

Transport method and transport apparatus for high-quality fresh milk in transport- and environment-critical conditions

TECHNICAL FIELD

The invention relates to a transport method for high-quality fresh milk in transport- and environment-critical conditions and to a transport apparatus for carrying out the method. The method comprises storing the high-quality fresh milk by filling a container which has an undivided volume of several cubic meters, preferably 20 cubic meters or more, a fresh milk temperature that is lowered with respect to an ambient temperature, preferably to 3.5 to 4°C, and a headspace in the container which is supplied with a gaseous fluid, preferably hygienically treated air. Furthermore, the method comprises transportation of the high-quality fresh milk by a transport means that is earthbound and transported by rail and road and/or is designed as a ship. Following transportation, the method provides for emptying of the high-quality fresh milk from the container.

The term “high-quality fresh milk” should be understood in the following to mean a standardized fresh milk that keeps for longer or an ESL (extended shelf life) milk having a pH of ≥ 6.65 and a fat content of 1.5/3 or 3.5%. This milk is such that it can withstand storage for at least 30 days or more at a storage temperature of at most 4°C and remain unaffected in terms of the microbiology and the chemical, physical and technological properties or respectively functionalities of ingredients of said milk, such as milk fat, milk protein and lactose.

PRIOR ART

Today, processed foodstuffs or raw products each having their own aspect of freshness are transported over vast distances from the country of manufacture or origin to the sales markets or respectively consumer countries. For example, products having a pH of ≤ 4.5 , such as fruits, concentrates, juices having an aspect of freshness, are delivered for example from Arab, Southern European or South American regions to the consumer regions of South-East Asia (SEA: inter alia, Indonesia,

Philippines, Singapore, Thailand, Vietnam), including China. Transportation takes place in hygienic tanks having an undivided volume of 20 cubic meters or more, the tanks preferably being elongate and capable of being transported horizontally. The transportability, which encompasses actual transportation as well as the loading and
5 reloading procedures, is preferably achieved by designing the transport means in the form of a tank container. A tank container of this kind has a frame structure in which a receptacle, referred to as container in the following, is fastened.

A hygienic tank, which must be designed as a so-called sterile tank in the case of
10 very high standards of quality, should be understood to mean a container that has all necessary functions and monitoring systems that are usually required such that, during handling of the container, any reinfection of the product transported on account of spread of germs from the container and/or its surroundings to the product with the result of microbiological decay of the product is excluded. In addition to
15 sufficient cleaning of the interior of the container, critical areas include a manhole, valve devices for filling and emptying, sampling devices, safety and cleaning apparatuses, and measuring and monitoring apparatuses, which must also be cleaned and sterilized sufficiently prior to the container being filled with the product.

20 On account of changing consumer wishes and demands (purchasing behavior), it has become necessary to deliver high-quality fresh milk (see specification above) from New Zealand, Australia or Europe to the SEA regions, including China. This delivery occurred and occurs in packaged 1-liter cartons by airplane, incurring corresponding transportation costs and producing corresponding environmental im-
25 pacts.

There is therefore the urgent desire to transport said high-quality fresh milk over long distances in containers containing 20 m³ or more in sterile and cost-effective conditions, preferably by ship transport means, which, however, also entails corre-
30 spondingly long transport and storage times (3 to 4 weeks). The high-quality fresh milk available in large volumes can then be poured into consumer-friendly cartons and placed on the market in the target region. If this is done successfully, it opens up other advantageous opportunities in the target region, specifically further processing of the high-quality fresh milk into fresh yogurt or fresh dairy drinks.

However, the transportation of sensitive raw materials such as high-quality fresh milk having a $\text{pH} \geq 6.65$ in a hygienic tank using existing technologies, methods and devices over a transport time of 30 days or more has so far proven to be unsuccessful. The degree of reinfection cannot be reduced to the absolutely required level in a hygienic tank using existing handling methods that include careful use of and treatment with sterilizing fluids during filling, transportation and emptying such that after a transport time of 30 days or more (≥ 30 days) at a temperature of 4°C no product defects with regard to the microbiological and physical properties of the high-quality fresh milk (fat-protein structure) are produced.

As it stands, no storing has been successful, even in satisfactory, complex hygienic conditions, with the headspace of the container being supplied with air. The only current control procedure is to reduce the temperature and keep it constant in order to maintain the microbiological stability of the high-quality fresh milk. No other control procedures are used during transportation or respectively throughout the entire storage time in the container in order to counteract multi-phase separation of the high-quality fresh milk, namely cream (fat) in the uppermost layer, fat-containing milk thereunder and a low-fat layer in the lower region. Further lowering of the temperature below the above-mentioned approx. 4°C in order to inhibit formation of psychrophilic germs is not currently possible, since the fat in the milk would crystallize in connection with the significant creaming or sedimentation of fat that occurs. Subsequent stirring, mixing and stabilization of the fat phase in the milk would then be impossible without making significant and unacceptable sensory changes to the high-quality fresh milk.

The challenge associated with this is that the standardized fresh milk or ESL milk must withstand transportation for at least 30 days or more at a storage temperature of at most 4°C and remain unaffected in terms of the microbiology and the chemical, physical and technological properties or respectively functionalities of ingredients of said milk, such as milk fat, milk protein and lactose. Furthermore, to exacerbate this, a long storage time at high temperatures and/or interruption of the cold chain with the result of microbiological changes must be accepted as a worst-case scenario before further processing the high-quality fresh milk. Moreover, in the case of

transportation by ship, transport times and transport stresses arising in connection with earthbound transport means over land or rail to the ship and from the ship to the processing plants must also be considered.

- 5 The introductory description of **WO 2014/040 700 A1** discusses transportation of some basic materials for foodstuffs such as the basic material for fresh and largely untreated orange juice and the associated germ load in large-volume tank containers. The manhole, sampling apparatuses and a valve device for the receptacle are identified as weak points in these tank containers. The known subject matter is re-
- 10 stricted to the design of the valve device. The document gives no further indications of method features for minimizing effects on the transported product resulting from transport- and environment-critical transport and storage conditions.

Transport conditions include transport stresses on the high-quality fresh milk stored

15 in the container caused by the earthbound transport means and in particular by the ship transport means, which, on account of its substantial degrees of freedom of movement, has the broadest load spectrum for the container and thus also for the stored and transported high-quality fresh milk. In the drawings,

20 **Fig. 1, 2, 2a,**

3 and **3a** are schematic views of the possible forms of movement known per se for the transport means primarily used.

Fig. 1 shows the possible forms of movement of a transport means TM in the form

25 of a ship TM2 (**Fig. 3**) in relation to the spatial axes x, y and z of a geometric reference system BS on a schematically shown, elongate, horizontal container 10, which has an undivided volume V of several cubic meters and which forms a headspace 10.1 after being filled with a high-quality fresh milk P, which headspace is supplied with a gaseous fluid F*, preferably air. The spatial axes x, y and z are intended to

30 coincide with the main axes of the container 10, i.e., a first main axis Lx, a second Ly and a third Lz. The high-quality fresh milk P forms a free surface N to the headspace 10.1.

