates of the concentrate liquid of bifidobacteria after the heat process of the working example 1, and the sizes of aggregates of the concentrate liquid of bifidobacteria after the heat process of the comparative example 1.

[0097]

Table 1

	Working example 1 (before the heat process)	Working example 1 (after the heat process)	Comparative example 1 (after the heat process)
Mean diameter (μm)	1.658	32.13	73.57
Medium diameter (μm)	1.31	4.199	40.48
Most frequent diameter (μm)	1.097	3.359	23.82

[0098]

As shown in Table 1, for each of the mean diameter, the medium diameter, and the most frequent diameter, values for the concentrate liquid of bifidobacteria before the heat process of the working example 1 are the smallest. For the concentrate liquid of bifidobacteria before the heat process of the working example 1, the mean diameter, the medium diameter, and the most frequent diameter range from 1.0 to 1.7 μm, which corresponds to the size of

bifidobacteria. This shows that no aggregate is formed in the concentrate liquid of bifidobacteria before the heat process of the working example 1.

[0099]

The mean diameter, medium diameter, and most frequent diameter of aggregates contained in the concentrate liquid of bifidobacteria after the heat process of the working example 1 are respectively larger than the mean diameter, medium diameter, and most frequent diameter of aggregates contained in the concentrate liquid of bifidobacteria before the heat process of the working example 1. This shows that heating the concentrate liquid of bifidobacteria of the working example 1 causes the formation of aggregates to progress to some extent.

[0100]

However, aggregates contained in the concentrate liquid of bifidobacteria after the heat process of the working example 1 are smaller than aggregates contained in the concentrate liquid of bifidobacteria after the heat process of the comparative example 1. This clarifies that heating the concentrate liquid of bifidobacteria of the working example 1 prevents the formation of aggregates from progressing as compared with a case of heating it at a temperature higher than

or equal to 100°C.

[0101]

The tip speed of the stirring blade of the working example 1 is approximately two thirds of the tip speed of the stirring blade of the comparative example 1; however, aggregates contained in the concentrate liquid of bifidobacteria after the heat process of the working example 1 is smaller than aggregates contained in the concentrate liquid of bifidobacteria after the heat process of the comparative example 1. This clarifies that heating using the vacuum vapor prevents large-sized aggregates from forming without stirring for destroying aggregates.

[0102]

[Evaluation Test 2]

Time change when the concentrate liquid of bifidobacteria is heated using the vacuum vapor with a temperature of 100°C or below is investigated. In the working example 2, changes in temperatures of the concentrate liquid of bifidobacteria with time when the vacuum vapor is used is measured; in the comparative example 2, changes in temperatures of the concentrate liquid of bifidobacteria with time when the hot water heating is used is measured.

[0103]

{Working example 2}

Through the same procedures as in the above working example 1, 50 kg of the concentrate liquid of bifidobacteria of a working example 2 is acquired. The 50kg of the concentrate liquid of bifidobacteria of the working example 2 is injected into the 100L tank manufactured by Osaka sanitary Co., Ltd., and then is heated by supplying the vacuum vapor into the jacket unit of the 100L tank. In heating, the 50 kg of the concentrate liquid of the working example 2 is stirred by rotating the stirring blade. The above-described stirring process is performed under the conditions in which the rotation speed of the stirring blade is set to 120 rpm and the tip speed of the stirring blade is set to 0.88 m/sec. While the temperature of the vacuum vapor of the jacket unit is being adjusted in accordance with increases in temperature of the concentrate liquid of the bifidobacteria, changes in temperatures of the 50 kg of the concentrate liquid of bifidobacteria are measured.

[0104]

Fig. 3 is a graph showing time-temperature characteristics (changes in temperatures with time)

for a concentrate liquid of bifidobacteria according to the present working example. As shown in Fig. 3, the setting value of the temperature of the vacuum vapor supplied into the jacket unit of the 100L tank is changed in accordance with increases in temperatures of the concentrate liquid of bifidobacteria. When the 50 kg of the concentrate liquid of bifidobacteria is heated using the vacuum vapor, the time required for the temperature of the 50 kg of the concentrate liquid of the bifidobacteria to reach 80°C is 80 minutes.

