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(54) Title: METHOD FOR SMEAR-RIPENING OF CHEESE

(57) Abstract: This invention relates to a method for smear-ripening a cheese comprising: (a) applying an envelope on a freshly brined cheese which is in direct physical contact with the surface of the cheese and which is permeable for metabolites produced by microorganisms and for microorganisms themselves and for components of the cheese and for gaseous elements, in particular surrounding air; (b) ripening the cheese within the envelope and (c) removing the envelope and at least part of a smear. After step c) the cheese may be packaged. Moreover the invention relates to a cheese which is in particular obtainable by the method disclosed herein. Said cheese is less susceptible to develop an off-odour after storage in a packaging material, in particular an air-tight packaging material, than a comparable cheese that was not produced according to the inventive method. Furthermore, such cheese typically comprises a residual smear layer of not more than 10% of a comparable cheese.



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Method for smear-ripening of cheeseTechnical Field

5 The present invention relates to a method for producing a smear-ripened cheese and to a cheese obtainable or obtained by such method. In particular, the present invention relates to a method by which it is possible to remove part of the smear surface prior to packaging.

10

Background Art

Smear-ripened cheeses are characterized by a complex microflora, which develops on the surface during ripening. The development of the microflora contributes to a red-orange pigmented surface.

15 Methods for smear-ripening a cheese are known in the art. According to a conventional process for providing a smear-ripened cheese, a freshly brined cheese block is frequently brushed (smeared) with a smear liquid. Such a process is either labour-intensive in case of manual brushing or capital-intensive in case brushing is performed by robots. Moreover, frequent brushing usually leads to an at least partial destruction of the primary structure of the cheese which results from the press mould.

25 Usually the cheese is brushed 3-5 times per week until growth of the microorganisms within the smear layer has started. Then, the frequency of brushing can be reduced stepwise to 1-2 times per week until the ripening process is complete.

30 Suitable smear liquids are known in the art. Usually, a smear liquid comprises salty water or a whey liquid solution and may or may not comprise commercially available microorganisms, so called surface starters.

Usually, the salty water comprises 2-5% sodium chloride. Examples of surface starter organisms are *Debaryomyces hansenii*, *Geotrichum candidum*, *Brevibacterium linens*, *Brevibacterium casei*, *Staphylococcus equorum*, *Microbacterium*

35

gubbeenense, *Arthrobacter* spp., *Corynebacterium casei* and mixtures thereof.

Ripening occurs in a climate-controlled environment at a temperature of 8°C to 20°C and a high relative humidity.

5 Usually the relative humidity is at least 90% RH.

Irrespective of whether or not such microorganisms are comprised in the smear liquid, the resulting smear in general comprises a mixture of microorganisms. Such microor-
10 ganisms in general are (1) yeasts, (2) Gram-positive bacteria, (3) Gram-negative bacteria, (4) moulds and mixtures thereof.

Usually, in smear liquids one or more of the following microorganisms are found:

15 - yeasts such as *Debaryomyces hansenii*, *Kluyveromyces marxianus*, *Kluyveromyces lactis*, *Geotrichum candidum* and mixtures thereof;

- Gram-positive bacteria such as coryneform bacteria, *Micrococcaceae* and mixtures thereof, wherein
20 examples of coryneform bacteria are *Brevibacterium linens*, *Brevibacterium aurantiacum* and *Arthrobacter* sp. and mixtures thereof; and

examples of *Micrococcaceae* are *Micrococcus* sp., non-pathogenic *Staphylococcus* sp. and mixtures thereof,

25 - Gram-negative bacteria such as *Enterobacteriaceae*, *Halomonadaceae*, *Alcaligenaceae*, *Caulobacteriaceae*, *Moraxellaceae*, *Oceanospirillaceae*, *Pseudoalteromonadaceae*, *Pseudomonadaceae*, *Vibrionaceae*, *Xanthomonadaceae*, in particular *Enterobacteriaceae*, and mixtures thereof; and

30 - Moulds such as *Bisifusarium domesticum*.

Selected moulds such as *Bisifusarium domesticum* can have a positive effect on the smear by reducing stickiness. Many moulds, however, lead to undesirable discolouration or can even form mycotoxins.

35 The composition of the smear typically changes during ripening.

In some cases it is desired to pack the cheese in a packaging material for post-ripening storage, distribution and/or sales. Such packaging material is typically air-tight. During storage in such a packaging material, the metabolism and/or composition of the microflora of a smear-ripened cheese in general changes. During storage in a packaging material, in particular air-tight packaging material, the smear surface may also become sticky and an off-odour may develop. Such a sticky surface and/or off-odourous surface is also referred to as a defective or faulty smear. The off-odour that may escape the packaging material upon opening is also referred to as off-flavouring.

The group of substances that contribute to the off-flavour comprises ammonia and low molecular weight sulphur compounds such as methanethiol (CH_3SH), hydrogen sulphide (H_2S), dimethyl sulphide (DMS), dimethyl disulphide (DMDS), dimethyl trisulphide (DMTS) and carbonyl sulphide (herein collectively referred to as "off-flavour compounds"). Moreover, sulphur compounds may interact with each other and with other compounds in the cheese, generating other volatile off-flavour compounds.

Hostin et al. [Hostin S and Palo V, 1992, Milchwirtsch. Ber. Bundesanst. Wolfpassing Rotholz No. 111: 106-109, Eigenschaften der Schmiere der Käsoberfläche der Roquefort-art, International food information service, database accession no. FS-1993-01-P-0075] describes the properties of smear from the surface of Roquefort-type cheeses. However, this document does not provide any guidance for a manufacturing method for a smear-ripened cheese, or a cheese obtainable by such method, with improved properties for storage in a packaging material.

US 2641545 describes production of a soft surface cured cheese using a porous fabric. The fabric is removed by the consumer and facilitates removal of a mould pad that is

formed during ripening. However, this document does not provide any guidance for a manufacturing method for a smear-ripened cheese, or a cheese obtainable by such method, with improved properties for storage in a packaging material.

FR 2774556 describes production of a cheese comprising a peelable rind and a ribbon that facilitates removal of the rind by the consumer. However, this document does not provide any guidance for a manufacturing method for a smear-ripened cheese, or a cheese obtainable by such method, with improved properties for storage in a packaging material.

FR 2710820 describes a production method for a cheese comprising jellification of the cheese and introduction of the cheese, before or after jellification, into an intestine casing which is semi-permeable for gas and humidity. However such intestine casing is inherently impermeable for microorganisms. Moreover, the casing is to be removed by the consumer. Thus, this document does not provide any guidance for a manufacturing method for a smear-ripened cheese, or a cheese obtainable by such method, with improved properties for storage in a packaging material.

FR 1437562 also describes a method of manufacturing a cheese using a casing that is removed by the consumer in order to facilitate removal of the rind of a cheese. Thus, this document does not provide any guidance for a manufacturing method for a smear-ripened cheese, or a cheese obtainable by such method, with improved properties for storage in a packaging material.