Depending on how the horizontal container 10 is mounted in the ship TM2, the first main axis Lx may be arranged in the direction of a direction of travel FR or transversely to said direction of travel FR. The possible forms of ship movement shown are produced in relation to the direction of travel FR aligned with the first main axis

5 Lx:

- rotational, reciprocating movements RO
(rolling about the first main axis Lx);
- rotational, reciprocating movements ST
(pitching about the second main axis Ly)

- 10
- rotational, reciprocating movements GI
(yawing about the third main axis Lz);
 - translational, reciprocating movements WO
(surging in the direction of the first main axis Lx);

- translational, reciprocating movements SW
(swaying in the direction of the second main axis L_y);
 - translational, reciprocating movements TA
(heaving in the direction of the third main axis L_z);
- 5 • translational movement SL
(slamming in the direction of the positive first main axis L_x).

The above-mentioned forms of movement can almost all be applied more or less fully to an earthbound transport means TM1 in the form of a truck (tanker), the first
 10 main axis L_x of the preferably horizontal container 10 being oriented in the direction of travel FR (**Fig. 2**). The container 10, arranged in a transport apparatus 1* (**Fig. 2, 2a, 3, 3a**), may, irrespective of the transport means TM1, TM2, have a circular 10a, elliptical 10b or suitcase 10c receptacle shape (**Fig. 2a**). A fresh milk temperature T is kept constant at a temperature lowered with respect to the ambient temperature
 15 generally prior to filling of the container 10 with the high-quality fresh milk P by means of a cooling apparatus 40*. This process of keeping the temperature constant is assisted by means of insulation 10d of the container 10. A filling and emptying apparatus 30* comprising valve devices and associated pipe systems that are known per se is provided for filling and emptying the container 10. Furthermore, the
 20 container 10 has a temperature measuring apparatus 14 for detecting the fresh milk temperature T and a fill level measuring apparatus 12 having a first measuring probe L1 for detecting the fill level of the high-quality fresh milk P in the container 10.

The quantities of the high-quality fresh milk P stored and transported in the container
 25 10 that move in a reciprocating manner in the direction of the longitudinal axis of the container 10, the first main axis L_x (**Fig. 2, 2a, 3, 3a**), are particularly critical to said fresh milk if the transport time, in the ship TM2 in particular, lasts three to four weeks or more and if rough sea conditions prevail. This displacement of the moving quantities, also referred to as sloshing movements, cause the free surface N to relocate and change. This relocation and change is also accompanied by a corresponding
 30 relocation and change of the fat layer, cream layer RA, adjoining the free surface N. The contact surface of the fat layer on the inner wall of the container 10 changes constantly and in a quantitatively substantial manner.

The sloshing movements of the free surface N are particularly pronounced and have a particularly large impact if said free surface shifts relative to the selected reference system BS by an angle designated as an angle of inclination $\pm\alpha$ in **Fig. 2** and **3**. These sloshing movements arise in particular when there is pitching ST in the case of the direction of travel FR oriented in the direction of the first main axis Lx or when there is rolling RO in the case of a direction of travel FR oriented in the direction of the second main axis Ly.

Proceeding from the above-mentioned prior art, the object of the present invention is to provide a transport method of the generic type and a transport apparatus of the generic type for carrying out the transport method that ensure minimization of the creaming in conjunction with a reduction in the adherence of the cream to the inner walls of the container in question and that prevent, as far as possible, separation of the high-quality fresh milk while also stabilizing the microbiology during transportation.

SUMMARY OF THE INVENTION

This object is achieved by a transport method having the features of independent claim 1 and 10. Advantageous embodiments of the transport method according to the invention are the subject matter of the associated dependent claims. A transport apparatus for carrying out the transport method is the subject matter of independent claim 12. Advantageous embodiments of the transport apparatus according to the invention are described in the associated dependent claims. A system having a transport apparatus is the subject matter of claim 21.

In terms of the method, the invention proceeds from a transport method known per se that comprises the following features under normal transport and environmental conditions (duration, ambient temperatures, force-related stresses on the transported high-quality fresh milk P):

- storage of the high-quality fresh milk
 - by filling a container that has an undivided volume of several cubic meters and that meets the specification of a hygienic container,

- at a fresh milk temperature that is lowered with respect to an ambient temperature,
 - with a headspace in the container that is supplied with a gaseous fluid, preferably hygienically treated air;
- 5 • transportation of the high-quality fresh milk using a transport means that is designed as an earthbound transport means and/or as a ship;
- emptying the high-quality fresh milk from the container.

10 The object of the invention is achieved if the following steps are provided in the method of the generic type:

- (A) filling the container with the high-quality fresh milk under sterile conditions and, within a storage time that comprises a period of time from after filling to emptying of the container,
- 15 (B) detecting an angle of inclination that is formed between a free surface of the high-quality fresh milk formed toward the headspace and a reference system based on the container;
- (C) detecting a pressure in the headspace;
- (D) increasing the pressure depending on and in proportion to the magnitude of the angle of inclination by feeding a gaseous, sterile fluid into the headspace
- 20 under sterile conditions and
- (E) emptying the high-quality fresh milk from the container under sterile conditions.

25 The basic concept of the invention initially proceeds from the factual circumstances surrounding transportation of a liquid, in the present case high-quality fresh milk, in a container of the above-described type moved over a relatively long period of time, as shown in a manner known per se in **Fig. 5, 5a to 5g** of the drawings. For this reason, the reference signs and abbreviations already introduced above with reference to the prior art as well as some designations of the invention that help to improve understanding will be used in the following description based on these figures.

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In the drawings,

Fig. 5a to 5g are schematic representations of the shape of the free surface of the high-quality fresh milk during inclination of the container or

during sloshing movements of the high-quality fresh milk within a horizontally oriented container.

In a stationary, horizontally oriented container 10 (**Fig. 5, 5a**; circular or elliptical or suitcase-shaped cross-section) having the headspace 10.1, which is supplied with a gaseous, sterile fluid F, or in the case of smooth advancement of said container 10, a maximum possible free surface N of the high-quality fresh milk P forms, above which the gaseous, sterile fluid F fills the correspondingly geometrically formed headspace 10.1. The thickness of the unavoidable cream layer RA is thus minimized. The adhesion surface of the cream (fat) on the inner wall of the container 10 is substantially formed as a thin, elongate rectangular surface that extends circumferentially over the lateral surface and the end surfaces of the container 10. The possibility of the fat adhering to the readily available inner wall of the container 10 is thus limited.

In the moved container 10 filled with liquid and having the headspace 10.1 supplied with the gaseous, sterile fluid, on account of pitching ST or rolling of the ship TM2 or on account of positive and negative acceleration and/or turning maneuvers of the earthbound transport means TM1, the container 10 tilts in the direction of the first main axis Lx thereof by the angle of inclination $\pm\alpha$ and therefore takes the reference system BS based on the container 10 along at the same time (**Fig. 5b to 5d**). Under the influence of gravity, the free surface N continues to align itself horizontally and thus forms the angle of inclination $\pm\alpha$ relative to the reference system BS. The high-quality fresh milk P located under said free surface moves, depending on the magnitude of the angle of inclination $\pm\alpha$, in alternating manner into one or the other corner region of the interior of the container 10, said relevant corner region being flooded either fully or in part. In the presence of a conventionally dimensioned headspace 10.1, the correspondingly inclined free surface N has a smaller areal extent than when the container 10 is oriented horizontally.

