

DAIRY PRODUCT AND PROCESS

FIELD OF THE INVENTION

[0001] The present invention relates to the use of protein compositions comprising one or more caseins as functional ingredients in the preparation of foods. The invention particularly relates to cheeses, cheese-like products and methods for manufacture of such products, particularly processed cheeses and processed cheese-like products.

BACKGROUND TO THE INVENTION

[0002] Cheese manufacture fractionates milk components to concentrate the milk proteins, fat, and mineral salts into highly nutritional and flavourful foods that are easier to preserve, store, and transport. Traditional cheese manufacturing methods coagulate milk proteins, primarily the caseins, to produce a curd.

[0003] Processed cheese manufacture proceeds by grinding, blending, and heating or cooking blends of natural cheeses with other permitted ingredients including salt (or sodium chloride), emulsifying salts, colours, flavours, etc. Emulsifying salts are essential in processed cheese manufacture to modify the caseins into forms that emulsify the milk fat to eliminate free fat. Cheese-like products are generally made by blending a casein source, such as rennet casein, with milk and/or vegetable fats, starches, emulsifying salts, salt, flavours, and other allowed ingredients. Manufacture of such products usually proceeds in a processed cheese cooker and employs heat and shear treatments that gelatinize any starch(s) present. Therefore, the cooking step in cheese-like product manufacture resembles processed cheese manufacture. (Bachmann, H. P. 2001. Cheese analogues: a review. Int. Dairy J. 11:505-515.)

[0004] Despite excellent nutritional value and desirable flavours, some consumers reject cheeses, processed cheeses, and many cheese-like products because these products are made with dairy, or animal proteins. Such potential customers may identify themselves as "vegetarians" or "vegans". Such customers may welcome the availability of cheeses, processed cheeses, and/or cheese-like products produced with minimal amounts of milk proteins, or with recombinant milk proteins that are not derived from milk.

[0005] It is an object of the present invention to provide improved or alternative cheeses and/or cheese-like products, or to at least provide the public with a useful choice.

[0006] In this specification, where reference has been made to external sources of information, including patent specifications and other documents, this is generally for the

purpose of providing a context for discussing the features of the present invention. Unless stated otherwise, reference to such sources of information is not to be construed, in any jurisdiction, as an admission that such sources of information are prior art or form part of the common general knowledge in the art.

5 SUMMARY OF THE INVENTION

[0007] Accordingly, the invention broadly comprises a cheese or cheese-like product comprising α_s -casein and/or β -casein, one or more hydrocolloids comprising at least one of a starch or a gum, optionally one or more non-dairy proteins and optionally one or more emulsifying salts, and having one or more characteristics of a dairy product, such as flavour, taste, aroma, body, appearance, texture, firmness, handling, density, structure, coagulation, binding, leavening, aeration, foaming, emulsification, elasticity, viscoelasticity, melt, creaminess and mouthfeel.

[0008] In one aspect the invention relates to a cheese or cheese-like product comprising

- 15 a) about 0.2 to about 35% by weight α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
- b) one or more hydrocolloids, comprising at least one of a starch or a gum,
- c) optionally one or more non-dairy proteins,
- d) optionally one or more emulsifying salts,
- 20 e) optionally about 15 to about 65% by weight moisture, and
- f) optionally about 0.05 to about 35% by weight lipid.

[0009] In one aspect the invention relates to a cheese or cheese-like product comprising

- 25 a) about 0.2 to about 6% by weight α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
- b) one or more hydrocolloids, comprising at least one of a starch or a gum,
- c) optionally one or more non-dairy proteins,
- d) optionally one or more emulsifying salts,
- e) optionally about 15 to about 65% by weight moisture, and

- f) optionally about 0.05 to about 35% by weight lipid.

[0010] In one aspect the invention relates to a cheese or cheese-like product comprising

- 5 a) about 0.2 to about 35% by weight α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
- b) one or more hydrocolloids, comprising at least one of a starch or a gum,
- c) optionally one or more non-dairy proteins,
- d) optionally one or more emulsifying salts,
- e) about 15 to about 65% by weight moisture, and
- 10 f) about 0.05 to about 35% by weight lipid.

[0011] In one aspect the invention relates to a cheese or cheese-like product comprising

- a) about 0.2 to about 6% by weight α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
- 15 b) one or more hydrocolloids, comprising at least one of a starch or a gum,
- c) optionally one or more non-dairy proteins,
- d) optionally one or more emulsifying salts,
- e) about 15 to about 65% by weight moisture, and
- f) about 0.05 to about 35% by weight lipid.

20 **[0012]** In a further aspect the invention provides a cheese or cheese-like product comprising

- a) about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof,
- 25 b) at least about 5% by weight of one or more hydrocolloids, wherein the one or more hydrocolloids comprises one or more starches, and
- c) about 0.2 to about 20% by weight total dairy protein,

wherein total casein in the cheese or cheese-like product comprises

- i) at least about 55% by weight α_s -casein, and/or
- ii) at least about 40% by weight β -casein.

[0013] In another aspect the invention provides a cheese or cheese-like product
5 comprising

- a) about 0.2 to about 6% by weight of α_s -casein,
- b) at least about 5% by weight of one or more hydrocolloids, wherein the one or more hydrocolloids comprises one or more starches, and
- c) about 0.2 to about 20% by weight total dairy protein,

10 wherein total casein in the cheese or cheese-like product comprises at least about 55% by weight α_s -casein.

[0014] In a further aspect the invention provides a cheese or cheese-like product comprising

- a) about 0.2 to about 6% by weight of β -casein,
- 15 b) at least about 5% by weight of one or more hydrocolloids, wherein the one or more hydrocolloids comprises one or more starches, and
- c) about 0.2 to about 20% by weight total dairy protein,

wherein total casein in the cheese or cheese-like product comprises at least about 40% by weight β -casein.

20 **[0015]** In one aspect the invention provides a cheese or cheese-like product comprising

- a) about 0.2 to about 6% by weight α_s -casein,
- b) at least about 5% by weight of one or more hydrocolloids, comprising at least one starch,
- 25 c) about 0.5 to about 20% by weight total protein;

wherein the α_s -casein comprises

- i) at least about 60% of the casein in the cheese or cheese-like product, and/or
- ii) at least about 55% by weight of the total protein in the cheese or cheese-like product.

5 **[0016]** In another aspect the invention relates to a method for preparing a cheese or cheese-like product, the method comprising

a) providing a composition comprising

- i) α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
- 10 ii) one or more hydrocolloids, comprising at least one of a starch or a gum,
- iii) optionally one or more lipids
- iv) optionally one or more non-dairy proteins,
- v) optionally one or more emulsifying salts, and
- vi) optionally one or more additional ingredients,

15 b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and

c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- 20 1. about 0.2 to about 35% by weight α_s -casein,
- 2. optionally about 15 to about 65% by weight moisture, and
- 3. optionally about 0.05 to about 35% by weight lipid.

[0017] In another aspect the invention relates to a method for preparing a cheese or cheese-like product, the method comprising

25 a) providing a composition comprising

- i) α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,

- ii) one or more hydrocolloids, comprising at least one of a starch or a gum,
 - iii) optionally one or more lipids
 - iv) optionally one or more non-dairy proteins,
 - 5 v) optionally one or more emulsifying salts, and
 - vi) optionally one or more additional ingredients,
- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- 10 c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- 1. about 0.2 to about 6% by weight α_s -casein,
 - 2. optionally about 15 to about 65% by weight moisture, and
 - 3. optionally about 0.05 to about 35% by weight lipid.
- 15 **[0018]** In another aspect the invention relates to a method for preparing a cheese or cheese-like product, the method comprising

- a) providing a composition comprising
 - i) α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
 - 20 ii) one or more hydrocolloids, comprising at least one of a starch or a gum,
 - iii) one or more lipids
 - iv) optionally one or more non-dairy proteins,
 - v) optionally one or more emulsifying salts, and
 - vi) optionally one or more additional ingredients,
- 25 b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and

- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

1. about 0.2 to about 35% by weight α_s -casein,
- 5 2. about 15 to about 65% by weight moisture, and
3. about 0.05 to about 35% by weight lipid.