Disclosure of the Invention

Hence, it is a general object of the invention to provide an improved method for providing a smear-ripened cheese with reduced off-flavouring and/or reduced stickiness of

the surface upon storage in a packaging material, in particular an air-tight packaging material, and/or a facilitated smear-ripening method.

5 Unless otherwise stated, the following **definitions** shall apply in this specification:

As used herein, the term "a", "an", "the" and similar terms used in the context of the present invention (especially
10 in the context of the claims) are to be construed to cover both the singular and plural unless otherwise indicated herein or clearly contradicted by the context.

As used herein, the terms "including", "containing" and
15 "comprising" are used herein in their open, non-limiting sense. It is understood that the various embodiments, preferences and ranges may be combined at will.

The term "fabric" is known in the field and particularly
20 relates to textile materials made from fibers. The term "fabric" also encompasses the terms "textile fabric", "textile sheet material", "fibre aggregate", "textile surface", "textile structure", "textile surface structure".

25 The term "woven fabric" is known in the field and relates to a fabric formed by weaving. Woven fabrics are often created on a loom, and made of many threads woven on a warp and a weft. A woven fabric is made by interlacing two or more threads at right angles to one another.

30 The term "knitted fabric" is known in the field and relates to a fabric made (i.e. knitted) of thread systems by forming stitches on a knitting machine. Knitted fabrics are commonly used, for example, to make underwear or curtain
35 fabrics.

The term "non-woven fabric" is known in the field and relates to sheet or web structures bonded together by entangling fiber or filaments (and by perforating films) mechanically, thermally or chemically. The term is used to
5 denote fabrics which are neither knitted nor woven.

As used herein, the term "biodegradable" or "biodegradability" relates to the "cradle to cradle" (C2C) standard. C2C Certified compostability requirements are specified
10 for example in EN 13432 (alternatively ISO 17088, ISO 18606 or ASTM D6400). However, to meet C2C Certified compostability requirements, the fabric must be appropriate for home composting, and must not be limited to industrial composting facilities.

15 As used herein, the term "comparable cheese" relates to a smear-ripened cheese of the same cheese group, according to the German cheese regulation as of date 02 June 2021, as the cheese produced by the inventive method.

20 Now, in order to implement these and still further objects of the invention, which will become more readily apparent as the description proceeds, a manufacturing method for smear-ripened cheese is disclosed. The inventive method
25 for producing a smear-ripened cheese is manifested by the steps

- a) applying an envelope on a pressed and freshly brined cheese, said envelope being in direct physical contact
30 with the surface of the cheese, said envelope being permeable for metabolites produced by microorganisms and for microorganisms themselves and for components of the cheese and for gaseous elements, in particular surrounding air;
- 35 b) ripening the cheese within the envelope;

c) removing the envelope with thereon adherent part of a smear (or smear pad) formed during ripening.

In a preferred embodiment, after step c), the thus obtained
5 cheese is packaged for transport and/or sale in a subsequent step d).

Such a procedure leads to a smear-ripened cheese with a residual smear layer of less than 50%, preferably less than
10 30%, more preferably less than 10%, of the smear layer of a comparable cheese which was produced by a method for smear-ripening which is currently known in the art.

Further, the inventive method leads to a smear-ripened cheese with an improved preservation of the primary structure of the cheese resulting from the press mould and with
15 improved properties upon storage in a packaging material. A further advantage of the method is that regular brushing with a smear liquid is not required. Instead, immersing the cheese in a smear liquid, optionally comprising surface
20 starter organisms, preferably directly after step (a), and afterwards keeping the cheese humid is sufficient. This shall be explained in more detail below.

A **first aspect** of the invention is that the microorganisms
25 are cultured on a removable envelope, which is permeable for metabolites produced by microorganisms and for the microorganisms themselves and for components of the cheese and for gaseous elements, in particular surrounding air. The envelope is applied onto the cheese immediately after
30 brining.

The envelope is in direct physical contact with the cheese, preferably over its entire surface.

In an advantageous embodiment, the envelope contains pores and/or micropores, preferably pores having a mean pore size
35 in the range of 0.01 mm - 2.00 mm, preferably in the range of 0.1 mm - 1.0 mm, such as 0.3 mm - 0.7 mm.

The mean pore size may be measured by clamping the envelope in a tenting frame and applying to the envelope maximum extension in the elastic range of the envelope (no overstretching of the envelope). The mean pore size can be measured using a microscope, preferably a digital microscope, e.g. an Olympus DSX110 microscope. Typically, the mean pore size is determined from the pores that are visible on a 5.8x5.8 mm sized microscopy image with 48 fold magnification (see e.g. Fig. 2 - 4), or from a suitable multitude of pores, such as 10 pores that are visible on said microscopy image.

In general, pores can have different shapes. A broad range of pore shapes of the envelope is suitable for the inventive method, e.g. a circular shape or an oval shape, such as an ellipse, or a polygonal shape, such as a quadrangle, pentagon, hexagon, heptagon, octagon, nonagon, or decagon. In case of a circular shape, the pore size relates to the diameter of the pore. In case of a polygonal shape, the pore size can be determined either by measuring the width or the height of the pore, i.e. the distance between the most distant corners (sometimes also referred to as vertices) of a polygonal pore in horizontal ("from left to right") or vertical ("from top to bottom") direction, respectively. Alternatively, pore size can be determined by measuring the distance between the most distant points (e.g. of an oval shape) or corners (e.g. of a polygonal shape) of the pore. In each case, the pore size is measured in the extended state of the envelope as described above. However, the exact method of measuring the mean pore size is not critical as long as the mean pore size is measured in the extended state of the envelope as described above.

In another advantageous embodiment, the envelope is elastic. Suitable elasticity values are in the range of 10-500%, i.e. the envelope can be elastically extended by 10 - 500% of its size in a non-extended state, measured according to DIN EN 14704-1. More preferably, the envelope

is 50-350% elastic, most preferably 100-300% elastic, again measured according to DIN EN 14704-1.

Suitable fabrics complying with the elasticity and porosity
5 as defined above are known in the field and commercial items. In an advantageous embodiment, the envelope comprises, particularly consists of, knitted fabrics or woven fabrics or non-woven fabrics, in particular knitted fabrics or woven fabrics, most preferably knitted fabrics.

10

In another advantageous embodiment, the envelope comprises materials selected from the group consisting of natural or synthetic polymeric materials and mixtures thereof.

Natural polymeric materials may be selected from the group
15 consisting of cellulose, cotton, wool, silk, cashmere and mixtures thereof.

Synthetic materials may be selected from the group consisting of cellulose-derivatives such as cellulose acetate and nitrocellulose, polyamides such as nylon, elastomers,
20 polyurethanes, polyolefins such as polypropylenes, polyesters such as polyethylene terephthalate (PET), polyethylene glycols (PEG), acrylics and mixtures thereof. Elastane (synonymously spandex or lycra) is a mixture of polyurethane and polyethylene glycol.