This fact is demonstrated in an approximately quantitative manner in **Fig. 5f, 5g** in conjunction with **Fig. 5, 5a** on the one hand and **Fig. 5c, 5d** on the other. When the container 10 is oriented horizontally (**Fig. 5, 5a**), a rectangular surface is produced as the free surface N, formed of a double equivalent area A1 and a double

differential area ΔA . The sum of the two areas A_1 and ΔA results from a dimension of a first chord s_1 formed in circular cross-section on account of the fill level and approximately from a longitudinal dimension of the container 10 (**Fig. 5a, 5g**). In the presence of the angle of inclination $\pm\alpha$ (**Fig. 5c**), the free surface N assumes the shape of a triangle, of which only half can be seen in **Fig. 5f**. This half triangle surface has the size of the equivalent area A_1 . It in turn results from a dimension of a second chord s_2 formed in circular cross-section on account of the fill level and approximately from the longitudinal dimension of the container 10 (**Fig. 5d, 5g**). The difference between the free surface N in the case of a horizontal orientation of the container 10 and that in the case of an angle of inclination $\pm\alpha$ therefore equals the double differential area ΔA .

The cream layer RA must rearrange itself accordingly and is forced to form a thicker layer in the inclined position. Moreover, the high-quality fresh milk sloshes together with said thicker cream layer RA into the assigned corner region of the container 10, where it finds a corresponding, amassed, extensive inner wall surface to adhere to. Clusters form in these corner regions as well as amassed accumulations or respectively sedimentation similar to solid deposits in narrow bottle necks in liquid-solid mixtures.

Comparable situations arise under the influence of sloshing movements of the high-quality fresh milk P in the direction of the first main axis L_x about an angle of inclination $\pm\alpha$ relative to a horizontally oriented container 10 and corresponding position of the reference system BS (**Fig. 5e**).

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Mechanism and justification for the inventive features

The basic concept of the invention and the related inventive features can be further justified by the physical mechanism outlined below. Subsequently, an approximate numerical estimation will be carried out in relation to this mechanism.

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The high-quality fresh milk P contains air if the gaseous, sterile fluid F is correspondingly treated and supplied air. Said air is present in the milk in a more or less fine-bubble form, distributed throughout the entire high-quality fresh milk P and caused

in particular by the usual homogenization process with the aim of a fine-particulate fat distribution in the high-quality fresh milk P.

5 These air bubbles, the density of which is negligible in relation to a density ρ of the high-quality fresh milk P in a first approximation, can more or less be considered to be spheres having a sphere diameter d , a sphere cross-sectional area $A_s = d^2\pi/4$ resulting therefrom and a sphere volume $V_s = d^3\pi/6$. The air bubbles are subjected to buoyancy forces F_B in the Earth's gravitational field (gravitational acceleration g) in the more or less viscous high-quality fresh milk P (dynamic viscosity $\eta = f(T)$) that
10 is dependent on the fresh milk temperature T , which buoyancy forces are counter-acted by frictional forces F_F from the high-quality fresh milk P during the inherent buoyancy movement.

15 The air bubbles act as so-called crystallization seeds for fat particles, such that flotation-like transportation of these fat particles counter to the gravitational force takes place on account of the air bubbles. Said transportation is assisted further by the difference in density between the fat particles and the milk phase receiving same.

By increasing the pressure p in the headspace 10.1 in the manner according to the
20 invention, as a result of which the pressure in the high-quality fresh milk P located there below also increases accordingly, the air bubbles are constantly reduced in terms of the volume V_s thereof in accordance with the law of thermodynamics pV_s . As a result, the buoyancy force F_B acting on the reduced air bubble is reduced ($F_B \sim V_s \sim 1/p$). However, the frictional force F_F also becomes smaller, but not in the same
25 ratio as the buoyancy force F_B , since the frictional force F_F is dependent, inter alia, on the sphere cross-sectional area A_s , which is proportional to d^2 , and since the buoyancy force F_B is dependent, inter alia, on the sphere volume V_s , which is proportional to d^3 .

30 The frictional force F_F acting on the bubble is also substantially dependent on the dynamic viscosity η of the high-quality fresh milk P. The dynamic viscosity η is inversely proportional to the fresh milk temperature T ($\eta \sim 1/T$).

If the movement of the air bubble is substantially caused by buoyancy forces F_B , the velocity of the air bubble corresponds to the stationary buoyancy velocity v . Stokes' law applies in the region of the sluggish flow, as per equation (1), with

$$\zeta = 24/\text{Re} = 24 \eta/vd\rho \quad (1)$$

- 5 where ζ is the drag coefficient for the sphere surrounded by the flow of milk and according to equation (2) Re is the Reynolds number, with

$$\text{Re} = vd/v = vd\rho/\eta \quad (2)$$

From a force perspective, a resulting force is produced on the air bubble in accordance with equation (3), with

$$10 \quad \Delta F = F_A - F_R \quad (3)$$

Proceeding from the equilibrium for $\Delta F = 0$ and the above-mentioned calculation equations (1) to (3) and the following equations (4) to (8), with

$$F_A = V_K \Delta\rho g \quad (4)$$

$$F_R = \zeta A_K \frac{\rho}{2} v^2 \quad (5)$$

$$15 \quad p V_K = \text{const} \quad (6)$$

$$V_K = \frac{\pi}{6} d^3 \quad (7)$$

$$A_K = \frac{\pi}{4} d^2 \quad (8)$$

the stationary buoyancy velocity v is obtained according to equation (9), with

$$v = \text{KONST} \frac{1}{p^{2/3}} \frac{1}{\eta(T)} \quad (9)$$

- 20 The stationary buoyancy velocity v of the air bubbles and the fat particles bound thereto is therefore inversely proportional to the dynamic viscosity η ($\eta \sim 1/T$), which rises from approx. $\eta = 1.2$ cp to approx. $\eta = 1.6$ cp (cp: centipoise) within the context of lowering the temperature according to the invention and according to claim 2 from 3.5–4°C to 2–2.5°C. Furthermore, the stationary buoyancy velocity v is inversely
- 25 proportional to the pressure p in the headspace of the container, which can rise to 1.4 bar excess pressure in the configuration according to the invention. The two physical variables of pressure p and dynamic viscosity η or respectively fresh milk temperature T have, in the magnitude thereof according to the invention, approximately the same reductive effect on the buoyancy velocity v of the air bubbles and
- 30 thus the fat particles.

Concerning the claims of the invention

An essential feature is the handling of the high-quality fresh milk during filling and emptying of the container under sterile conditions. These measures include all critical regions of the container, as already described above. Other significant features are detecting the angle of inclination of the free surface in relation to the reference system and detecting the pressure in the headspace. The above-described situations with regard to the formation of the free surface, to the thickness of the cream layer that depends on this and to the influence of the pressure on the buoyancy velocity of the air bubbles or respectively fat particles serve as justification for these measures. The pressure is thereupon increased depending on and in proportion to the magnitude of the angle of inclination by feeding in a gaseous, sterile fluid, said measure also being carried out under sterile conditions.