[0019] In another aspect the invention relates to a method for preparing a cheese or cheese-like product, the method comprising

- a) providing a composition comprising
 - 10 i) α_s -casein, the α_s -casein comprising α_{s1} -casein and/or α_{s2} -casein,
 - ii) one or more hydrocolloids, comprising at least one of a starch or a gum,
 - iii) one or more lipids,
 - iv) optionally one or more non-dairy proteins,
 - 15 v) optionally one or more emulsifying salts, and
 - vi) optionally one or more additional ingredients,
- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,
- 20

wherein the cheese or cheese-like product comprises

1. about 0.2 to about 6% by weight α_s -casein,
2. about 15 to about 65% by weight moisture, and
3. about 0.05 to about 35% by weight lipid.

25 **[0020]** In one aspect the invention provides a method for preparing a cheese or cheese-like product, the method comprising

- 5 a) providing a cheese composition comprising
- i) α_s -casein, β -casein, or a combination thereof,
 - ii) one or more hydrocolloids, comprising one or more starches,
 - iii) optionally one or more lipids, and
 - 5 iv) optionally one or more additional ingredients,
- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,
- 10 wherein the cheese or cheese-like product comprises
- i) about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof, and
 - ii) at least about 5% by weight of one or more hydrocolloids, and
 - iii) about 0.2 to about 20% by weight total dairy protein,
- 15 wherein total casein in the cheese or cheese-like product comprises
1. at least about 55% by weight α_s -casein, and/or
 2. at least about 40% by weight β -casein.

[0021] In another aspect the invention provides a method for preparing a cheese or cheese-like product, the method comprising

- 20 a) providing a cheese composition comprising
- i) α_s -casein,
 - ii) one or more hydrocolloids, comprising one or more starches,
 - iii) optionally one or more lipids, and
 - iv) optionally one or more additional ingredients,

- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

5 wherein the cheese or cheese-like product comprises

- i) about 0.2 to about 6% by weight of α_s -casein, and
- ii) at least about 5% by weight of one or more hydrocolloids, and
- iii) about 0.2 to about 20% by weight total dairy protein,

10 wherein total casein in the cheese or cheese-like product comprises at least about 55% by weight α_s -casein.

[0022] In a further aspect the invention provides a method for preparing a cheese or cheese-like product, the method comprising

- a) providing a cheese composition comprising

- i) β -casein,
- 15 ii) one or more hydrocolloids, comprising one or more starches,
- iii) optionally one or more lipids, and
- iv) optionally one or more additional ingredients,

- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and

- 20 c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- i) about 0.2 to about 6% by weight of β -casein, and
- ii) at least about 5% by weight of one or more hydrocolloids, and
- 25 iii) about 0.2 to about 20% by weight total dairy protein,

wherein total casein in the cheese or cheese-like product comprises at least about 40% by weight β -casein.

[0023] In yet another aspect the invention provides a method for preparing a cheese or cheese-like product, the method comprising

- 5 a) providing a cheese composition comprising
 - i) α_s -casein,
 - ii) one or more hydrocolloids, comprising at least one starch,
 - iii) optionally one or more lipids, and
 - iv) optionally one or more additional ingredients,
- 10 b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- 15 i) about 0.2 to about 6% by weight of α_s -casein,
- ii) at least about 5% by weight of one or more hydrocolloids, and
- iii) about 0.5 to about 20% by weight total protein,

and wherein the α_s -casein comprises

- 20 a. at least about 60% of the casein in the cheese or cheese-like product, and/or
- b. at least about 55% by weight of the total protein in the cheese or cheese-like product.

[0024] The following embodiments may relate to any of the above aspects.

- [0025]** In various embodiments the cheese or cheese-like product comprises about 25 0.2% w/w to about 6% w/w α_s -casein, β -casein, or a combination thereof. In various embodiments the cheese or cheese-like product comprises at least about 0.2, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, or at least about 6% by weight of α_s -casein, β -casein, or a

combination thereof, and suitable ranges may be selected from between any two of these values, for example, from about 0.2 to about 5.5, about 0.2 to about 5, about 0.2 to about 4.5, about 0.2 to about 4, about 0.2 to about 3.5, about 0.2 to about 3, about 0.2 to about 2.5, about 0.2 to about 2, about 0.2 to about 1.5, about 0.2 to about 1, about 0.5 to about 5.5, about 0.5 to about 5, about 0.5 to about 4.5, about 0.5 to about 4, about 0.5 to about 3.5, about 0.5 to about 3, about 0.5 to about 2.5, about 0.5 to about 2, about 0.5 to about 1.5, about 0.5 to about 1, about 1 to about 5.5, about 1 to about 5, about 1 to about 4.5, about 1 to about 4, about 1 to about 3.5, about 1 to about 3, about 1 to about 2.5, about 1 to about 2, about 1 to about 1.5, about 1.5 to about 5.5, about 1.5 to about 5, about 1.5 to about 4.5, about 1.5 to about 4, about 1.5 to about 3.5, about 1.5 to about 3, about 1.5 to about 2.5, or about 1.5 to about 2% by weight of α_s -casein, β -casein, or a combination thereof.

[0026] In various embodiments the α_s -casein comprises α_{s1} -casein, α_{s2} -casein, or a combination thereof. In various embodiments the cheese or cheese-like product comprises about 0.2% w/w to about 6% w/w α_s -casein. For example, the cheese or cheese-like product comprises about 0.5% w/w to about 5.5% w/w α_s -casein, from about 0.5% w/w to about 5.0% w/w α_s -casein, from about 0.5% w/w to about 4.5% w/w α_s -casein, from about 0.5% w/w to about 4% w/w α_s -casein, from about 0.5% w/w to about 3.5% w/w α_s -casein, from about 0.5% w/w to about 3% w/w α_s -casein, from about 0.5% w/w to about 2.5% w/w α_s -casein, or from about 0.5% w/w to about 2% w/w α_s -casein.

[0027] In other representative embodiments, the cheese or cheese-like product comprises from about 1% w/w to about 5.5% w/w α_s -casein, from about 1% w/w to about 5.0% w/w α_s -casein, from about 1% w/w to about 4.5% w/w α_s -casein, from about 1% w/w to about 4% w/w α_s -casein, from about 1% w/w to about 3.5% w/w α_s -casein, from about 1% w/w to about 3% w/w α_s -casein, from about 1% w/w to about 2.5% w/w α_s -casein, or from about 1% w/w to about 2% w/w α_s -casein.

[0028] In other representative embodiments, the cheese or cheese-like product comprises from about 1.5% w/w to about 5.5% w/w α_s -casein, from about 1.5% w/w to about 5.0% w/w α_s -casein, from about 1.5% w/w to about 4.5% w/w α_s -casein, from about 1.5% w/w to about 4% w/w α_s -casein, from about 1.5% w/w to about 3.5% w/w α_s -casein, from about 1.5% w/w to about 3% w/w α_s -casein, from about 1.5% w/w to about 2.5% w/w α_s -casein, or about 2% w/w α_s -casein.

[0029] In various embodiments the cheese or cheese-like product comprises about 0.2% w/w to about 6% w/w β -casein. For example, the cheese or cheese-like product comprises about 0.5% w/w to about 5.5% w/w β -casein, from about 0.5% w/w to about 5.0% w/w β -casein, from about 0.5% w/w to about 4.5% w/w β -casein, from about

0.5% w/w to about 4% w/w β -casein, from about 0.5% w/w to about 3.5% w/w β -casein, from about 0.5% w/w to about 3% w/w β -casein, from about 0.5% w/w to about 2.5% w/w β -casein, or from about 0.5% w/w to about 2% w/w β -casein.

[0030] In other representative embodiments, the cheese or cheese-like product

5 comprises from about 1% w/w to about 5.5% w/w β -casein, from about 1% w/w to about 5.0% w/w β -casein, from about 1% w/w to about 4.5% w/w β -casein, from about 1% w/w to about 4% w/w β -casein, from about 1% w/w to about 3.5% w/w β -casein, from about 1% w/w to about 3% w/w β -casein, from about 1% w/w to about 2.5% w/w β -casein, or from about 1% w/w to about 2% w/w β -casein.

[0031] In other representative embodiments, the cheese or cheese-like product

10 comprises from about 1.5% w/w to about 5.5% w/w β -casein, from about 1.5% w/w to about 5.0% w/w β -casein, from about 1.5% w/w to about 4.5% w/w β -casein, from about 1.5% w/w to about 4% w/w β -casein, from about 1.5% w/w to about 3.5% w/w β -casein, from about 1.5% w/w to about 3% w/w β -casein, from about 1.5% w/w to about 2.5% w/w β -casein, or about 2% w/w β -casein.

[0032] α_s -Caseins generally account for about 45-50% of the casein in cow's milk.

In some embodiments, the α_s -casein comprises at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 95% of the casein in the cheese or cheese-like product.