25 In addition, suitable synthetic materials may also be made from and/or comprise natural polymeric materials, in particular cellulose, and/or cellulose-derivatives such as cellulose acetate and nitrocellulose. Such synthetic materials are sometimes also referred to as semi-synthetic materials. Suitable examples of such synthetic (or semi-synthetic)
30 materials are rayon, lyocell, modal and micromodal.

Cellulose derivatives include materials comprising a characteristic backbone of cellulose wherein one or more of
35 the hydroxyl groups are substituted, e.g. by nitro- or acetate groups.

In an advantageous embodiment, the envelope comprises cellulose and/or cellulose derivatives such as cellulose acetate and nitrocellulose. Preferably, the envelope comprises cellulose or cellulose derivatives that have been
5 obtained from hard wood, in particular obtained from beech tree.

Modal is a form of rayon and consists of cellulose and/or cellulose derivatives as defined above. Micromodal is a
10 finer variant of modal. Micromodal fibres have a diameter of less than 10 μm (microfiber). The term "micromodal" as used herein is thus synonymous to "modal fibres having a diameter of 0.1 - 10 μm ".

In an advantageous embodiment, the envelope comprises modal
15 or micromodal.

Lyocell is a form of rayon and consists of cellulose and/or cellulose derivatives as defined above. In another advantageous embodiment, the envelope comprises lyocell.

20 In another advantageous embodiment, the envelope comprises elastane (synonymously spandex, lycra).

In another advantageous embodiment, the envelope consists
25 of a mixed fabric comprising cellulose or cellulose derivatives and elastane.

In a particularly advantageous embodiment, the envelope consists of a mixed fabric comprising, preferably consisting of, (i) modal or micromodal and (ii) elastane.

30 In an advantageous embodiment, the envelope consists of a mixed fabric comprising, preferably consisting of, (i) 80-95% modal or micromodal, and (ii) 5-20% elastane. A particularly suitable envelope consists of (i) 92% modal or micromodal and (ii) 8% elastane.

35 An example of such an envelope is an envelope consisting of the fabric "26319/1, 28 E Single Jersey Micromodal-Elastane".

In another advantageous embodiment, the envelope comprises 0-100% polyamide, 0-60% elastane, 0-70% polyurethane, 0-40% polypropylene and 0-70% cotton.

5

Preferably, the envelope comprises, more preferably consists of, materials that are biodegradable. Examples of biodegradable materials are modal, micromodal and lyocell.

10 In a further embodiment, the envelope comprises materials selected from the group consisting of natural or synthetic polymeric materials and mixtures thereof, in particular materials selected from the group comprising polyamides such as nylon, elastomers, polyurethanes, polypropylenes,
15 polyesters, acrylics, polyolefins, rayon, cotton, wool, silk, cashmere and mixtures thereof.

In another advantageous embodiment, the envelope has a thickness of between 0.001 mm - 1.0 mm, preferably 0.01 mm
20 - 0.1 mm. The envelope may thus also be a sheet-like material or a thin film.

In another advantageous embodiment, the envelope comprises knitted or woven-fabrics, preferably knitted fabrics, consisting of yarns having a linear mass density (i.e. the
25 thickness of a yarn in only one dimension; also referred to as linear density) of 5-165 DTEX, preferably 10-120 DTEX, more preferably 15-100 DTEX.

The linear mass density of a yarn can be measured according
30 to DIN EN ISO 2060.

An alternative unit for expressing the linear mass density of a yarn is "metric count (Nm)". The unit "Nm" is defined as the number of meters per gram of fiber or yarn. For example, 50.8 Nm correspond to 50.8 m per gram of yarn.

Thus in an advantageous embodiment, the envelope comprises knitted or woven-fabrics, preferably knitted fabrics, consisting of yarns having a linear mass density of 2.000-61 Nm, preferably 667-83 Nm, more preferably 667-400 Nm.

5

In another advantageous embodiment, the envelope prevents or at least reduces spread of mycelium on the cheese surface. Preferably, the envelope serves as a physical barrier against the spread of mould mycelium.

10

In another advantageous embodiment, before step a) the envelope is elastically extended and applied in step a) in such an at least partially elastically extended state.

15 In another advantageous embodiment, in step (b) ripening is achieved by

(b1) immersing the enveloped cheese in a smear liquid, optionally comprising surface starter organisms; and afterwards

20 (b2) keeping the cheese humid by spraying onto said cheese water, optionally water comprising 2-5% sodium chloride.

Preferably, in step (b2), water, optionally comprising 2-5% sodium chloride, is sprayed onto the enveloped cheese
25 3-5 times per week until growth of the microorganisms within the smear layer has started. Then, the frequency of spraying can be reduced stepwise to 1-2 times per week until the ripening process is complete.

Hence, a further advantage of the method is that brushing
30 of the cheese surface with a smear liquid is not required. Nevertheless, brushing is possible within the scope of the method.

A **second aspect** of the invention relates to a cheese or
35 piece of cheese obtainable or obtained by the method of the invention. Due to the removal of the envelope with thereon adherent part of a smear, the inventive method in

particular leads to a smear-ripened cheese that is less susceptible to develop an off-odour after storage in a packaging material, in particular an air-tight packaging material, than a comparable cheese that was not produced according to the inventive method. Nevertheless, a cheese or piece of cheese obtainable or obtained by the inventive method typically maintains, or at least partially maintains, the optical characteristics of a comparable cheese that was produced according to a traditional method. Some of the advantageous characteristics of a smear-ripened cheese that was produced according to the inventive method are described in further detail in the following embodiments (also third to eighth aspect of the invention). These characteristics of the cheese are a consequence of the inventive method by which the cheese was produced.

In an advantageous embodiment, a cheese or piece of cheese obtainable or obtained by the method of the invention has a red-orange surface.

It is clear to the person skilled in the art that the various types of smear-ripened cheese differ in their exact composition and physical properties. Moreover, smear-ripened cheeses of the same type that were produced at different sites can also differ in their composition and physical properties. Nevertheless, the composition and the physical properties of a given cheese can be determined by one or more of the methods described below.

Hence, in order to determine if a smear-ripened cheese was produced according to the method of the invention, a comparable cheese (or a statistically significant number of comparable cheeses) can be produced by the method of the invention and be used as reference material. As defined above, such comparable cheese is a smear-ripened cheese of the same cheese group according to the German cheese regulation as of date 02 June 2021. Comparison of a smear-ripened cheese with this reference material thus offers a

possibility to determine if a smear-ripened cheese was produced by the method of the invention.

In an alternative method, a comparable cheese or a statistically significant number of comparable cheeses is produced using a currently known method for smear ripening and a similar number of cheese(s) is produced using the inventive method. The respective characteristics of a cheese of interest are determined and compared with the characteristics of the comparable cheese(s). Again, a comparable cheese is a smear-ripened cheese of the same cheese group according to the German cheese regulation as of date 02 June 2021.

As an example, the specific values given in the further aspects below were obtained using a traditional semi-hard cheese variety produced in an artisanal cheese dairy.