The buoyancy velocity of the fat particles and thus the extent of creaming are significantly reduced if the transport method according to step (G) lowers the fresh milk temperature from 3.5°C–4°C to 2°C–2.5°C during a final time stage of the storage time. It has proven particularly expedient if the final time stage corresponds to one third of the storage time.

With regard to the dependency according to the invention between the angle of inclination and the pressure, the transport method is advantageously conceived such that an angle of inclination range and a permissible pressure range are predefined. The angle of inclination range is formed in each case between a maximum negative angle of inclination and a maximum positive angle of inclination for the angle of inclination. The angle of inclination range may be +/- 5 degrees depending on the sea conditions and the relevant dimensions of the ship, and in extreme situations may be even more.

The permissible pressure range moves between a minimum pressure, which may at least correspond to atmospheric pressure, and a permissible maximum pressure, which is limited by the strength design of the container and is measured at up to 1.4 bar excess pressure according to one proposal. In the simplest case, a correlation is provided between the angle of inclination range and the pressure range, i.e., the maximum pressure is assigned the magnitude of the maximum positive or respectively maximum negative angle of inclination.

In order not to once again increase the volume of the air bubbles, reduced by means of the pressure increase according to the invention, after the tilting movements have subsided by reducing the pressure and therefore in order not to increase the buoyancy velocity of the air bubbles or the resulting creaming velocity either, according to the transport method, the pressure only follows the temporal progression of the magnitude of the detected angle of inclination if a subsequent magnitude of the detected angle of inclination is equal to or greater than a previous magnitude. The previous magnitude is not the immediately preceding magnitude, but rather is any magnitude that has arisen over the course of the elapsed transport time.

The reference system for determining the angle of inclination is preferably an orthogonal triaxial reference system consisting of an x, y and z axis. The inclination of the free surface is measured in each case in a plane spanned by the x and z axis and in a plane spanned by the y and z axis. The relevant angle of inclination is determined from these two orthogonal measurement values. It has proven expedient if the orthogonal triaxial reference system is formed of a first main axis of the container in the x direction, a second main axis of the container in the y direction and a third main axis of the container in the z direction. According to another proposal, the determination of the critical tilting movements is simplified if either the first main axis or the second main axis is oriented in a direction of travel of the transport means.

A simplified embodiment of the transport method according to the invention is achieved if step (B) is omitted from the above-described transport method and step (D) is modified according to a step (D1). According to this step, this modification consists in the following:

(D1) increasing the pressure by feeding a gaseous, sterile fluid into the head-space under sterile conditions.

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The pressure may correspond to the maximum pressure, which is determined by the strength design of the container.

According to another proposal, a sloshing movement of the high-quality fresh milk in the resting, horizontally oriented container is identified if a fill level measuring apparatus for detecting the fill level of the high-quality fresh milk in the container is designed to have two measuring probes which are immersed in the free surface at
 5 a distance from one another and which quantitatively determine a corresponding change in position of the free surface in conjunction with a correspondingly configured control system by means of the differing degree to which they are wetted.

A transport device according to the invention for carrying out the transport method
 10 according to the invention comprises the following features known per se:

- A container, which has an undivided volume of several cubic meters for storing the high-quality fresh milk. The undivided volume also duly undergoes sufficient cleaning under sterile conditions.
- A filling and emptying apparatus for filling the container with and for emptying
 15 the high-quality fresh milk from the container.
- A headspace in the container, which is supplied with a gaseous fluid.
- A temperature measuring apparatus for detecting a fresh milk temperature in the container.
- A fill level measuring apparatus having a first measuring probe.
- 20 • A cooling apparatus, which at least keeps the fresh milk temperature, lowered with respect to an ambient temperature, constant. The temperature is expediently lowered to the fresh milk temperature prior to filling of the container.
- A transport means for transporting the container in the form of an earthbound transport means and/or a ship.

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Proceeding from the generic transport apparatus, the object of the invention in terms of the device is achieved by

- the container, which, in conjunction with the filling and emptying apparatus, is designed to treat the high-quality fresh milk in a comprehensive and sterile manner;
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- a first apparatus having at least one inclinometer for detecting an angle of inclination that is formed between a free surface of the high-quality fresh milk formed toward the headspace and a reference system based on the container;

- a second apparatus for detecting a pressure in the headspace;
- a third apparatus for feeding a gaseous, sterile fluid into the headspace under sterile conditions;
- a control apparatus, which controls the increase of the pressure depending on
5 and in proportion to the magnitude of the angle of inclination by feeding a gaseous, sterile fluid into the headspace.

The control apparatus has a data memory in which an angle of inclination range, which comprises a maximum negative angle of inclination and a maximum positive
10 angle of inclination, is stored. A permissible pressure range comprising a minimum pressure and a maximum pressure is also stored therein. The permissible pressure range correlates with the magnitude of the angle of inclination range during the provided control of the pressure depending on the respectively measured angle of inclination. The minimum pressure may start at atmospheric pressure; but it may also
15 be set at a higher pressure. The maximum pressure is determined by the strength design of the container, which also takes account of economic factors.

Reliable detection of the relevant angle of inclination that is spatially oriented in the most general case is achieved if two inclinometers are provided in the reference
20 system, which is preferably an orthogonal triaxial reference system having an x, y and z axis. The first inclinometer measures the inclination of the free surface in a first plane spanned by the x and z axis and a second inclinometer measures the inclination of the free surface in a second plane spanned by the y and z axis. The pertinent angle of inclination is determined from these two orthogonal measurement
25 values.

The orthogonal reference system is expediently oriented such that it is formed of a first main axis of the container in the x direction, a second main axis of the container in the y direction and a third main axis of the container in the z direction. The deter-
30 mination of the critical tilting movements of the container is simplified if either the first main axis or the second main axis is oriented in a direction of travel of the transport means.

The arrangement of the container preferably within a tank container produces an elongate, horizontal design of the container, the x axis of the reference system being oriented in the longitudinal direction of the container, i.e., in line with the first main axis.

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For reasons of economy and cost optimization, the container has an undivided volume of 20 m³ or more, the volume generally being limited within the scope of a design of a tank container by means of the standardized construction size thereof.

- 10 In order to identify and determine sloshing movements of the high-quality fresh milk inside a horizontally arranged and/or immobile container, the fill level measuring apparatus provided on the container has a second measuring probe. The first and the second measuring probe are arranged at a distance from one another and engage with the free surface of the high-quality fresh milk via the headspace, it being
- 15 possible to evaluate differing measurement results obtained at the two measuring probes in a productive manner.

- Supplying the headspace of the container with the gaseous, sterile fluid during transportation is simplified significantly in terms of equipment if a buffer receptacle having
- 20 a buffer volume matched to the size of the headspace is provided, which buffer receptacle is optionally connected to the headspace and in which the gaseous, sterile fluid is stored at an excess pressure. Said excess pressure is measured such that it ensures provision of the maximum pressure in the headspace of the container throughout the entire storage time.