Preferably, the α_s -casein comprises at least 50%, preferably at least 65%, of the casein

20 in the cheese or cheese-like product. In some embodiments, the casein in the cheese or cheese-like product may comprise only α_s -casein, in particular only α_{s2} -casein. In various embodiments the α_s -casein comprises or consists of α_{s1} -casein, α_{s2} -casein, or a combination thereof. The α_s -casein the cheese or cheese-like product may comprise from 0% to 100% α_{s1} -casein, α_{s2} -casein, or a combination thereof.

[0033] In various embodiments the cheese or cheese-like product comprises at least

25 about 0, 0.01, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 25 or at least about 30 % by weight total casein. Total casein in the

cheese or cheese-like product is the sum of all casein protein contributed by all casein-containing ingredients in the cheese or cheese-like product. Various ranges can be

30 selected from between these values, for example, the cheese or cheese-like product may comprise from about 0 to about 30, about 0.01 to about 30, about 0.1 to about 30, about 0.2 to about 30, about 0.5 to about 30, about 1 to about 30, about 0 to about 25, 0.01 to about 25, about 0.1 to about 25, about 0.2 to about 25, about 0.5 to about 25, about 0 to about 20, 0.01 to about 20, about 0.1 to about 20, about 0.2 to about 20, about 0.5 to about 20, about 0.2 to about 19, about 0.5 to about 19, about 1 to about 19, about 0.2 to about 18, about 0.5 to about 18, about 1 to about 18, about 0.2 to about 17,

about 0.5 to about 17, about 1 to about 17, about 0.1 to about 17, about 0.2 to about 16, about 0.5 to about 16, about 1 to about 16, about 0.2 to about 15, about 0.5 to about 15, about 1 to about 25, about 2 to about 25, about 3 to about 25, about 5 to about 25, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 5 to about 20, about 0 to about 10, about 0.01 to about 10, about 0.2 to about 10, about 0.5 to about 10, about 1 to about 10 % by weight total casein.

[0034] In various embodiments total casein in the cheese or cheese-like product comprises at least about 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% by weight α_s -casein, and suitable ranges may be selected from between any two of these values. For example, in various embodiments, total casein in the cheese or cheese-like product comprises about 55% to about 100%, about 56% to about 100%, about 57% to about 100%, about 58% to about 100%, about 59% to about 100%, about 60% to about 100%, about 61% to about 100%, about 62% to about 100%, about 63% to about 100%, about 64% to about 100%, about 65% to about 100%, about 70% to about 100%, about 75% to about 100%, about 80% to about 100%, about 85% to about 100%, about 90% to about 100%, about 95% to about 100%, about 55% to about 95%, about 56% to about 95%, about 57% to about 95%, about 58% to about 95%, about 59% to about 95%, about 60% to about 95%, about 61% to about 95%, about 62% to about 95%, about 63% to about 95%, about 64% to about 95%, about 65% to about 95%, about 70% to about 95%, about 75% to about 95%, about 80% to about 95%, about 85% to about 95%, about 90% to about 95%, about 55% to about 90%, about 56% to about 90%, about 57% to about 90%, about 58% to about 90%, about 59% to about 90%, about 60% to about 90%, about 61% to about 90%, about 62% to about 90%, about 63% to about 90%, about 64% to about 90%, about 65% to about 90%, about 70% to about 90%, about 75% to about 90%, about 80% to about 90%, about 85% to about 90%, about 55% to about 85%, about 56% to about 85%, about 57% to about 85%, about 58% to about 85%, about 59% to about 85%, about 60% to about 85%, about 61% to about 85%, about 62% to about 85%, about 63% to about 85%, about 64% to about 85%, about 65% to about 85%, about 70% to about 85%, about 75% to about 85%, about 80% to about 85%, about 55% to about 80%, about 56% to about 80%, about 57% to about 80%, about 58% to about 80%, about 59% to about 80%, about 60% to about 80%, about 61% to about 80%, about 62% to about 80%, about 63% to about 80%, about 64% to about 80%, about 65% to about 80%, about 70% to about 80%, about 75% to about 80%, about 55% to about 75%, about 56% to about 75%, about 57% to about 75%, about 58% to about 75%, about 59% to about 75%, about 60% to about 75%, about 61% to about 75%, about 62% to about 75%, about 63% to about 75%, about 64% to about 75%, about 65% to about 75%, about 70% to about 75%,

- about 55% to about 70%, about 56% to about 70%, about 57% to about 70%, about 58% to about 70%, about 59% to about 70%, about 60% to about 70%, about 61% to about 70%, about 62% to about 70%, about 63% to about 70%, about 64% to about 70%, about 65% to about 70%, about 55% to about 65%, about 56% to about 65%,
 5 about 57% to about 65%, about 58% to about 65%, about 59% to about 65%, about 60% to about 65%, about 61% to about 65%, about 62% to about 65%, about 63% to about 65%, about 64% to about 65%, about 55% to about 60%, about 56% to about 60%, about 57% to about 60%, about 58% to about 60%, or about 59% to about 60% by weight α_s -casein.
- 10 **[0035]** In various embodiments, the α_s -casein in the cheese or cheese-like product comprises from about 50% to about 100% α_{s1} -casein. In some cases, the cheese or cheese-like product comprises α_s -casein protein and total casein comprises 100% α_{s1} -casein. In some cases, the cheese or cheese-like product comprises α_s -casein protein and total casein comprises at least 50% α_{s1} -casein. The α_s -casein protein in the cheese or
 15 cheese-like product may comprise from 50% α_{s1} -casein to 70% α_{s1} -casein, 50% α_{s1} -casein to 90% α_{s1} -casein, 50% α_{s1} -casein to 100% α_{s1} -casein, 70% α_{s1} -casein to 90% α_{s1} -casein, 70% α_{s1} -casein to 100% α_{s1} -casein, or 90% α_{s1} -casein to 100% α_{s1} -casein. The α_s -casein protein in the cheese or cheese-like product may comprise about 50% α_{s1} -casein, 70% α_{s1} -casein, 90% α_{s1} -casein, or 100% α_{s1} -casein.
- 20 **[0036]** In various embodiments, the α_s -casein in the cheese or cheese-like product comprises from about 50% to 100% α_{s2} -casein. In some cases, the cheese or cheese-like product comprises α_s -casein protein and total α_s -casein comprises 100% α_{s2} -casein. In some cases, the cheese or cheese-like product comprises α_s -casein protein and total casein comprises at least 50% α_{s2} -casein. The α_s -casein protein in the cheese or cheese-
 25 like product may comprise from 50% α_{s2} -casein to 70% α_{s2} -casein, 50% α_{s2} -casein to 90% α_{s2} -casein, 50% α_{s2} -casein to 100% α_{s2} -casein, 70% α_{s2} -casein to 90% α_{s2} -casein, 70% α_{s2} -casein to 100% α_{s2} -casein, or 90% α_{s2} -casein to 100% α_{s2} -casein. The α_s -casein protein in the cheese or cheese-like product may comprise about 50% α_{s2} -casein, 70% α_{s2} -casein, 90% α_{s2} -casein, or 100% α_{s2} -casein.
- 30 **[0037]** In various embodiments, the α_s -casein in the cheese or cheese-like product is a mixture of α_{s1} -casein, α_{s2} -casein. The casein in the cheese or cheese-like product may comprise, for example from 1% α_{s2} -casein to 99% α_{s2} -casein and from 99% α_{s1} -casein to 1% α_{s1} -casein, respectively. In some embodiments, the α_s -casein in the cheese or cheese-like product is a mixture of α_{s1} -casein and α_{s2} -casein in ratio of 10:90, 20:80,
 35 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, or 90:10.