[0105]

{Comparative Example 2}

Through the same procedures as in the above working example 1, 100 kg of the concentrate liquid of bifidobacteria of a comparative example 2 is acquired. The 100 kg of the concentrate liquid of bifidobacteria of the comparative example 2 is injected into a 250L tank, and then is heated by feeding hot water into the jacket unit of the 250L tank manufactured by Scanima Company. In heating, the concentrate liquid of bifidobacteria is stirred using a stirring blade and a scraper provided in the 250L tank. The above-described stirring process is performed under the conditions in which the rotation speed of the stirring

blade is set to 350 rpm and the tip speed of the stirring blade is set to 1.85 m/sec. While the temperature of the vacuum vapor of the jacket unit is being adjusted in accordance with increases in temperature of the bifidobacteria, changes in temperatures of the 100 kg of the concentrate liquid of bifidobacteria are measured.

[0106]

Fig. 4 is a graph showing time-temperature characteristics (changes in temperatures with time) for a concentrate liquid of bifidobacteria according to the present comparative example. As shown in Fig. 4, the temperature of hot water supplied into the jacket unit of the 250L tank is changed in accordance with increases in temperatures of the concentrate liquid of bifidobacteria. When the 100 kg of the concentrate liquid of bifidobacteria is heated using hot water, the time required for the temperature of the 100 kg of the concentrate liquid of the bifidobacteria to reach 80°C is 180 minutes.

[0107]

As described above, the embodiments of the present invention are described; however, the above embodiments are merely examples for implementing the present invention. The present invention should not

be limited to the above embodiments; the present invention may be implemented and/or modified freely without departing from the scope and the spirit of the invention.

WHAT IS CLAIMED IS:

1. A thermal processing method of a microorganism, comprising:

a) heating a liquid containing the microorganism to a predetermined sterilization temperature using vacuum vapor; and

b) maintaining a temperature of the liquid containing the microorganism heated in the step a) at the sterilization temperature for a predetermined time using the vacuum vapor.

2. The thermal processing method according to claim 1, further comprising

c) cultivating the microorganism, and

wherein the step a) includes heating a liquid containing a microorganism cultivated in the step c).

3. The thermal processing method according to claim 2, wherein the step c) includes:

c-1) inoculating the microorganism into a medium and cultivating the microorganism inoculated into the medium; and

c-2) generating a concentrate liquid of the microorganism from the medium containing the

microorganism cultivated in the step c-1), and wherein the step a) includes heating the concentrate liquid.

4. The thermal processing method according to any one of claims 1 to 3, wherein the step a) includes:

a-1) when the temperature of a liquid containing the microorganism is an intermediate temperature lower than or equal to the sterilization temperature, heating the liquid containing the microorganism using vacuum vapor with a temperature that is higher than or equal to the intermediate temperature and is lower than or equal to the sterilization temperature; and

a-2) when the temperature of the liquid containing the microorganism is a temperature that is higher than or equal to the intermediate temperature and is lower than or equal to the sterilization temperature, heating the liquid containing the microorganism using vacuum vapor with a temperature that is higher than or equal to the sterilization temperature.

5. The thermal processing method according to claim 4, wherein the intermediate temperature is a

temperature for generating aggregates in the liquid containing the microorganism.

6. The thermal processing method according to any one of claims 1 to 5, wherein the step a) and the step b) each includes adjusting a temperature of the vacuum vapor by changing a pressure of the vacuum vapor.

7. The thermal processing method according to any one of claims 1 to 6, wherein the step a) includes:

heating a liquid containing the microorganism using a jacket tank including a tank unit into which the liquid containing the microorganism is injected and a jacket unit having an inner space into which the vapor vacuum is supplied; and

reducing the pressure of the inner space to a pressure lower than an atmospheric pressure before supplying the vacuum vapor into the inner space.