A **third aspect** of the invention relates to a cheese or piece of cheese obtainable or obtained by the method of the invention which has a residual smear layer with a mean thickness of less than 50%, preferably less than 30%, more preferably less than 10%, of the smear layer of a comparable cheese which was produced by a method for smear-ripening which is currently known in the art, i.e. smear-ripening without an envelope.

In another advantageous embodiment, a cheese or piece of cheese, obtainable or obtained by the method of the invention, has a residual smear layer with a mean thickness of in general not more than 0.2 mm, preferably less than 0.1 mm.

In a preferred embodiment, a cheese or piece of cheese, obtainable or obtained by the method of the invention, has a residual smear layer with a mean thickness of between 0.05 mm to 0.2 mm, preferably 0.05 mm to 0.1 mm.

The mean thickness of the smear layer can be measured by microscopy, e.g. using an Olympus DSX110 microscope.

A **fourth aspect** of the invention relates to a cheese or piece of cheese, obtainable or obtained by the method of the invention, which has an increased water content compared to a comparable cheese which was smear-ripened by a method currently known in the art.

It was surprisingly found that the inventive method reduces the loss of water during ripening which results in a softer cheese texture (may be measured using a texture analyser; cf. sixth aspect of the invention) and a more aromatic cheese.

In particular, the water content after 1, 2, 3 and/or 4 months of ripening is increased by at least 1%, preferably 2%, more preferably 3% compared to a smear-ripened cheese which was produced without an envelope. The water content is dependent on the type of cheese. For example, for the aforementioned traditional semi-hard cheese variety which was produced according to the method of the invention, the water content is at least 370 g/kg as measured according to Agroscope method 13.8 ME.068 (accredited according to ISO/IEC 17025:2017) as of date 25.02.2019, available from Agroscope upon request.

In an advantageous embodiment, said lesser decrease in water content leads to a thinner cheese rind compared to a cheese that was smear-ripened by a method currently known in the art.

A **fifth aspect** of the invention relates to a cheese or piece of cheese, obtainable or obtained by the method of the invention, where the ripening process occurs faster than during a process for smear-ripening a cheese which is currently known in the art.

In case of the aforementioned traditional semi-hard cheese variety, said faster ripening is characterised by at least one of the following characteristics, determined after 4 months of ripening, in comparison to a comparable cheese, which was smear-ripened by a method which is currently known in the art:

- a decrease in total lactic acid of at least 20 mmol/kg as measured according to Agroscope method 13.6 ME.026 (accredited according to ISO/IEC 17025:2017) as of date 04.03.2014, available from Agroscope upon request;
- an increase in the concentration of total volatile carboxylic acids of at least 10 mmol/kg as measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from Agroscope upon request.

In more detail:

- the concentration of iso-valeric acid is increased by at least 0.2 mmol/kg as measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from Agroscope upon request;
- the concentration of iso-butyric acid is increased by at least 0.2 mmol/kg as measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from Agroscope upon request.

Furthermore, in said cheese, which was smear ripened according to the method of the invention, the concentration of

- total lactic acid is less than 60 mmol/kg; and/or
- total volatile carboxylic acids is at least 25 mmol/kg; and/or
- iso-valeric acid is at least 0.23 mmol/kg; and/or
- iso-butyric acid is at least 0.4 mmol/kg

as measured according to the corresponding method described above.

In another preferred embodiment, said faster ripening is characterised by an increase in the fraction of non-protein

nitrogen relative to total nitrogen compared to a comparable cheese that was smear-ripened by a method currently known in the art for 4 months. In particular, the fraction of non-protein nitrogen relative to total nitrogen is at least 16.5%. The concentration of total nitrogen is measured according to Agroscope method 13.8.ME.061 (accredited according to ISO/IEC 17025:2017) as of date 22.02.2019, available from Agroscope upon request. The concentration of non-protein nitrogen is measured according to Agroscope method 13.8.ME.054 (accredited according to ISO/IEC 17025:2017) as of date 22.02.2019, available from Agroscope upon request.

The fraction of non-protein nitrogen relative to total nitrogen is calculated by dividing the concentration of non-protein nitrogen by the concentration of total nitrogen.

In another advantageous embodiment, said faster ripening is characterised by an increase of the pH value in the cheese distant from the smear such as 10 cm from the smear or at the centre of the cheese in case of whole cheeses. For the semi-hard cheese investigated, after 4 months of ripening the pH increased by at least 0.15 compared to a comparable cheese that was smear-ripened by a method currently known in the art. In particular, the pH value after 4 months of ripening is at least 5.80. The pH value is measured according to Agroscope method 13.8.ME.056 (accredited according to ISO/IEC 17025:2017) as of date 12.02.2019, available from Agroscope upon request.

A **sixth aspect** of the invention relates to a cheese or piece of cheese obtainable or obtained by the method of the invention, which is softer (softer cheese texture) than a comparable cheese that was smear-ripened by a method currently known in the art. In particular, the force required for a 33% deformation of the aforementioned traditional semi-hard cheese variety upon uniaxial compression is 3 N lower compared to a comparable cheese that was

smear-ripened by a method currently known in the art. In particular, the force required for a 33% deformation of the cheese upon uniaxial compression is lower than 17 N. Suitable methods of measuring the texture of a cheese are known in the art. For example, the cheese texture may be measured using a texture analyser. In particular, the force required for a 33% deformation as described above is measured according to Agroscope method 18.6.2.ME.026 (accredited according to ISO/IEC 17025:2017) as of date 23.01.2017, available from Agroscope upon request.

A **seventh aspect** of the invention relates to a cheese or piece of cheese obtainable or obtained by the method of the invention, which leads to less off-flavouring during storage in an air-tight (or essentially air-tight) packaging than a comparable cheese that was not produced according to the method of the invention. An air-tight (or essentially air-tight) packaging is a packaging leading to an anaerobic environment.

The group of substances which contribute to the off-flavouring ("off-flavour compounds") comprises ammonia and low molecular weight sulphur compounds such as methanethiol, hydrogen sulphide, dimethyl sulphide (DMS), dimethyl disulphide (DMDS), dimethyl trisulphide (DMTS) and carbonyl sulphide. Moreover, sulphur compounds may interact with each other and with other compounds in the cheese, generating other volatile off-flavour compounds.

In an advantageous embodiment, a cheese or piece of cheese, obtainable or obtained by the method of the invention, shows less, in particular 10-80% (w/w) less, volatile off-flavour compounds compared to a comparable cheese that was not produced according to the inventive method, measured by gas chromatography (GC) upon storage in an air-tight packaging for at least 10 days.

In particular the off-flavour compounds are as defined above (ammonia, low molecular weight sulphur compounds).

In more detail, the formation of ammonia and other volatile off-flavour compounds from a first packaged cheese, which was smear-ripened according to the method of the invention, and a second packaged cheese, which was not smear-ripened according to the method of the invention but according to a currently known method for smear-ripening and which has the same remaining time to the expiry date, can be determined according to the following methods:

10 The amount of ammonia can be measured according to Agroscope method 13.6.ME.089 (accredited according to ISO/IEC 17025:2017) as of date 20.12.2019, available from Agroscope upon request.