[0038] In various embodiments total casein in the cheese or cheese-like product comprises at least about 30%, 32%, 34%, 35%, 36%, 38%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49%, 50%, 52%, 54%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% by weight β -casein, and suitable ranges may be selected from between any two of these values. For example, in various embodiments, total casein in the cheese or cheese-like product comprises about 30% to about 100%, 32% to about 100%, about 34% to about 100%, about 35% to about 100%, about 36% to about 100%, about 38% to about 100%, about 40% to about 100%, about 41% to about 100%, about 42% to about 100%, about 43% to about 100%, about 44% to about 100%, about 45% to about 100%, about 46% to about 100%, about 47% to about 100%, about 48% to about 100%, about 49% to about 100%, about 50% to about 100%, about 55% to about 100%, about 60% to about 100%, about 30% to about 95%, about 40% to about 95%, about 45% to about 95%, about 50% to about 95%, about 52% to about 95%, about 55% to about 95%, about 60% to about 95%, about 65% to about 95%, about 70% to about 95%, about 75% to about 95%, about 80% to about 95%, about 85% to about 95%, about 90% to about 95%, about 30% to about 90%, about 35% to about 90%, about 40% to about 90%, about 42% to about 90%, about 44% to about 90%, about 45% to about 90%, about 47% to about 90%, about 50% to about 90%, about 55% to about 90%, about 60% to about 90%, about 65% to about 90%, about 70% to about 90%, about 75% to about 90%, about 80% to about 90%, about 85% to about 90%, about 30% to about 85%, about 35% to about 85%, about 40% to about 85%, about 42% to about 85%, about 44% to about 85%, about 45% to about 85%, about 46% to about 85%, about 47% to about 85%, about 48% to about 85%, about 50% to about 85%, about 55% to about 85%, about 60% to about 85%, about 65% to about 85%, about 70% to about 85%, about 75% to about 85%, about 80% to about 85%, about 30% to about 80%, about 35% to about 80%, about 40% to about 80%, about 42% to about 80%, about 44% to about 80%, about 45% to about 80%, about 50% to about 80%, about 55% to about 80%, about 60% to about 80%, about 62% to about 80%, about 65% to about 80%, about 70% to about 80%, about 75% to about 80%, about 30% to about 75%, about 35% to about 75%, about 40% to about 75%, about 42% to about 75%, about 44% to about 75%, about 45% to about 75%, about 48% to about 75%, about 50% to about 75%, about 55% to about 75%, about 60% to about 75%, about 65% to about 75%, about 70% to about 75%, about 30% to about 70%, about 35% to about 70%, about 40% to about 70%, about 42% to about 70%, about 44% to about 70%, about 45% to about 70%, about 47% to about 70%, about 50% to about 70%, about 55% to about 70%, about 60% to about 70%, about 65% to about 70%, about 30% to about 65%, about 35% to about 65%, about 40% to about 65%, about 42% to about 65%, about 44% to about 65%,

about 45% to about 65%, about 47% to about 65%, about 50% to about 65%, about 55% to about 65%, about 60% to about 65%, about 35% to about 60%, about 40% to about 60%, about 45% to about 60%, about 50% to about 60%, or about 55% to about 60% by weight β -casein.

5 **[0039]** In various embodiments, α_s -casein comprises at least about 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 99 or at least about 100% by weight of the total protein in the cheese or cheese-like product, and various ranges may be selected from between any of these values. The total protein in the composition is the sum of all protein contributed by all protein-containing ingredients in the composition. For example, α_s -casein may comprise from about 30% to about 90%, about 50% to about 95%, or about 30% to about 100% w/w of total protein content of the cheese or cheese-like product. In some embodiments, α_s -casein may comprise at least 30% w/w of total protein content of the cheese or cheese-like product. In some 10 embodiments, α_s -casein may comprise at least 50% w/w of total protein content of the cheese or cheese-like product. In some embodiments, α_s -casein may comprise at least 90% or at least 95% w/w of total protein content of the cheese or cheese-like product. In some embodiments, α_s -casein may comprise from 30% to 35%, 30% to 40%, 30% to 50%, 30% to 55%, 30% to 70%, 30% to 75%, 30% to 80%, 30% to 85%, 30% to 90%, 35% to 40%, 35% to 50%, 35% to 55%, 35% to 70%, 35% to 75%, 35% to 80%, 35% to 85%, 35% to 90%, 40% to 50%, 40% to 55%, 40% to 70%, 40% to 75%, 40% to 80%, 40% to 85%, 40% to 90%, 50% to 55%, 50% to 70%, 50% to 75%, 50% to 80%, 50% to 85%, 50% to 90%, 55% to 70%, 55% to 75%, 55% to 80%, 55% to 85%, 55% to 90%, 70% to 75%, 70% to 80%, 70% to 85%, 70% to 90%, 75% to 80%, 75% to 85%, 75% to 90%, 80% to 85%, 80% to 90%, 85% to 90% 20 or 90 to 95% w/w of total protein content of the cheese or cheese-like product. The α_s -casein may comprise 30%, 35%, 40%, 50%, 55%, 70%, 75%, 80%, 85%, 90%, 95% or 99% w/w of total protein content of the cheese or cheese-like product. The α_s -casein may comprise at least 30%, 35%, 40%, 50%, 55%, 70%, 75%, 80% 85% or 90% w/w of total protein content of the cheese or cheese-like product. The α_s -casein may comprise 25 at most 40%, 50%, 55%, 70%, 75%, 80%, 85%, 90% or 95% w/w of total protein content of the cheese or cheese-like product. 30

[0040] In various embodiments, β -casein comprises at least about 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 99 or at least about 100% by weight of the total protein in the cheese or cheese-like product, and various ranges may be selected from between any of these values. For example, β -casein may comprise 35 from about 30% to about 90%, about 50% to about 95%, or about 30% to about 100% w/w of total protein content of the cheese or cheese-like product. In some embodiments,

5 β -casein may comprise at least 30% w/w of total protein content of the cheese or cheese-like product. In some embodiments, β -casein may comprise at least 50% w/w of total protein content of the cheese or cheese-like product. In some embodiments, β -casein may comprise at least 90% or at least 95% w/w of total protein content of the cheese or cheese-like product. In some embodiments, β -casein may comprise from 30% to 35%, 30% to 40%, 30% to 50%, 30% to 55%, 30% to 70%, 30% to 75%, 30% to 80%, 30% to 85%, 30% to 90%, 35% to 40%, 35% to 50%, 35% to 55%, 35% to 70%, 35% to 75%, 35% to 80%, 35% to 85%, 35% to 90%, 40% to 50%, 40% to 55%, 40% to 70%, 40% to 75%, 40% to 80%, 40% to 85%, 40% to 90%, 50% to 55%, 50% to 70%, 50% to 75%, 50% to 80%, 50% to 85%, 50% to 90%, 55% to 70%, 55% to 75%, 55% to 80%, 55% to 85%, 55% to 90%, 70% to 75%, 70% to 80%, 70% to 85%, 70% to 90%, 75% to 80%, 75% to 85%, 75% to 90%, 80% to 85%, 80% to 90%, 85% to 90% or 90 to 95% w/w of total protein content of the cheese or cheese-like product. The β -casein may comprise 30%, 35%, 40%, 50%, 55%, 70%, 75%, 80%, 85%, 90%, 95% or 99% w/w of total protein content of the cheese or cheese-like product. The β -casein may comprise at least 30%, 35%, 40%, 50%, 55%, 70%, 75%, 80%, 85% or 90% w/w of total protein content of the cheese or cheese-like product. The β -casein may comprise at most 40%, 50%, 55%, 70%, 75%, 80%, 85%, 90% or 95% w/w of total protein content of the cheese or cheese-like product.

20 **[0041]** In various embodiments the cheese or cheese-like product may comprise less than about 5, 4, 3, 2 or about 1% by weight non-dairy animal protein. In various embodiments the cheese or cheese-like product may comprise from about 0 to about 5%, about 0 to about 4%, about 0 to about 3%, about 0 to about 2% or about 0 to about 1% by weight non-dairy animal protein. In some embodiments the cheese or cheese-like product may comprise no non-dairy animal protein.

[0042] In various embodiments the α_s -casein and/or β -casein is provided by a protein ingredient comprising an α_s -casein enriched fraction, a β -casein enriched fraction, recombinant α_{s1} -casein, recombinant α_{s2} -casein, recombinant β -casein, or any combination of any two or more thereof.

30 **[0043]** In various embodiments the α_s -casein comprises, or is provided by a protein ingredient comprising, an α_s -casein enriched fraction, recombinant α_{s1} -casein, recombinant α_{s2} -casein, or any combination of any two or more thereof.

35 **[0044]** In various embodiments, the cheese or cheese-like product further comprises κ -casein, β -casein, or any combination thereof. In various embodiments, the cheese or cheese-like product further comprises κ -casein, β -casein, p- κ -casein, or any combination of any two or more thereof.