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In order to ensure a sufficient sterile connection to supply and disposal systems and sterile handling of the transport apparatus during filling and emptying of the container, according to the invention, a filling and emptying platform is provided which forms a system in conjunction with the transport apparatus such that

- 30 • the filling and emptying platform comprises the following functional apparatuses:
- a fourth apparatus for providing cleaning agent,
 - filling and emptying lines,
 - a fifth apparatus for providing coolant and
 - a sixth apparatus for providing gaseous, sterile fluid,

and such that, via an intersection and coupling point,

- the fourth apparatus is connected to the cleaning agent ports of the transport apparatus,
- the filling and emptying lines are connected to the filling and emptying apparatus
- 5 of the transport apparatus,
- the fifth apparatus is connected to the cooling apparatus of the transport apparatus, and
- the sixth apparatus is connected to the third apparatus of the transport apparatus.

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BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed representation of the invention is given by the following description

15 and the other appended figures of the drawings as well as the claims. While the invention is implemented in the wide range of embodiments of a transport method of the generic type and the wide range of embodiments of a transport apparatus of the generic type for carrying out the transport method, a preferred exemplary embodiment of the transport method according to the invention and of the transport

20 apparatus according to the invention is described below with reference to the drawings. In the drawings,

Fig. 4 is a schematic representation of a transport apparatus according to the invention in a possible arrangement thereof on the ship transport

25 means;

Fig. 6 is a block diagram of the transport method according to the invention;

Fig. 6a is a block diagram of the transport method according to the invention according to **Fig. 6**, supplemented by an additional method step (G);

Fig. 7 is a schematic representation of a transport apparatus according to the invention for carrying out the transport methods according to **Fig. 6** or

30 **Fig. 6a** in conjunction with a filling and emptying platform according to the invention;

Fig. 8 shows an exemplarily assumed temporal progression of an angle of inclination over an entire storage time, which includes a transport time,

as well as an exemplarily assumed temporal progression of a fresh milk temperature according to the invention extending over the entire storage time; and

5 **Fig. 9** shows an exemplarily assumed temporal progression of a pressure in the headspace of the container over an entire storage time in correlation with the temporal progression of the angle of inclination according to **Fig. 8**.

10 In order to avoid repetitions, the following description of **Fig. 4, 6a, 6b** and **7 to 9** shall use the reference signs and abbreviations used in the description of **Fig. 1 to 3, 5, 5a to 5g** above. The same applies with regard to the situations already described above.

15 A second apparatus 16 for detecting a pressure p of a gaseous, sterile fluid F that supplies the headspace 10.1 is arranged on the headspace 10.1 of the container 10, having the undivided volume V , of a transport apparatus 1 according to the invention (**Fig. 4**). The fill level measuring apparatus 12 has a second measuring probe $L2$ in addition to the first measuring probe $L1$, the first and the second measuring probe $L1, L2$ being arranged at a distance from one another and engaging
20 with the free surface N of the high-quality fresh milk P via the headspace 10.1.

The reference system BS is conceived as an orthogonal triaxial reference system BS_{x-y-z} , consisting of the x, y and z axis. An associated inclination of the free surface N is measured in each case in a plane E_{x-z} spanned by the x and z axis and in a
25 plane E_{y-z} spanned by the y and z axis. The relevant spatial angle of inclination $\pm a$ is determined from these angles of inclination $\pm a$ associated with the relevant plane, i.e., two orthogonally obtained measurement values.

30 The orthogonal triaxial reference system BS_{x-y-z} is formed of the first main axis L_x of the container 10 oriented in the x direction, the second main axis L_y of the container 10 oriented in the y direction and the third main axis L_z of the container 10 oriented in the z direction. Preferably, either the first main axis L_x or the second main axis L_y is oriented in the direction of travel FR of the transport means TM or respectively

TM1, TM2. Furthermore, the container 10 is designed to be elongate in the x direction and is arranged horizontally in this direction.

The transport method according to the invention according to claim 1 (**Fig. 6**) comprises the steps (A) to (D), step (E) of emptying the high-quality fresh milk P from the container 10 following step (D) if no further subsequent or simultaneous measure is carried out. After filling of the container 10 with the high-quality fresh milk P according to step (A), and prior to the step (E), the storage time Δt is recorded in the direction of a time t. According to step (B), the angle of inclination $\pm a$ is determined in the first apparatus 60 and, if necessary, sloshing movements of the free surface N are determined at the same time in the fill level measuring apparatus 12 using the first and the second measuring probe L1, L2. According to step (C), the pressure p in the headspace 10.1 is detected in the second apparatus 16, which pressure is then increased according to step (D) depending on and in proportion to the magnitude $|a|$ of the angle of inclination $\pm a$ ($p = f(|a|)$) by feeding the gaseous, sterile fluid F into the headspace 10.1.

The transport method according to the invention according to claim 2 (**Fig. 6a**) differs from that according to claim 1 (**Fig. 6**) in that, according to step (G), the fresh milk temperature T prevailing after filling is lowered by a targeted temperature difference by means of a cooling apparatus 40 and then kept at this level during a final time stage Δt_x of the storage time Δt in order to prevent possible psychrophilic germ growth. Lowering the temperature from 3.5°C–4°C to 2°C–2.5°C has proven particularly desirable with regard to maintaining the fat-protein structure. Step (G) is temporally parallel with the steps (B) to (D).

In **Fig. 7**, the container 10 is once again in exactly the same state as described in relation to **Fig. 4**. The container has the undivided volume V of several cubic meters for storing the high-quality fresh milk P. The temperature measuring apparatus 14 for detecting the fresh milk temperature T is provided in the container 10. Furthermore, the container 10 comprises the cooling apparatus 40, which at least keeps the fresh milk temperature T, lowered with respect to an ambient temperature, constant. For this purpose, a heat exchanger 42, which can be supplied with a coolant K via a third and a fourth valve apparatus 44, 46 and a second line system 48, is

preferably located in the base region of the container 10. The high-quality fresh milk P can be cooled prior to filling, preferably outside the transport apparatus 1, for example via a fifth apparatus 240 that is provided in a filling and emptying platform 200 and that comprises a coolant receptacle 242 containing the coolant K, a coolant pump 244 and coolant lines 246. The cooling apparatus 40 is connected via the coolant lines 246 thereof to the associated second line system 48 via detachable connection points k7, k8 at an intersection and coupling point S between the filling and emptying platform 200 and the transport apparatus 1. During transportation, the fresh milk temperature T can be connected to the above-described cooling apparatus 40 via a cooling apparatus (not shown) operated autonomously within the transport apparatus 1.

The container 10, in conjunction with a filling and emptying apparatus 30, is designed to treat the high-quality fresh milk P in a comprehensive and sterile manner. The filling and emptying apparatus 30 has a first and a second valve apparatus 32, 34, which are connected to an associated filling and emptying line 230 in the filling and emptying platform 200 via a first line system 36 and associated detachable connection points k5, k6 at the intersection and coupling point S. The high-quality fresh milk P is fed via the filling and emptying line 230 initially to the filling and emptying platform 200 and from there to the transport apparatus 1.