15 The amount of ammonia and also other volatile off-flavour compounds can be measured according to Agroscope method 18.6.3.AA.003 ("Flüchtige Komponenten in Lebensmitteln mit Purge & Trap/GC") as of date 03.01.2014 and/or Agroscope method 18.6.3.AA.002 ("HS-SPME/GC - Flüchtige Komponenten in Lebensmitteln") as of date 03.01.2014. Both methods are available from Agroscope upon request.

25 In another advantageous embodiment, the above-mentioned first packaged cheese or piece of cheese leads to the formation of less than 100 ppm ammonia, preferably less than 80 ppm ammonia, more preferably less than 50 ppm ammonia when analysed according to the procedure mentioned above.

30 In addition, it was surprisingly found that a cheese or piece of cheese obtainable or obtained by the method of the invention leads to the formation of more of volatile flavour compounds that contribute to a positive flavour of the cheese (said cheese being more aromatic) than a comparable cheese that was not produced according to the method of the invention.

35

The group of substances which contribute to the positive flavour ("positive volatile flavour compounds") comprises ketones, aldehydes, alcohols and carboxylic acids but not ammonia or low molecular weight sulphur compounds.

5

In another advantageous embodiment, a cheese or piece of cheese obtainable or obtained by the method of the invention shows more positive volatile flavour compounds such as ketones, aldehydes, alcohols and carboxylic acids, in particular 10-80% (w/w) more positive volatile flavour compounds, than a comparable cheese that was not produced according to the inventive method. Methods for measuring such positive volatile flavour compounds are known in the art. A suitable method is analysis by headspace in-tube extraction (HS-ITEX) and solid phase microextraction (HS-SPME) sampling, followed by gas chromatography-mass spectrometry (GC-MS) detection.

An **eighth aspect** of the invention relates to a cheese or piece of cheese, in particular obtainable or obtained by the method of the invention, which has a residual smear layer comprising a lower total count of microorganisms calculated based on the surface area of the cheese or smear layer of the cheese, in particular a 50-99% lower total count of microorganisms (based on surface area of the cheese or smear), compared to a comparable cheese that was smear-ripened by a method currently known in the art. In particular, said lower total count relates to microorganisms selected from the group consisting of anaerobic bacteria, aerobic bacteria, yeasts, moulds and mixtures thereof, compared to a comparable cheese that was smear-ripened by a method currently known in the art.

Without wishing to be bound by theory, the thinner residual smear layer of a cheese or piece of cheese obtained by the inventive method, contributes to the lower total count of microorganisms.

Given the above definition, it is clear that the total count of microorganisms is not calculated relative to the weight of the smear but relative to the surface area of the cheese.

As above, in order to perform such a comparison, a reference cheese can be produced according to the method of the invention.

Various methods for the determination of such microorganisms are known in the art. Such methods are routinely performed by certified laboratories such as the Laboratoire agroalimentaire fribourgeois (LAAF). Exemplary methods are described in "Amato, Lea; ETH Diss. No. 21744; Impact of different packaging films on smear microflora composition, metabolic activity and quality of red-smear cheeses during cold storage". In general, while above, some amounts for specific characteristics have been indicated, it has to be understood that dependent on the actual cheese variety, the amounts can vary. Therefore, for determining whether a cheese has been produced according to the method of the invention, comparative cheeses of the same cheese group according to the German cheese regulation as of date 02 June 2021 have to be produced by the inventive method and preferably also by a method for smear ripening that is currently known, and the characteristics indicated above be compared. For such comparative studies, the actually used method is not critical as long as for the test cheese and the comparative cheeses the same method is applied. In addition, also the ripening time is not crucial as long as all cheeses have the same age upon analysis.

A **ninth aspect** of the invention relates to the use of a sheet-like material (e.g. an envelope) in a method for producing smear-ripened cheese. The sheet-like material is as defined above in the context of an envelope and the method of manufacturing is also as described herein.

Brief Description of the Drawings

The invention will be better understood and objects other
5 than those set forth above will become apparent when consideration is given to the following detailed description thereof. This description makes reference to the annexed drawings, wherein:

10 Figure 1: Picture (30x zoom) of the surface structure after 4 months of smear-ripening. A) No envelope. B) Envelope A. C) Envelope B. D) Envelope C

Figure 2: Picture of envelope A in a non-extended state
15 (A) and in an elastically extended state (B)

Figure 3: Picture of envelope B in a non-extended state
(A) and in an elastically extended state (B)

20 Figure 4: Picture of envelope C in a non-extended state (A) and in an elastically extended state (B)

Modes for Carrying Out the Invention

25 The following examples were performed with cheeses of one traditional semi-hard cheese variety. Different envelopes were compared to a cheese of the same cheese group (according to the German cheese regulation as of date 02 June 2021) that was smear-ripened without an envelope. In the
30 embodiments of the invention, an envelope was applied on a freshly brined cheese. Said envelope was applied on the cheese immediately after brining. Said envelope was in direct physical contact with the cheese over its entire surface. The envelope was permeable for metabolites produced
35 by microorganisms and for microorganisms themselves and for gaseous elements, in particular surrounding air. Said envelopes were 100-300% elastic, as measured according to

DIN EN 14704-1, and comprised pores with a mean pore size in the range of 0.01 mm - 2.00 mm.

The envelopes comprised knitted fabrics consisting of yarns having a linear mass density in the range of 15-100 DTEX.

5 The envelopes were in an elastically extended state before applying on the freshly brined cheese.

Exemplary envelopes and their characteristics are listed in table 1 below.

10 Table 1. Exemplary envelopes

Specifi- cation	Envelope A	Envelope B	Envelope C	Envelope D
Mean pore size ex- tended state	0.3-0.6 mm	0.2-0.7 mm	0.2-1.0 mm	0.05-0.5 mm
Linear mass den- sity	17 DTEX 588 Nm	22 DTEX 455 Nm	17 DTEX 588 Nm	100 DTEX 100 Nm
Material				
Polyamide	90%	100%	79%	0%
Elastane	10%	0%	21%	8%
Micro- modal	0%	0%	0%	92%

Directly after applying the envelope, the cheese was immersed in a smear liquid comprising 2-5% sodium chloride and a combination of microorganisms selected from the group consisting of yeasts, Gram-positive bacteria, Gram-
15 negative bacteria and moulds.

Subsequently, the enveloped cheese was kept humid by spraying onto said cheese water, optionally comprising 2-5% sodium chloride, 3-5 times per week until growth of
20 the microorganisms within the smear layer had started. Then, the frequency of brushing was reduced stepwise to

1-2 times per week until the ripening process was complete.

Upon completion of the ripening, the envelope was removed
5 and the cheese was packaged for distribution or sale.