- [0045]** When the α_s -casein is provided by a dairy starting material, the dairy starting material preferably comprises an α_s -casein enriched fraction. In various embodiments at least about 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 95, 99 or 100% of the total casein in the starting material is provided by an α_s -casein enriched casein, and various ranges may be selected from between any two of these values. Preferably, total casein in the starting material comprises at least 20%, preferably at least 40% and most preferably at least 60% α_s -casein enriched casein.
- [0046]** In various embodiments the β -casein comprises, or is provided by a protein ingredient comprising, a β -casein enriched fraction, recombinant β -casein, or a combination thereof.
- [0047]** In various embodiments, the cheese or cheese-like product further comprises κ -casein, α_s -casein, or any combination thereof. In various embodiments, the cheese or cheese-like product further comprises κ -casein, α_s -casein, p- κ -casein, or any combination of any two or more thereof.
- [0048]** When the β -casein is provided by a dairy starting material, the dairy starting material preferably comprises a β -casein enriched fraction. In various embodiments at least about 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 95, 99 or 100% of the total casein in the starting material is provided by a β -casein enriched fraction, and various ranges may be selected from between any two of these values. Preferably, total casein in the starting material comprises at least 20%, preferably at least 40% and most preferably at least 60% β -casein enriched casein.
- [0049]** In various embodiments the protein ingredient may comprise an α_s -casein enriched fraction, and:
- a) total casein in the protein ingredient comprises at least about 50%, 55%, 60%, 65%, 70%, 80%, 85%, 90% or 95% by weight α_s -casein, and/or
 - b) the protein ingredient comprises α_s -casein and β -casein in a weight ratio of at least about 50:50, 55:45, 60:40, 65:35, 70:30, 75:25, or at least about 80:20.
- [0050]** In various embodiments the protein ingredient may comprise a β -casein enriched fraction, and:
- a) total casein in the β -casein enriched fraction comprises at least about 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 80%, 85%, 90% or 95% by weight β -casein, and/or

- b) the β -casein enriched fraction comprises β -casein and α_s -casein in a weight ratio of at least about 50:50, 55:45, 60:40, 65:35, 70:30, 75:25, or at least about 80:20.

[0051] The preferred total casein concentration of the cheese or cheese-like product is in the range 1-30% (w/w), more preferably 2-20% (w/w). In various embodiments, the total casein concentration of the cheese or cheese-like product is about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18% or about 19% w/w. In various embodiments the total casein concentration of the cheese or cheese-like product is from about 1 to about 25, about 1 to about 20, about 1 to about 15, about 1 to about 10, about 1 to about 6, about 2 to about 25, about 2 to about 20, about 2 to about 15, about 2 to about 10, or about 2 to about 6% by weight.

[0052] In various embodiments, the cheese or cheese-like product comprises at least about 0, 0.01, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25 or at least about 30% by weight total protein, and various ranges can be selected from between these values, for example, from about 0 to about 30, about 0.01 to about 30, about 0.2 to about 30, about 0.5 to about 30, about 1 to about 30, about 0 to about 25, 0.01 to about 25, about 0.1 to about 25, about 0.2 to about 25, about 0.5 to about 25, about 0 to about 20, 0.01 to about 20, about 0.1 to about 20, about 0.2 to about 20, about 0.5 to about 20, about 0.1 to about 15, about 0.2 to about 15, about 0.5 to about 15, about 1 to about 15, about 1 to about 25, about 2 to about 25, about 3 to about 25, about 5 to about 25, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 5 to about 20, about 0 to about 10, about 0.01 to about 10, about 0.2 to about 10, about 0.5 to about 10, about 1 to about 10 %, about 0.2 to about 7%, about 0.5 to about 7%, about 1 to about 7%, about 0.2 to about 5%, about 0.5 to about 5%, about 1 to about 5%, about 0.2 to about 4%, about 0.5 to about 4%, about 1 to about 4%, about 0.2 to about 3%, about 0.5 to about 3%, or about 1 to about 3%, by weight total protein.

[0053] In various embodiments the cheese or cheese-like product comprises at least about 0, 0.01, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 25 or at least about 30% by weight total dairy protein. Total dairy protein in the cheese or cheese-like product is the sum of all dairy protein contributed by all dairy protein-containing ingredients in the cheese or cheese-like product. Various ranges can be selected from between these values, for example, the cheese or cheese-like product may comprise from about 0 to about 30, about 0.01 to about 30, about 0.1 to about 30, about 0.2 to about 30, about 0.5 to about 30, about 1 to about 30, about 0 to about 25, 0.01 to about 25, about 0.1 to about 25, about 0.2 to about 25, about 0.5

to about 25, about 0 to about 20, 0.01 to about 20, about 0.1 to about 20, about 0.2 to about 20, about 0.5 to about 20, about 0.2 to about 19, about 0.5 to about 19, about 1 to about 19, about 0.2 to about 18, about 0.5 to about 18, about 1 to about 18, about 0.2 to about 17, about 0.5 to about 17, about 1 to about 17, about 0.1 to about 17, about 0.2 to about 16, about 0.5 to about 16, about 1 to about 16, about 0.2 to about 15, about 0.5 to about 15, about 1 to about 25, about 2 to about 25, about 3 to about 25, about 5 to about 25, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 5 to about 20, about 0 to about 10, about 0.01 to about 10, about 0.2 to about 10, about 0.5 to about 10, about 1 to about 10% by weight total dairy protein.

10 **[0054]** In various embodiments the cheese or cheese-like product comprises one or more non-dairy proteins. In various embodiments the one or more non-dairy proteins may comprise or consist of one or more plant proteins or hydrolysed plant proteins.

[0055] In various embodiments the cheese or cheese-like product comprises at least about 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 15 0.85, 0.9, 0.95, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5 or at least about 5% w/w hydrocolloids. Suitable ranges may be selected from any of these values, for example from about 0.1 to about 5, 0.1 to about 4, 0.1 to about 3, 0.1 to about 2, about 0.1 to about 1, about 0.1 to about 0.75, about 0.1 to about 0.5, about 0.1 to about 0.3, about 0.15 to about 1, about 0.15 to about 0.75, about 0.15 to about 0.5, about 0.15 to about 0.3, about 2 to about 1, about 0.2 to about 0.75, about 0.2 to about 0.5, about 0.2 to about 0.3, about 0.3 to about 1, about 0.3 to about 0.75, about 0.3 to about 0.5, about 0.5 to about 1, about 0.5 to about 0.75, or about 0.75 to about 1% w/w of the cheese or cheese-like product. In various embodiments the cheese or cheese-like product comprises one type of hydrocolloid. However, cheese or cheese-like products comprising more than one type 25 of hydrocolloids are also contemplated herein.

[0056] In various embodiments the cheese or cheese-like product comprises at least about 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 25, 26, 28, 30, 35 or 40% by weight hydrocolloids. Suitable ranges may be selected from any of these values, for example, the cheese or cheese-like product may comprise from about 5 to about 40%, about 6 to about 40%, about 7 to about 40%, about 8 to about 40%, about 9 to about 40%, about 10 to about 40%, about 11 to about 40%, about 12 to about 40%, about 13 to about 40%, about 14 to about 40%, about 15 to about 40%, about 16 to about 40%, about 17 to about 40%, about 18 to about 40%, about 19 to about 40%, about 20 to about 40%, about 22 to about 40%, about 24 to about 40%, about 25 to about 40%, about 26 to about 40%, about 28 to about 40%, about 30 to about 40%, 35 about 35 to about 40%, about 5 to about 35%, about 6 to about 35%, about 7 to about