The transport apparatus 1 further comprises a first apparatus 60 having at least one first inclinometer 62 for detecting an angle of inclination $\pm\alpha$ formed between the free surface N of the high-quality fresh milk P formed toward the headspace 10.1 and a reference system BS based on the container 10. In a preferred embodiment, a second inclinometer 64 is provided in the reference system BS, which is preferably an orthogonal triaxial reference system BS_{x-y-z} consisting of an x, y and z axis. The first inclinometer 62 measures the inclination of the free surface N in the first plane E_{x-z} spanned by the x and z axis. The second inclinometer 64 measures the inclination of the free surface N in a second plane E_{y-z} spanned by the y and z axis. A control apparatus 70 determines the relevant angle of inclination $\pm\alpha$ from the two orthogonal measurement values of the first and the second inclinometer 62, 64.

A third apparatus 50 for feeding the gaseous, sterile fluid F into the headspace 10.1 under sterile conditions is further provided in the transport apparatus 1, the third apparatus 50 having a buffer receptacle 52, a fifth and sixth valve apparatus 54, 56 as well as an associated third line system 58. The third line system 58 is connected
 5 via detachable connection points k1, k2 at the intersection and coupling point S to a sixth apparatus 250 for providing the gaseous, sterile fluid F by means of the filling and emptying platform 200. The buffer receptacle 52, which is expediently dimensioned so as to have a buffer volume matched to the size of the headspace 10.1, is optionally connected to the headspace 10.1, the gaseous, sterile fluid F preferably
 10 being stored in the buffer receptacle 52 at an excess pressure of 4 bar.

In order to create sterile inner regions of the container 10 and sterile conditions in all apparatuses of the transport apparatus 1 connected to said inner regions, a fourth apparatus 210 for providing required cleaning agents RM (water, acid, lye, steam
 15 and gaseous, sterile fluids) is provided in the filling and emptying platform 200. The fourth apparatus 210 is connected to a first, a second and a third cleaning agent port a, b, c of the transport apparatus 1 via detachable connection points k3, k4 at the intersection and coupling point S of the filling and emptying platform 200. The third apparatus 50 is cleaned up to and beyond the point at which it transitions into
 20 the headspace 10.1 via the first cleaning agent port a in the region of the valve apparatuses 54, 56. The filling and emptying apparatus 30 is cleaned, also up to and beyond the point at which it transitions into the container 10, via the second cleaning agent port b in the region of the valve apparatuses 32, 34. The entire interior of the container 10 is supplied with cleaning agent RM via a cleaning agent
 25 distribution system (not shown), for example several spray balls, of which one is indicated schematically, via the third cleaning agent port c.

The control apparatus 70 controls, inter alia, an increase of the pressure p depending on and in proportion to the magnitude of the angle of inclination $\pm\alpha$ by feeding
 30 a gaseous, sterile fluid F into the headspace 10.1. The control apparatus 70 has a data memory 72 in which an angle of inclination range $\pm\Delta\alpha_{\max}$ between a maximum negative angle of inclination $-\alpha_{\max}$ and a maximum positive angle of inclination $+\alpha_{\max}$ for the angle of inclination $\pm\alpha$ is stored. Furthermore, a permissible pressure range Δp between a minimum pressure $p_{\min}$ and a maximum pressure $p_{\max}$ for the pressure

p is stored therein. The control apparatus 70 is configured to correlate the permissible pressure range Δp with the magnitude of the angle of inclination range $\pm \Delta a_{\max}$.

The control apparatus 70, in conjunction with the data memory 72 thereof, is further
 5 set to process measurement values of the fresh milk temperature T and the detected fill levels in the container 10 and to control actuators for the supply of the gaseous, sterile fluid F and the cooling apparatus 40.

The fill level measuring apparatus 12 advantageously comprises the second measuring probe L2, the first and the second measuring probe L1, L2 being arranged at
 10 a distance from one another and engaging with the free surface N of the high-quality fresh milk P via the headspace 10.1. On account of the differing degrees of wetting arising during sloshing movements of the high-quality fresh milk P, said sloshing movement can be detected and determined if a correspondingly set control system
 15 is provided.

The filling and emptying platform 200 forms a system 100 together with the transport apparatus 1 that, as a whole, ensures the filling and emptying of the container 10, cooling thereof, the supply of the gaseous, sterile fluid F to the buffer receptacle 52
 20 and from there to the container 10, and the cleaning and sterilization of the entire transport apparatus 1, in each case constantly and entirely under sterile conditions.

In **Fig. 8**, a temporal progression ($|a| = f(t)$) of a magnitude $|a|$ of the angle of inclination $\pm a$ is postulated by way of example. Prominent changes in the progression
 25 are marked on the abscissa, the time t, by times t1 to t9 within the storage time Δt . An assumed set of values for the magnitude $|a|$ of the angle of inclination on the left ordinate comprises the values 0 to $\pm a_{\max} = 5$ degrees, meaning that the magnitude of the angle of inclination range is $|\pm \Delta a_{\max}| = 5$ degrees. This constitutes a wholly realistic range which may also be wider in extreme situations. The fresh milk tem-
 30 perature T is plotted on the right ordinate with a set of values of from 0 to 5°C. During the final time stage Δt_x of the storage time Δt , for example at a point in time prior to the time t5, the fresh milk temperature T is lowered from 3.5°C–4°C (margin) to 2°C–2.5°C (margin).

Fig. 9 shows a temporal progression ($p = f(t)$) of the absolute pressure p (atmospheric pressure p_b plus the excess pressure) in the headspace 10.1 of the container 10 by way of example, the times t_1 to t_9 on the abscissa, the time axis t , covering the same range as in the diagram in **Fig. 8**. The relationship according to the invention between the pressure p and the magnitude of the angle of inclination $|a|$ is shown in an auxiliary diagram $p = f(|a|)$ on a right-hand edge of **Fig. 9**, which preferably consists in the permissible pressure range Δp correlating with the magnitude of the angle of inclination range $\pm \Delta a_{\max}$. The relationship between the independent angle of inclination $\pm a$ and the dependent pressure p is shown in **Fig. 8** and **9**. The definition according to the invention that the pressure p only follows the temporal progression of the magnitude of the detected angle of inclination $\pm a$ if a subsequent magnitude of the detected angle of inclination $\pm a$ is equal to or greater than a previous magnitude ($|a| = f(t)$) is further shown in **Fig. 8** and **9**. In the exemplary embodiment shown, the minimum pressure $p_{\min}$ corresponds to atmospheric pressure p_b and the maximum pressure $p_{\max}$ is 1.4 bar excess pressure, by way of example. The permissible pressure range $\Delta p = p_{\max} - p_{\min}$ is therefore 1.4 bar. The minimum pressure $p_{\min}$ may also be set higher at the start of the storage time Δt , for example at 0.4 to 0.6 bar excess pressure.