As mentioned before, since the various types of a smear-ripened cheese differ in their composition as well as in their physical properties, the specific values given below were obtained using one traditional semi-hard cheese
10 variety produced in one artisanal cheese dairy. Other types of smear-ripened cheeses may deviate from these values.

The specific values obtained for said traditional semi-hard cheese variety, which was either produced using the
15 envelope A, B, C, D, or according to a conventional process, which does not include ripening within an envelope, are listed in tables 2, 3 and 4 below.

Table 2. Results after 4 months of ripening (I)

Parameter	Number of replicates	Total volatile carboxylic acids [mmol/kg +/- SD]	Iso-valeric acid [mmol/kg +/- SD]	Iso-butyric acid [mmol/kg +/- SD]	Acetic acid [mmol/kg +/- SD]
No envelope	4	16.9 +/- 1.9	0.06 +/- 0.02	0.20 +/- 0.08	13.1 +/- 1.5
Envelope A	4	34.2 +/- 5.4	0.66 +/- 0.26	0.95 +/- 0.19	21.4 +/- 3.0
Envelope B	4	31.7 +/- 8.0	0.37 +/- 0.25	0.43 +/- 0.31	20.6 +/- 3.1
Envelope C	4	35.8 +/- 2.5	0.73 +/- 0.20	1.05 +/- 0.19	22.1 +/- 2.1

Table 3. Results after 4 months of ripening (II)

Parameter	Number of replicates	Total nitrogen [g/kg +/- SD]	Non-protein nitrogen[g/kg +/- SD]	Non-protein nitrogen[% total nitrogen +/- SD]
No envelope	4	39.2 +/- 0.3	6.1 +/- 0.2	15.5 +/- 0.6
Envelope A	4	37.7 +/- 0.2	6.5 +/- 0.1	17.3 +/- 0.2
Envelope B	4	38.6 +/- 0.9	6.4 +/- 0.2	16.7 +/- 0.8
Envelope C	4	37.7 +/- 0.5	6.4 +/- 0.1	17.0 +/- 0.4

Table 4. Results after 4 months of ripening (III)

Parameter	Number of replicates	Total lactic acid [mmol/kg +/- SD]	pH +/- SD; dimensionless	Force required for 33% deformation [N +/- SD]	Loss on drying [g/kg +/- SD]
Before ripening	1	-	-	-	383
No envelope	4	90.6 +/- 3.3	5.66 +/- 0.04	21.1 +/- 0.4	357.3 +/- 6.7
Envelope A	4	59.6 +/- 14.4	5.90 +/- 0.09	16.7 +/- 3.5	382.8 +/- 5.7
Envelope B	4	41.7 +/- 10.3	5.82 +/- 0.04	14.2 +/- 1.4	376.3 +/- 5.5
Envelope C	4	46.7 +/- 15.1	5.93 +/- 0.09	13.6 +/- 0.9	389.5 +/- 6.2

The following analysis methods were used to obtain the results listed in table 2.

Water content (Loss on drying):

5 The water content was measured according to Agroscope method 13.8.ME.068 (accredited according to ISO/IEC 17025:2017), as of date 25.02.2019, available from Agroscope upon request.

10 Total lactic acid:

Total lactic acid was measured according to Agroscope method 13.6 ME.026 (accredited according to ISO/IEC 17025:2017) as of date 04.03.2014, available from Agroscope upon request.

15

Total volatile carboxylic acids:

Total volatile carboxylic acids were measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from

20 Agroscope upon request.

Iso-valeric acid:

Iso-valeric acid was measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from Agroscope upon request.

25

Iso-butyric acid:

Iso-butyric acid was measured according to Agroscope method 13.8.ME.030 (accredited according to ISO/IEC 17025:2017) as of date 11.08.2017, available from Agroscope upon request.

30

Total nitrogen:

35 The concentration of total nitrogen was measured according to Agroscope method 13.8.ME.061 (accredited according to

ISO/IEC 17025:2017) as of date 22.02.2019, available from Agroscope upon request.

Non-protein nitrogen:

5 The concentration of non-protein nitrogen was measured according to Agroscope method 13.8.ME.054 (accredited according to ISO/IEC 17025:2017) as of date 22.02.2019, available from Agroscope upon request.

10 The fraction of non-protein nitrogen relative to total nitrogen was calculated by dividing the concentration of non-protein nitrogen by the concentration of total nitrogen.

pH value:

15 The pH value was measured at the center of the cheese according to Agroscope method 13.8.ME.056 (accredited according to ISO/IEC 17025:2017) as of date 12.02.2019, available from Agroscope upon request.

20 Force required for a 33% deformation:

The force required for a 33% deformation was measured according to Agroscope method 18.6.2.ME.026 (accredited according to ISO/IEC 17025:2017) as of date 23.01.2017, available from Agroscope upon request.

25

Any of said cheeses that were produced using either of the envelopes A, B or C - also after removal of the envelope - had a red-orange coloured surface.

30 Any of said cheeses, which were produced using either of the envelopes A, B or C - after removal of the envelope - had a residual smear layer with a mean thickness of less than 10% compared to an otherwise identical traditional semi-hard cheese variety that was produced according to a
35 conventional method for smear-ripening, which does not include ripening within an envelope and removing the envelope.

Any of the cheeses that were smear-ripened according to the method of the invention had a residual smear layer with a mean thickness of 0.1 mm whereas the cheese that was produced according to a conventional method had a residual
5 smear layer with a mean thickness of 1 mm.

While there are shown and described presently preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may
10 be otherwise variously embodied and practiced within the scope of the following claims.

Claims

1. A method for producing smear-ripened cheese, characterized in that the method comprises the steps
 - (a) applying an envelope on a pressed and freshly
5 brined cheese, said envelope being in direct physical contact with the surface of the cheese, said envelope being permeable for metabolites produced by microorganisms and for microorganisms themselves and for components of the cheese and for gaseous elements, in
10 particular surrounding air;
 - (b) ripening the cheese within the envelope;
 - (c) removing the envelope with thereon adherent part of a smear formed during ripening; and
 - 15 (d) packaging the cheese for transport and/or sale.
2. The method according to claim 1,
wherein the envelope contains pores having a mean size in the range of 0.01 mm - 2.00 mm, wherein the mean
20 size relates to
 - a) in case of a circular pore, the pore size relates to the diameter of the pore; or
 - b) in case of an oval or polygonal shape of the pore, the pore size relates to the distance between the
25 most distant points or corners of the pore
as measured by light microscopy, preferably according to the following protocol:
 - (i) clamping the envelope in a tenting frame; and
 - (ii) applying to the envelope maximum extension in the
30 elastic range of the envelope; and
 - (iii) measuring the size of a multitude of pores that are visible on a 5.8x5.8 mm sized microscopy image with 48 fold magnification.
- 35 3. The method according to any one of the preceding claims wherein the envelope is 10-500% elastic as measured according to DIN EN 14704-1.