35%, about 8 to about 35%, about 9 to about 35%, about 10 to about 35%, about 11 to about 35%, about 12 to about 35%, about 13 to about 35%, about 14 to about 35%, about 15 to about 35%, about 16 to about 35%, about 17 to about 35%, about 18 to about 35%, about 19 to about 35%, about 20 to about 35%, about 22 to about 35%,
5 about 24 to about 35%, about 25 to about 35%, about 26 to about 35%, about 28 to about 35%, about 30 to about 35%, about 5 to about 30%, about 6 to about 30%, about 7 to about 30%, about 8 to about 30%, about 9 to about 30%, about 10 to about 30%, about 11 to about 30%, about 12 to about 30%, about 13 to about 30%, about 14 to about 30%, about 15 to about 30%, about 16 to about 30%, about 17 to about 30%,
10 about 18 to about 30%, about 19 to about 30%, about 20 to about 30%, about 22 to about 30%, about 24 to about 30%, about 25 to about 30%, about 26 to about 30%, about 28 to about 30%, about 5 to about 28%, about 6 to about 28%, about 7 to about 28%, about 8 to about 28%, about 9 to about 28%, about 10 to about 28%, about 11 to about 28%, about 12 to about 28%, about 13 to about 28%, about 14 to about 28%,
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20 26%, about 13 to about 26%, about 14 to about 26%, about 15 to about 26%, about 16 to about 26%, about 17 to about 26%, about 18 to about 26%, about 19 to about 26%, about 20 to about 26%, about 22 to about 26%, about 24 to about 26%, about 25 to about 26%, about 5 to about 24%, about 6 to about 24%, about 7 to about 24%, about 8 to about 24%, about 9 to about 24%, about 10 to about 24%, about 11 to about 24%,
25 about 12 to about 24%, about 13 to about 24%, about 14 to about 24%, about 15 to about 24%, about 16 to about 24%, about 17 to about 24%, about 18 to about 24%, about 19 to about 24%, about 20 to about 24%, about 22 to about 24%, about 5 to about 22%, about 6 to about 22%, about 7 to about 22%, about 8 to about 22%, about 9 to about 22%, about 10 to about 22%, about 11 to about 22%, about 12 to about
30 22%, about 13 to about 22%, about 14 to about 22%, about 15 to about 22%, about 16 to about 22%, about 17 to about 22%, about 18 to about 22%, about 19 to about 22%, about 20 to about 22%, about 5 to about 20%, about 6 to about 20%, about 7 to about 20%, about 8 to about 20%, about 9 to about 20%, about 10 to about 20%, about 11 to about 20%, about 12 to about 20%, about 13 to about 20%, about 14 to about 20%,
35 about 15 to about 20%, about 16 to about 20%, about 17 to about 20%, about 18 to about 20%, about 19 to about 20%, about 5 to about 18%, about 6 to about 18%, about 7 to about 18%, about 8 to about 18%, about 9 to about 18%, about 10 to about 18%, about 11 to about 18%, about 12 to about 18%, about 13 to about 18%, about 14 to

about 18%, about 15 to about 18%, about 16 to about 18%, about 17 to about 18%,
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 5 about 5 to about 14%, about 6 to about 14%, about 7 to about 14%, about 8 to about
 14%, about 9 to about 14%, about 10 to about 14%, about 11 to about 14%, about 12
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 about 7 to about 12%, about 8 to about 12%, about 9 to about 12%, about 10 to about
 12%, about 11 to about 12%, about 5 to about 10%, about 6 to about 10%, about 7 to
 10 about 10%, about 8 to about 10%, about 9 to about 10%, about 5 to about 8%, about 6
 to about 8%, about 7 to about 8%, or about 5 to about 6% by weight hydrocolloids.

[0057] In various embodiments, the cheese or cheese-like product comprises one or
 more starches. In various embodiments, the cheese or cheese-like product comprises
 two or more starches. In various embodiments, the cheese or cheese-like product
 15 comprises three or more starches. In various embodiments the starch comprises potato
 starch, maize starch, rice starch, tapioca (cassava) starch, wheat starch, pea starch,
 sweet potato starch, banana starch, barley starch, oat starch, sago starch, amaranth
 starch, arrowroot starch, canna starch, sorghum starch, or any combination of any two
 or more thereof. In various embodiments the starch comprises potato starch, maize
 20 starch, rice starch, tapioca (cassava) starch, wheat starch, pea starch, sweet potato
 starch, banana starch, barley starch, oat starch, sago starch, amaranth starch, arrowroot
 starch, canna starch, sorghum starch, chia seed starch, fava bean starch, jackfruit
 starch, bamboo starch, chickpea starch, cassava starch, carrot starch, or any
 combination of any two or more thereof. Particularly preferred starches include maize,
 25 potato, cassava, and rice starch.

[0058] In various embodiments the starch comprises a modified starch, for
 example, a pre-gelatinised starch, a thin-boiling starch, an oxidised starch, or octenyl
 succinic anhydride (OSA) modified starch.

[0059] In one embodiment the starch comprises modified potato starch.

30 **[0060]** In various embodiments the cheese or cheese-like product comprises at least
 about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 25, 26,
 27, or at least about 30% by weight starch. In various embodiments the cheese or
 cheese-like product comprises from about 4 to about 30%, about 5 to about 30%, about
 6 to about 30%, about 7 to about 30%, about 8 to about 30%, about 9 to about 30%,
 35 about 10 to about 30%, about 12 to about 30%, about 15 to about 30%, about 18 to
 about 30%, about 20 to about 30%, about 5 to about 25%, about 6 to about 25%, about

7 to about 25%, about 8 to about 30, 25 about 9 to about 25%, about 10 to about 25%, about 12 to about 25%, about 15 to about 25%, about 18 to about 25%, or about 20 to about 30% by weight starch. In various embodiments the cheese or cheese-like product comprises from about 4 to about 10%, about 4 to about 9%, about 4 to about 8%, about 5 to about 7%, about 5 to about 10%, about 5 to about 9%, about 6 to about 8%, about 6 to about 13%, about 6% to about 12%, about 6 to about 10%, about 7 to about 15%, about 7 to about 14%, about 7 to about 12%, about 8 to about 10%, about 8 to about 15%, about 8 to about 12%, about 9 to about 18%, about 9 to about 16%, about 9 to about 14%, about 10 to about 20%, about 10 to about 18%, about 10 to about 16%, about 10 to about 14%, about 12 to about 20%, about 12 to about 18%, about 12 to about 16%, about 13 to about 20%, about 13 to about 19%, about 13 to about 18%, about 13 to about 17%, about 14 to about 16%, about 14 to about 20%, about 14 to about 19%, about 14 to about 18%, about 15 to about 17%, about 15 to about 20%, about 15 to about 19%, about 15 to about 18%, about 20 to about 30%, about 20 to about 28%, about 20 to about 26%, about 20 to about 24%, about 21 to about 23%, about 22 to about 30%, about 22 to about 28%, about 22 to about 26%, about 22 to about 24%, about 24 to about 30%, about 24 to about 28% or about 24 to about 26% w/w starch.

[0061] In various embodiments, the cheese or cheese-like product comprises one or more gums. In various embodiments, the cheese or cheese-like product comprises two or more gums. In various embodiments, the cheese or cheese-like product comprises three or more gums. In various embodiments the gum comprises xanthan gum, guar gum, locust bean gum, tragacanth gum, acacia gum, karaya gum, tara gum, gellan gum, konjac gum (konjac mannan), carboxymethylcellulose (CMC), tragacanth, agar, pectin, alginate, carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan), Arabic gum, or any combination of any two or more thereof. In various embodiments the gum comprises xanthan gum, guar gum, locust bean gum, tragacanth gum, acacia gum, karaya gum, tara gum, gellan gum, konjac gum (konjac mannan), carboxymethylcellulose (CMC), tragacanth, agar, pectin, alginate, carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan), Arabic gum, pectin, alginate, flaxseed gum, guar gum, or any combination of any two or more thereof.

[0062] In various embodiments the gum comprises one or more carrageenans (κ -carrageenan, ι -carrageenan, λ -carrageenan), or any combination of any two or more thereof.

[0063] In various embodiments the cheese or cheese-like product comprises at least about 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7,

1.8, 1.9, or about 2.0% by weight of one or more gums. Suitable ranges may be selected from any of these values, for example from 0 to about 1.9%, 0 to about 1.8%, 0 to about 1.7%, 0 to about 1.6%, 0 to about 1.5%, 0 to about 1.4%, 0 to about 1.3%, 0 to about 1.2%, 0 to about 1.1%, 0 to about 1.0%, 0 to about 0.9%, 0 to about 0.8%, 0 to about 0.7%, 0 to about 0.6%, 0 to about 0.5%, 0 to about 0.4%, 0 to about 0.3%, 0 to about 0.2%, 0 to about 0.1%, about 0.1 to about 1.9%, about 0.1 to about 1.8%, about 0.1 to about 1.7%, about 0.1 to about 1.6%, about 0.1 to about 1.5%, about 0.1 to about 1.4%, about 0.1 to about 1.3%, about 0.1 to about 1.2%, about 0.1 to about 1.1%, about 0.1 to about 1.0%, about 0.1 to about 0.9%, about 0.1 to about 0.8%, about 0.1 to about 0.7%, about 0.1 to about 0.6%, about 0.1 to about 0.5%, about 0.1 to about 0.4%, about 0.1 to about 0.3%, or about 0.1 to about 0.2% by weight of one or more gums. In a preferred embodiment, the cheese or cheese-like product comprises 0 to about 0.8%, more preferably about 0.1 to about 0.24% by weight of one or more gums.