REFERENCE SIGN LIST OF THE ABBREVIATIONS USED

Fig. 1, 2, 2a, 3, 3a (relating to prior art)

	1*	Transport apparatus
5	10	Container
	10.1	Headspace
	10a	Circular receptacle shape
	10b	Elliptical receptacle shape
	10c	Suitcase receptacle shape
10	10d	Insulation
	12	Fill level measuring apparatus
	14	Temperature measuring apparatus
	30*	Filling and emptying apparatus
15	40*	Cooling apparatus
	BS	Reference system (geometric)
	F*	Gaseous fluid
	FR	Direction of travel
20	L1	First measuring probe
	Lx	First main axis
	Ly	Second main axis
	Lz	Third main axis
25	N	Free surface
	P	High-quality fresh milk
	RA	Cream layer
	T	Fresh milk temperature
30	TM	Transport means (general)
	TM1	Earthbound transport means
	TM2	Ship

V Undivided volume

Ship movements

5	GI	Yawing
	RO	Rolling
	SL	Slamming
	ST	Pitching
	SW	Swaying
10	TA	Heaving
	WO	Surging
	+/-a	Angle of inclination (measured against a reference axis)
15	X, y, z	Spatial axes

Physical variables for the numerical estimations

	A _s	Sphere cross-sectional area
20	F _B	Buoyancy force
	F _F	Friction force
	ΔF	Resulting force between buoyancy and friction force
	Re	Reynolds number
	V _s	Sphere volume
25	d	Sphere diameter
	g	Gravitational acceleration
	v	Buoyancy velocity
	ζ	Drag coefficient
	η	Dynamic viscosity
30	π	Ratio between circumference and diameter of the bubble
	ρ	Density of the liquid

Fig. 4 to 9 (invention)

	1	Transport apparatus
	100	System
5	16	Second apparatus (detection of pressure p)
	30	Filling and emptying apparatus
	32	First valve apparatus
	34	Second valve apparatus
10	36	First line system
	40	Cooling apparatus
	42	Heat exchanger
	44	Third valve apparatus
15	46	Fourth valve apparatus
	48	Second line system
	50	Third apparatus (supply and removal of fluid F)
	52	Buffer receptacle
20	54	Fifth valve apparatus
	56	Sixth valve apparatus
	58	Third line system
	60	First apparatus (detection of angle of inclination +/-a)
25	62	First inclinometer
	64	Second inclinometer
	70	Control apparatus
	72	Data memory
30		
	200	Filling and emptying platform
	210	Fourth apparatus (provision of cleaning agent RM)
	230	Filling and emptying line

	240	Fifth apparatus (provision of coolant)
	242	Coolant receptacle
	244	Coolant pump
5	246	Coolant lines
	250	Sixth apparatus (provision of gaseous, sterile fluid F)
	A1	Equivalent area
10	ΔA	Differential area
	BS _{x-y-z}	Orthogonal reference system
	E _{x-z}	x-z plane
15	E _{y-z}	y-z plane
	F	Gaseous, sterile fluid
	K	Coolant
	L2	Second measuring probe (of fill level measuring apparatus 12)
20	RM	Cleaning agent
	S	Intersection and coupling point
	a	First cleaning agent port
25	b	Second cleaning agent port
	c	Third cleaning agent port
	k1 to k8	Detachable connection points
30	p	Pressure (in headspace 10.1)
	p _{max}	Maximum pressure
	p _{min}	Minimum pressure
	Δp	Permissible pressure range ($\Delta p = p_{\max} - p_{\min}$)
	p _b	Atmospheric pressure

	s1	First chord
	s2	Second chord
5	t	Time, general
	t1 to t9	Times (sequence of times within storage time Δt)
	Δt	Storage time
	Δt_x	Final time stage
10	$\pm \Delta a_{\max}$	Angle of inclination range ($+\Delta a_{\max} = +a_{\max}$; $-\Delta a_{\max} = -a_{\max}$)
	$+a_{\max}$	Maximum positive angle of inclination
	$-a_{\max}$	Maximum negative angle of inclination
	$ a $	Magnitude of the angle of inclination $\pm a$

Claims

1. A transport method for high-quality fresh milk (P) in transport- and environment-critical transport conditions, comprising
 - storage of the high-quality fresh milk (P)
 - by filling a container (10) that has an undivided volume (V) of several cubic meters,
 - at a fresh milk temperature (T) that is lowered with respect to an ambient temperature,
 - with a headspace (10.1) in the container (10) that is supplied with a gaseous fluid (F*);
 - transportation of the high-quality fresh milk (P) using a transport means (TM) that is designed as an earthbound transport means (TM1) and/or as a ship (TM2);
 - emptying the high-quality fresh milk (P) from the container (10);

characterized by the following steps:

 - (A) filling the container (10) with the high-quality fresh milk (P) under sterile conditions and,
within a storage time (Δt) that comprises a period of time from after filling to emptying of the container (10),
 - (B) detecting an angle of inclination (+/-a) that is formed between a free surface (N) of the high-quality fresh milk (P) formed toward the headspace (10.1) and a reference system (BS) based on the container (10);
 - (C) detecting a pressure (p) in the headspace (10.1);
 - (D) increasing the pressure (p) depending on and in proportion to the magnitude of the angle of inclination (+/-a) by feeding a gaseous, sterile fluid (F) into the headspace (10.1) under sterile conditions and
 - (E) emptying the high-quality fresh milk (P) from the container (10) under sterile conditions.

2. The transport method according to claim 1,
characterized by the following step:
 (G) lowering the fresh milk temperature (T) during a final time stage (Δt_x) of
 the storage time (Δt) from 3.5°C–4°C to 2°C–2.5°C.
3. The transport method according to claim 2,
characterized
 in that the final stage (Δt_x) corresponds to one third of the storage time (Δt).
4. The transport method according to any one of claims 1 to 3,
characterized
 - by predefining an angle of inclination range ($\pm \Delta a_{\max}$), which is formed in
 each case between a maximum negative angle of inclination ($-a_{\max}$) and a
 maximum positive angle of inclination ($+a_{\max}$) for the angle of inclination ($\pm a$), and
 - by predefining a permissible pressure range (Δp) between a minimum pres-
 sure ($p_{\min}$) and a maximum pressure ($p_{\max}$) for the pressure (p) in the head-
 space (10.1),
 - the permissible pressure range (Δp) correlating with the magnitude of the
 angle of inclination range ($\pm \Delta a_{\max}$).
5. The transport method according to claim 4,
characterized
 in that the pressure range (Δp) extends to 1.4 bar excess pressure.
6. The transport method according to any one of claims 1 to 5,
characterized
 in that the pressure (p) only follows the temporal progression of the magnitude
 of the detected angle of inclination ($\pm a$) if a subsequent magnitude of the
 detected angle of inclination ($\pm a$) is equal to or greater than a previous mag-
 nitude.