4. The method according to any one of the preceding claims wherein the envelope comprises knitted fabrics or woven fabrics or non-woven fabrics, in particular knitted fabrics or woven fabrics, most preferred knitted fabrics.
5. The method according to any one of the preceding claims wherein the envelope comprises materials selected from the group consisting of natural polymeric materials, synthetic polymeric materials, and mixtures thereof, wherein natural polymeric materials are preferably selected from the group consisting of cellulose, cotton, wool, silk, cashmere and mixtures thereof, and wherein synthetic polymeric materials are preferably selected from the group consisting of cellulose-derivatives (such as cellulose acetate and nitrocellulose), polyamides, elastomers, polyurethanes, polyolefins such as polypropylenes, polyesters (such as polyethylene terephthalate), polyethylene glycols, acrylics, and mixtures thereof.
6. The method according to claim 5 wherein the envelope consists of a mixed fabric of (i) modal or micromodal and (ii) elastane.
7. The method according to any one of claims 4 to 6 wherein the envelope comprises knitted or woven-fabrics, preferably knitted fabrics, consisting of yarns having a linear mass density of 5-165 DTEX, preferably 10-120 DTEX, more preferably 15-100 DTEX.
8. The method according to any one of the preceding claims wherein before step a) the envelope is in an at least partially elastically extended state.

9. The method according to any one of the preceding claims wherein step (b) is divided into the following steps:
(b1) immersing the enveloped cheese in a smear liquid, optionally comprising surface starter organisms; and
5 (b2) keeping the cheese humid by spraying onto said cheese water, optionally comprising 2-5% sodium chloride, at regular time intervals, which are adjustable during the ripening period.
- 10 10. A cheese or a piece of cheese obtainable or obtained by the method according to any one of the preceding claims.
- 11 11. The cheese or a piece of cheese according to claim 10,
15 which has a residual smear layer with a thickness of less than 50% of the smear layer of a comparable cheese that was not produced by a method according to any of claims 1 to 9, said comparable cheese being a smear-ripened cheese of the same cheese group according to
20 the German cheese regulation as of date 02 June 2021; and/or
which has a residual smear layer with a mean thickness of not more than 0.2 mm, as measured by microscopy.
- 25 12. The cheese or a piece of cheese according to any one of claims 10 to 11 which shows 10-80% (w/w) less volatile off-flavour compounds when compared to a comparable cheese that was not produced by a method according to any one of claims 1 to 9,
30 wherein said comparable cheese being a smear-ripened cheese of the same cheese group according to the German cheese regulation as of date 02 June 2021, and
wherein said measurement is performed by gas-chromatography when both the inventive and the comparable
35 cheese are stored for at least 10 days in an air-tight packaging.

13. The cheese or a piece of cheese according to claim 12,
wherein the volatile off-flavour compounds are selected
from the group consisting of ammonia and/or low molec-
ular weight sulphur compounds such as methanethiol,
5 hydrogen sulphide, dimethyl sulphide (DMS), dimethyl
disulphide (DMDS), dimethyl trisulphide (DMTS), car-
bonyl sulphide and mixtures thereof.
14. A cheese or a piece of cheese according to any one of
10 claims 10 to 13, which shows a residual smear layer
comprising a 50-99% lower total count of microorganisms
than a comparable cheese that was not produced by a
method according to any of claims 1 to 9,
wherein the microorganisms are selected from the group
15 consisting of anaerobic bacteria, aerobic bacteria,
yeasts, moulds and/or mixtures thereof, and
wherein the total count of microorganisms is calculated
based on the surface area of the cheese, and
wherein said comparable cheese being a smear-ripened
20 cheese of the same cheese group according to the German
cheese regulation as of date 02 June 2021.
15. Use of an envelope as defined in any one of claims 1
to 7 in a method for producing smear-ripened cheese
25 according to any one of claims 1, 8 or 9.