15 **[0064]** In various embodiments the cheese or cheese-like product may have a pH of about 3 to about 7, preferably about 4 to about 6. The cheese or cheese-like product may have a pH of at least 4. The cheese or cheese-like product may have a pH of at most 6. The cheese or cheese-like product may have a pH of 4 to 4.5, 4 to 5, 4 to 5.1, 4 to 5.2, 4 to 5.5, 4 to 6, 4.5 to 5, 4.5 to 5.1, 4.5 to 5.2, 4.5 to 5.5, 4.5 to 6, 5 to 5.1, 5 to 5.2, 5 to 5.5, 5 to 6, 5.1 to 5.2, 5.1 to 5.5, 5.1 to 6, 5.2 to 5.5, 5.2 to 6, 5.5 to 6, 5.6 to 6, 5.6 to 5.9 or 5.6 to 5.8. The cheese or cheese-like product may have a pH of about 3, about 3.5, about 4, about 4.5, about 5, about 5.1, about 5.2, about 5.5, about 5.6, about 5.7, about 6, about 6.5, or about 7. The cheese or cheese-like product may have a pH of at least 3, 3.5, 4, 4.5, 5, 5.1, 5.2, 5.5, or 5.7. The cheese or cheese-like product may have a pH of at most 4.5, 5, 5.1, 5.2, 5.5, 5.6, 5.7, 6, 6.5, or 7. Preferably, the cheese or cheese-like product has a pH of from about 4.6 to about 5.5, about 4.6 to about 5.6, about 4.6 to about 5.4, from about 4.6 to about 5.2, from about 4.6 to about 5.0, from about 4.7 to about 5.0, or from about 4.7 to about 4.9.

[0065] In various embodiments the cheese or cheese-like product may comprise

30 a) one or more emulsifying salts,

b) about 15 to about 65% by weight moisture,

c) about 0.05 to about 35% by weight lipid, or

d) any combination of any two or more of a)-c).

[0066] In various embodiments the cheese or cheese-like product comprises one or more vegetable or animal lipids.

[0067] In some embodiments the cheese or cheese-like product comprises at least about 0.01, 0.1, 0.25, 0.5, 0.75, 1, 2, 2.5, 3, 4, 5, 6, 7, 7.5, 8, 9, 10, 11, 12, 12.5, 13, 14, 15, 16, 17, 17.5, 18, 19, 20, 21, 22, 22.5, 23, 24, 25, 26, 27, 27.5, 28, 29, 30, 31, 32, 33, 34 or at least about 35% by weight lipid, and suitable ranges may be selected from between any of these values, for example, from about 0.01 to about 35%, about 0.5 to about 35%, about 1 to about 35%, about 5 to about 35%, 0.01 to about 30%, about 0.5 to about 30%, about 1 to about 30%, about 5 to about 30%, 0.01 to about 25%, about 0.5 to about 25%, about 1 to about 25%, or about 5 to about 25% by weight lipid.

[0068] In various embodiments the cheese is a processed cheese or the cheese-like product is a processed cheese-like product, such as a processed cheese spread or "slice-on-slice" processed cheese. In other embodiments the cheese or cheese-like product is a pasta filata cheese or pasta filata cheese-like product, such as mozzarella or a mozzarella-like product, pizza cheese or a pizza cheese analogue, or a spreadable cheese.

[0069] In one embodiment, the cheese or cheese-like product has a Schreiber melt test value ≥ 3 , but more preferably a melt test value between about 6 to about 7.

[0070] In various embodiments the method may comprise

- a) providing an aqueous composition comprising α_s -casein, β -casein, or a combination thereof
- b) adding the one or more hydrocolloids, lipid and, optionally, the one or more additional ingredients, to the aqueous composition to produce a cheese composition,
- c) heating the cheese composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- d) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product.

[0071] In various embodiments the method may comprise

- a) providing an aqueous composition comprising α_s -casein, β -casein, or a combination thereof,

- b) adding lipid to the aqueous composition and mixing to form an emulsion,
- c) adding the emulsion to a second aqueous composition comprising the one or more hydrocolloids and, optionally, the one or more additional ingredients, to produce a cheese,
- 5 d) heating the cheese composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- e) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product.

[0072] In various embodiments the method may comprise dispersing the α_s -casein and/or β -casein in water at a temperature of from about 20 to about 50°C to substantially completely dissolve the α_s -casein and/or β -casein to produce the aqueous composition.

[0073] In various embodiments the method may comprise dispersing α_s -casein in water at a temperature of from about 40 to about 55°C to substantially completely dissolve the α_s -casein to produce the aqueous composition.

[0074] In various embodiments the method may comprise dispersing β -casein in water at a temperature of from about 15 to about 30°C, or at ambient temperature, to substantially completely dissolve the β -casein to produce the aqueous composition.

[0075] In various embodiments the method may comprise providing an aqueous composition comprising a protein ingredient comprising an α_s -casein enriched fraction, a β -casein enriched fraction, recombinant α_{s1} -casein, recombinant α_{s2} -casein, recombinant β -casein, or any combination of any two or more thereof.

[0076] In various embodiments the method comprises heating at a temperature of at least about 70, 75, 80, 85, 90, 95, 100, 105, 110, 115 or 120°C, and suitable ranges may be selected from between any two or these values, for example, from about 70 to about 120°C, 70 to about 110°C, about 70 to about 100°C, about 70 to about 95°C, about 70 to about 90°C, about 70 to about 85°C, about 70 to about 80°C, about 75 to about 120°C, 75 to about 110°C, about 75 to about 100°C, about 75 to about 95°C, about 75 to about 90°C, about 75 to about 85°C, or about 75 to about 80°C.

[0077] In various embodiments the method may comprise subjecting the composition to mixing under agitation during heating.

[0078] In various embodiments the method comprises adjusting the pH during, after, or both during and after heating to a pH of from about 4 to about 6.

[0079] In various embodiments the method comprises heating for a period of at least about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 20, 35, 30, 35, 40, 45, 50 or 60 minutes, and suitable ranges may be selected from between any two or these values, for example, from about 1 to about 60 minutes, about 1 to about 45 minutes, about 1 to about 30 minutes, about 1 to about 15 minutes, about 3 to about 60 minutes, about 3 to about 45 minutes, about 3 to about 30 minutes, from about 3 to about 15 minutes, about 3 to about 12 minutes or about 3 to about 10 minutes.

10 **[0080]** The term "variant" as used herein may include proteins comprising an amino acid sequence having at least about 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98% or at least about 99% sequence identity to the sequence of any native (wild type) α_{s1} -casein, α_{s2} -casein, or β -casein from any species, but particularly any native bovine, ovine, caprine, buffalo, equine, camel, or human α_{s1} -casein, α_{s2} -casein, or β -casein
15 sequence, including any sequence of SEQ ID Nos:1-40. In some embodiments the amino acid sequence of such variants may comprise truncations or elongations at the N-terminus and/or the C-terminus with respect to the native sequence, for example, elongations or truncations of from about 1 to about 10 residues. In some embodiments, variants may contain from 1 to 10 amino acid insertions, deletions, and/or substitutions
20 (collectively) with respect to the native sequence. In some embodiments the variants comprise one or more post-translational modifications that differ to a native α_{s1} -casein, α_{s2} -casein, or β -casein protein, including glycosylation and or phosphorylation at one or more residues.

[0081] The term "comprising" as used in this specification and claims means
25 "consisting at least in part of". When interpreting statements in this specification and claims which include the term "comprising", other features besides the features prefaced by this term in each statement can also be present. Related terms such as "comprise" and "comprised" are to be interpreted in similar manner.

[0082] As used herein the term "and/or" means "and" or "or", or both.

30 **[0083]** It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9 and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5 and 3.1 to 4.7) and, therefore, all sub-ranges of all ranges expressly disclosed herein are hereby expressly

disclosed. These are only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

- 5 **[0084]** To those skilled in the art to which the invention relates, many changes in construction and differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.
- 10 **[0085]** This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed
- 15 to be incorporated herein as if individually set forth.

DETAILED DESCRIPTION OF THE INVENTION

- [0086]** The present invention relates to the use of protein compositions comprising one or more caseins as functional ingredients in the preparation of cheeses, cheese-like products and methods for manufacture of such products, particularly processed cheeses
- 20 and processed cheese-like products. Preferably, the cheese and cheese-like products of the invention are produced with minimal amounts of milk proteins, or with recombinant milk proteins that are not derived from milk, to produce cheese-like products that are acceptable to those who wish to lower their dairy intake, or who identify as vegetarians and vegans. The invention particularly makes use of α_s -casein, β -casein, and/or blends of
- 25 α_s -caseins, β -caseins, and, optionally, specific α_s -casein and/or β -casein fractions that, when combined with starches and/or gums, produce processed cheese-like structure, flavour and mouthfeel, using surprisingly low amounts of protein.