7. The transport method according to any one of claims 1 to 6,
characterized
- in that the reference system (BS) is an orthogonal triaxial reference system (BS_{x-y-z}) consisting of an x, y and z axis,
 - 5 • in that the inclination of the free surface (N) is measured in each case in a plane (E_{x-z}) spanned by the x and z axis and in a plane (E_{y-z}) spanned by the y and z axis and
 - in that the angle of inclination (+/-a) is determined from these two orthogonal measurement values.
- 10
8. The transport method according to claim 7,
characterized
- in that the orthogonal triaxial reference system (BS_{x-y-z}) is formed of a first main axis (L_x) of the container (10) oriented in the x direction, a second main axis (L_y) of the container (10) oriented in the y direction and a third main axis (L_z) of the container (10) oriented in the z direction.
- 15
9. The transport method according to claim 8,
characterized
- 20 in that either the first main axis (L_x) or the second main axis (L_y) is oriented in a direction of travel (FR) of the transport means (TM; TM1, TM2).
10. The transport method for high-quality fresh milk (P) in transport- and environment-critical transport conditions, comprising
- 25
- storage of the high-quality fresh milk (P)
 - by filling a container (10) that has an undivided volume (V) of several cubic meters,
 - at a fresh milk temperature (T) that is lowered with respect to an ambient temperature,
 - 30 ○ with a headspace (10.1) in the container (10) that is supplied with a gaseous fluid (F*);
 - transportation of the high-quality fresh milk (P) using a transport means (TM) that is designed as an earthbound transport means (TM1) and/or as a ship (TM2);

- emptying the high-quality fresh milk (P) from the container (10);

characterized by the following steps:

- (A) filling the container (10) with the high-quality fresh milk (P) under sterile conditions and,
- 5 within a storage time (Δt) that comprises a period of time from after filling to emptying of the container (10),
- (C) detecting a pressure (p) in the headspace (10.1);
- (D1) increasing the pressure (p) by feeding a gaseous, sterile fluid (F) into the headspace (10.1) under sterile conditions and
- 10 (D) emptying the high-quality fresh milk (P) from the container (10) under sterile conditions.

11. The transport method according to any one of claims 1 to 10,
- characterized**
- 15 in that a fill level measuring apparatus (12) for detecting the fill level of the high-quality fresh milk (P) in the container (10) is designed to have two measuring probes (L1, L2) which are immersed in the free surface (N) at a distance from one another and which quantitatively determine a sloshing movement of the free surface (N) from the differing degree to which they are wetted.

20

12. The transport apparatus for high-quality fresh milk (P) in transport- and environment-critical transport conditions, comprising
- a container (10), which has an undivided volume (V) of several cubic meters for storing the high-quality fresh milk (P);
 - 25 • a filling and emptying apparatus (30*) for filling the container (10) with and for emptying the high-quality fresh milk (P) from the container (10);
 - a headspace (10.1) in the container (10) that is supplied with a gaseous fluid (F*),
 - a temperature measuring apparatus (14) for detecting a fresh milk temperature (T) in the container (10),
 - 30 • a fill level measuring apparatus (12) comprising a first measuring probe (L1),

- a cooling apparatus (40*), which at least keeps the fresh milk temperature (T), lowered with respect to an ambient temperature, constant,
- a transport means (TM) for transporting the container (10) in the form of an earthbound transport means (TM1) and/or a ship (TM2),

5 **characterized by**

- the container (10), which, in conjunction with a filling and emptying apparatus (30), is designed to treat the high-quality fresh milk (P) in a comprehensive and sterile manner;
- a first apparatus (60) having at least one inclinometer (62) for detecting an angle of inclination (+/-a) that is formed between a free surface (N) of the high-quality fresh milk (P) formed toward the headspace (10.1) and a reference system (BS) based on the container (10);
- a second apparatus (16) for detecting a pressure (p) in the headspace (10.1);
- a third apparatus (50) for feeding a gaseous, sterile fluid (F) into the headspace (10.1) under sterile conditions;
- a control apparatus (70), which controls an increase of the pressure (p) depending on and in proportion to the magnitude of the angle of inclination (+/-a) by feeding a gaseous, sterile fluid (F) into the headspace (10.1).

20

13. The transport apparatus according to claim 12,

characterized

in that the control apparatus (70) has a data memory (72) in which

- an angle of inclination range (+/- $\Delta a_{\max}$) between a maximum negative angle of inclination (- $a_{\max}$) and a maximum positive angle of inclination (+ $a_{\max}$) for the angle of inclination (+/-a) is stored,
- a permissible pressure range (Δp) between a minimum pressure ($p_{\min}$) and a maximum pressure ($p_{\max}$) for the pressure (p) is stored,
- the permissible pressure range (Δp) correlating with the magnitude of the angle of inclination range (+/- $\Delta a_{\max}$).

30

14. The transport apparatus according to claim 12 or 13,
characterized
- in that two inclinometers (62, 64) are provided in the reference system (BS), which is an orthogonal triaxial reference system (BS_{x-y-z}) consisting of an x, y and z axis,
 - in that the first inclinometer (62) measures the inclination of the free surface (N) in a first plane (E_{x-z}) spanned by the x and z axis and
 - in that a second inclinometer (64) measures the inclination of the free surface (N) in a second plane (E_{y-z}) spanned by the y and z axis and
 - in that the control apparatus (70) determines the angle of inclination (+/-a) from the two orthogonal measurement values of the first and the second inclinometer (62, 64).
15. The transport apparatus according to claim 14,
characterized
- in that the orthogonal triaxial reference system (BS_{x-y-z}) is formed of a first main axis (L_x) of the container (10) oriented in the x direction, a second main axis (L_y) of the container (10) oriented in the y direction and a third main axis (L_z) of the container (10) oriented in the z direction.
16. The transport apparatus according to claim 15,
characterized
- in that either the first main axis (L_x) or the second main axis (L_y) is oriented in a direction of travel (FR) of the transport means (TM; TM1, TM2).
17. The transport apparatus according to any one of claims 14 to 16,
characterized
- in that the container (10) is designed to be elongate in the x direction and is arranged horizontally in this direction.

18. The transport apparatus according to any one of claims 12 to 17,
characterized
 in that the volume (V) of the container (10) is equal to or greater than 20 m³
 (V ≥ 20 m³).
- 5
19. The transport apparatus according to any one of claims 12 to 18,
characterized
 in that the fill level measuring apparatus (12) comprises a second measuring
 probe (L2), the first and the second measuring probe (L1, L2) being arranged
 10 at a distance from one another and engaging with the free surface (N) of the
 high-quality fresh milk (P) via the headspace (10.1).
20. The transport apparatus according to any one of claims 12 to 19,
characterized
 15 in that a buffer receptacle (52) having a buffer volume matched to the size of
 the headspace (10.1) is provided, which buffer receptacle is optionally con-
 nected to the headspace (10.1) and in which the gaseous, sterile fluid (F) is
 stored at an excess pressure of 4 bar.
- 20 21. A system (100) having a transport apparatus (1) according to any one of claims
 12 to 20,
characterized
 • in that the system (100) has a filling and emptying platform (200),
 • in that the filling and emptying platform (200) comprises the following func-
 25 tional apparatuses (210, 230, 240, 250):
 • a fourth apparatus (210) for providing cleaning agents (RM),
 • filling and emptying lines (230),
 • a fifth apparatus (240) for providing coolant (K) and
 • a sixth apparatus (250) for providing gaseous, sterile fluid (F),
 30 and in that, via an intersection and coupling point (S),
 • the fourth apparatus (210) is connected to the cleaning agent ports (a, b,
 c),

- the filling and emptying lines (230) are connected to the filling and emptying apparatus (30),
- the fifth apparatus (240) is connected to the cooling apparatus (40) and
- the sixth apparatus (250) is connected to the third apparatus (50)