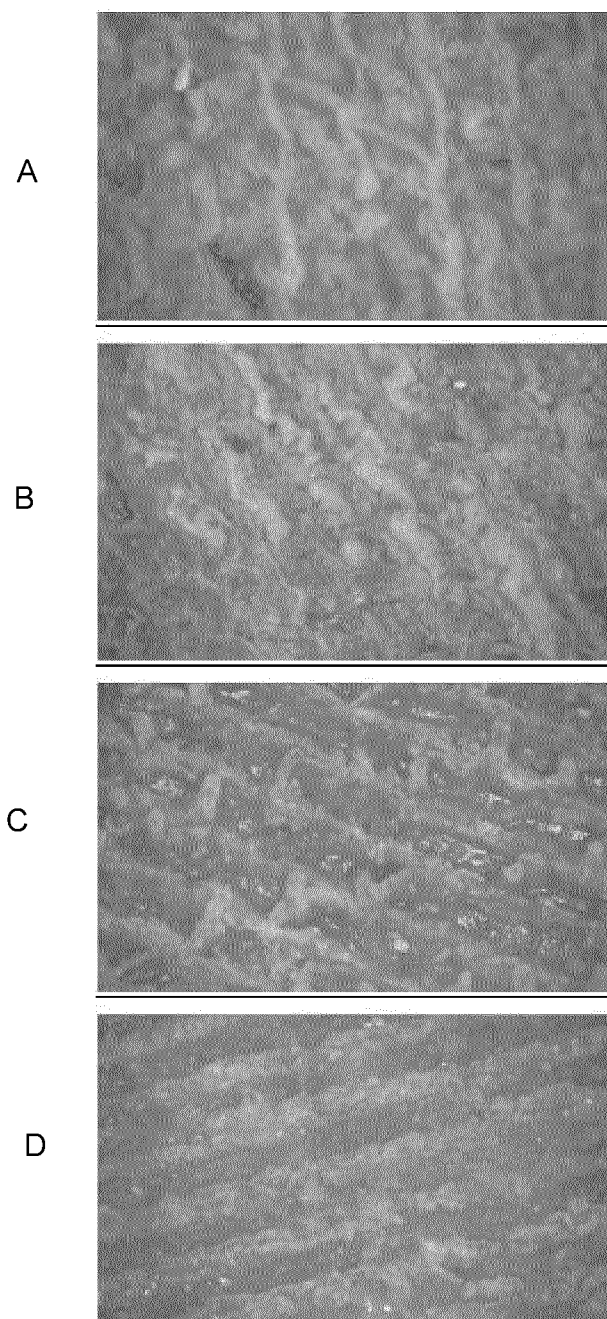


Figure 1

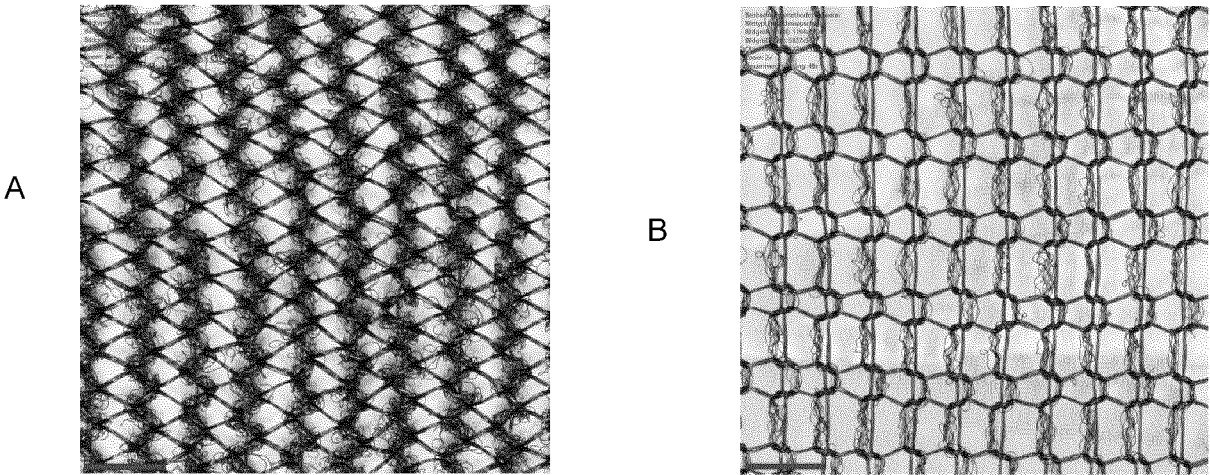


Figure 2

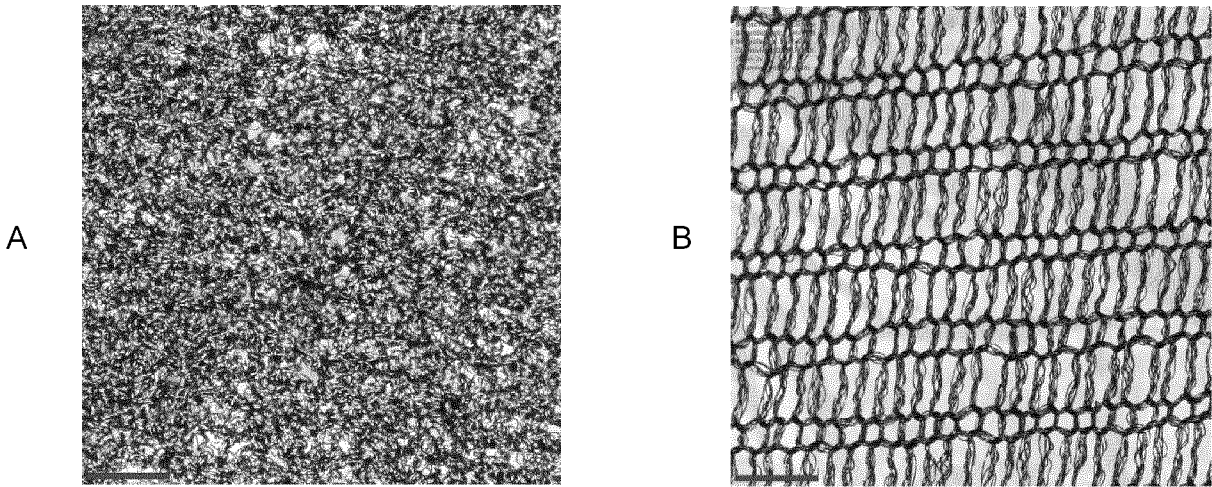


Figure 3

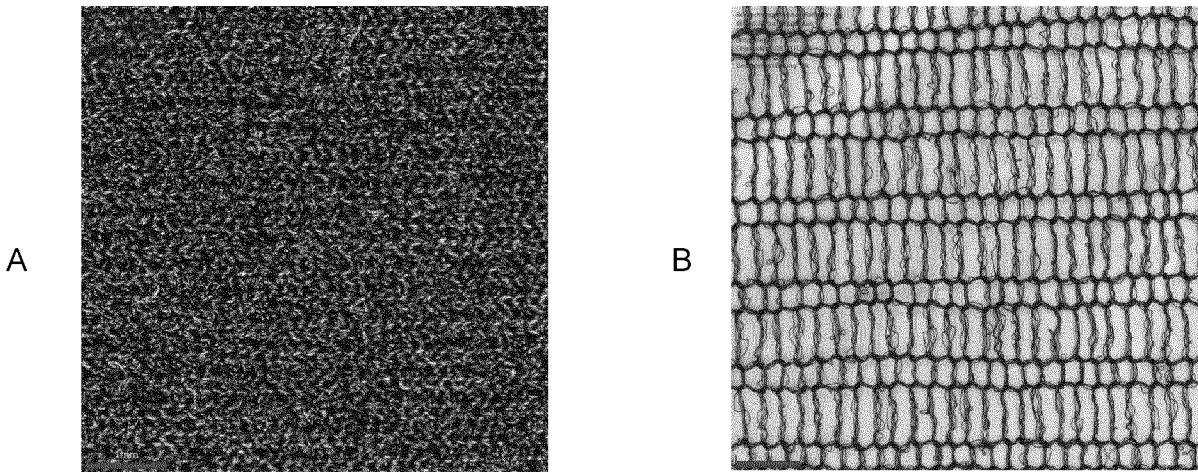


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/078069

A. CLASSIFICATION OF SUBJECT MATTER INV. A23C19/068 A23C19/16 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A23C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data, FSTA		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 641 545 A (KRAFT JOHN H) 9 June 1953 (1953-06-09) column 3, line 18 - line 33; figures 1-4 column 3, line 40 - line 46 column 3, line 60 - line 71 column 2, line 46 - line 50 column 4, line 1 - line 3 -----	1-15
A	FR 2 774 556 A1 (BEL FROMAGERIES [FR]) 13 August 1999 (1999-08-13) page 1, paragraph 4-8; figures 1-4D page 2, line 10 - line 35 page 5, line 29 - line 33 page 7, line 25 - page 8, line 10 page 10, line 27 - page 11, line 4 page 13, line 13 - line 25 ----- -/-	1-15
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 20 December 2021		Date of mailing of the international search report 11/01/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Czerny, M

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2021/078069

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 710 820 A1 (BEL FROMAGERIES [FR]) 14 April 1995 (1995-04-14) abstract page 13, line 31 - page 14, line 7 -----	1-15
A	FR 1 437 562 A (RENARD MICHEL MARIE MARCEL) 6 May 1966 (1966-05-06) column 1, paragraphs 4, 5; figures 1-3 column 2, paragraphs 1-3, 9 -----	1-15
X	DATABASE FSTA [Online] INTERNATIONAL FOOD INFORMATION SERVICE (IFIS), FRANKFURT-MAIN, DE; HOSTIN S ET AL: "Properties of smear from the surface of Roquefort-type cheeses. (translated) TIOL- Eigenschaften der Schmiere der Kaeseoberflaeche der Roquefortart.", XP002802532, Database accession no. FS-1993-01-P-0075	10
A	abstract -----	1-9, 11-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/078069

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2641545	A	09-06-1953	NONE	

FR 2774556	A1	13-08-1999	NONE	

FR 2710820	A1	14-04-1995	NONE	

FR 1437562	A	06-05-1966	NONE	