- [0087]** The present invention utilises casein proteins that interact with other proteins, simple carbohydrates, complex carbohydrates, fats, oils, gums, emulsifying
- 30 agents, salt (sodium and/or potassium chloride), ions (both cations and anions), starches and/or other GRAS ingredients to produce functional ingredients and foods.

Caseins and casein compositions

[0088] The present invention utilises casein proteins or blends of casein proteins, in particular, α_s -casein and/or β -casein, to produce cheese, such as processed cheese, and cheese-like products.

- 5 **[0089]** Following casein synthesis in mammary gland tissue, posttranslational phosphorylation occurs at selected serine residues in the primary structures of each of these caseins. The caseins in milk then form ionic bonds with calcium phosphate in combination with hydrophobic interactions between other caseins to create aggregates identified as casein micelles. (Farrell, J. M., Jr., R. Jimenez-Flores, G. T. Bleck, E. M. Brown, J. E. Butler, L. K. Creamer, C. L. Hicks, C. M. Hollar, K. F. Ng-Kwai-Hang, and H. E. Swaisgood. 2004. Nomenclature of the proteins of cow's milk, 6th revision. Dairy Sci. 87:1641-1674).
- 10

- [0090]** Casein proteins for use herein may include α_{s1} -casein, α_{s2} -casein, β -casein, γ -casein, κ -casein, p- κ -casein, and/or variants thereof. In various embodiments, the casein may be α_s -casein or β -casein.
- 15

[0091] Cow's milk typically comprises about 48% α_s -casein as a proportion of total casein, and about 36% β -casein as a proportion of total casein, as shown in Table 1 below (Davies and Law. 1980. J. Dairy Res. 47:83-90).

- [0092]** An average ratio of casein proteins in cow's milk is about 3:0.8:3:1 of α_{s1} -casein: α_{s2} -casein: β -casein: κ -casein (Brown and Ernstrom. 1988. Milk clotting enzymes and cheese chemistry Part I: Milk clotting enzymes in Fundamentals of dairy chemistry 3rd ed.; Schmidt, 1982. Association of caseins and casein micelle structure. In Dairy Chemistry. Col. 1. P. F. Fox, et.c Appl. Sci. Pub., Ltd., Essex, England).
- 20

Table 1. Theoretical milk casein content

Casein type	Casein (% by weight)
α_{s1} -casein	38
α_{s2} -casein	10
β -casein	36
κ -casein	13
γ -casein	3
Total	100.00

25

- [0093]** In various embodiments the α_s -casein may comprise α_{s1} -casein, α_{s2} -casein, or a combination thereof.

[0094] In various embodiments, the α_s -casein may be encoded by a protein sequence selected from SEQ ID NO. 1-26 or a variant thereof with at least 70%, 75%, 80%, 85%, 90%, 95%, 96%, 98%, or 99% sequence identity.

[0095] In various embodiments the α_s -casein comprises, or is provided by an ingredient that comprises or is enriched in, α_{s1} -casein and/or α_{s2} -casein, for example, α_s -casein-enriched fractions.

[0096] The term " α_s -casein-enriched fraction" as used herein refers to compositions fractionated from milk having a ratio of α_s -casein to β -casein that is greater than that of skim milk (1:0.94, as measured by polyacrylamide gel electrophoresis followed by staining with Coomassie Blue and densitometry. Other suitable analytical methods are also known to the skilled addressee). Preferably, the ratio is higher than 1.3:1, more preferably higher than 1.6:1, more preferably higher than 2:1, most preferably higher than 3:1. α_s -Casein-enriched fractions are enriched in at least one of α_{s1} and α_{s2} -casein, generally both, relative to casein in the casein source from which it was prepared (generally cows' milk).

[0097] In some embodiments, the α_s -casein-enriched fractions comprise at least about 55% by weight α_s -casein relative to total casein, preferably about 60%, more preferably about 65%, more preferably about 70%, more preferably about 75%, most preferably about 80% by weight α_s -casein relative to total casein. In a preferred embodiment, the α_s -casein-enriched fractions comprise at least about 55% by weight α_s -casein relative to total casein.

[0098] In some embodiments, the α_s -casein-enriched fractions may be prepared as described in published PCT application WO2007/100264 or WO 2009/108074 (hereby incorporated by reference in their entirety). Other methods that may be used will be apparent to those skilled in the art. For example, cold microfiltration may be used for at least part of the enrichment or depletion, for example, as described in US Patent 5,169,666.

[0099] In various embodiments, α_s -casein enriched fractions are prepared by fractionating lactic casein as described herein in the examples. Briefly, pasteurised skim milk is incubated with dairy starter cultures under acid conditions to produce lactic casein.

[00100] The lactic casein is dispersed in water to produce a slurry comprising solubilised casein. The temperature is adjusted to less than about 7°C and the pH of the slurry adjusted to about pH 10. Calcium chloride (dihydrate) is added to the slurry to

produce a coagulum. The curd is obtained, washed and dried to provide an α_s -casein enriched fraction.

5 **[00101]** In various embodiments the α_s -casein comprises one or more recombinant α_s -casein proteins. The use of recombinant proteins provides for the manufacture of cheeses or cheese-like products that comprise no ingredients derived from animals.

[00102] In various embodiments the recombinant α_s -casein protein comprises a variant of an α_s -casein protein.

10 **[00103]** In various embodiments the recombinant α_s -casein comprises a native α_{s1} -casein protein, a native α_{s2} -casein protein, a variant of α_{s1} -casein or α_{s2} -casein, or a combination thereof. In various embodiments the recombinant α_s -casein protein has an amino acid sequence of any one of SEQ ID Nos: 1-26. In various embodiments the variant of α_{s1} -casein or α_{s2} -casein has an amino acid sequence having at least about 70%, 75%, 80%, 85%, 90%, 95%, 96%, 98%, or 99% sequence identity to a sequence of SEQ ID Nos: 1-26.

15 **[00104]** In various embodiments, the β -casein may be encoded by a protein sequence selected from SEQ ID NO. 27-40 or a variant thereof with at least 70%, 75%, 80%, 85%, 90%, 95%, 96%, 98%, or 99% sequence identity.

20 **[00105]** In various embodiments the β -casein comprises, or is provided by an ingredient that comprises or is enriched in, β -casein, for example, β -casein-enriched fractions.

25 **[00106]** The term " β -casein-enriched fraction" as used herein refers to compositions fractionated from milk having a ratio of β -casein to α_s -casein that is greater than that of skim milk (0.94:1, as measured by polyacrylamide gel electrophoresis followed by staining with Coomassie Blue and densitometry. Other suitable analytical methods are also known to the skilled addressee). Preferably, the ratio is higher than 1:1, more preferably higher than 1.2:1, more preferably higher than 1.4:1, more preferably higher than 1.5:1, more preferably higher than 1.6:1, most preferably higher than 1.7:1. β -casein enriched fractions are enriched in β -casein relative to casein in the casein source from which it was prepared (generally cows' milk).

30 **[00107]** In some embodiments, the β -casein-enriched fractions comprise at least about 40% by weight β -casein relative to total casein, preferably at least about 45%, more preferably at least about 50%, more preferably at least about 52%, most preferably at least about 54%, by weight β -casein relative to total casein. In a preferred

embodiment, the β -casein-enriched fractions comprise at least about 40% by weight β -casein relative to total casein.

5 [00108] In some embodiments, the β -casein-enriched fractions may be prepared as described in published PCT application WO2007/100264 or WO2009/108074 (hereby incorporated by reference in their entirety). Other methods that may be used will be apparent to those skilled in the art. For example, cold microfiltration may be used for at least part of the enrichment or depletion, for example, as described in US Patent 5,169,666.

10 [00109] In various embodiments, β -casein enriched fractions are prepared by fractionating lactic casein as described herein in the examples. Briefly, pasteurised skim milk is incubated with dairy starter cultures under acid conditions to produce lactic casein.

15 [00110] The lactic casein is dispersed in water to produce a slurry comprising solubilised casein. The temperature is adjusted to less than about 7°C and the pH of the slurry adjusted to about pH 10. Calcium chloride (dihydrate) is added to the slurry to produce a coagulum. The liquid is obtained, and pH adjusted to 4.3-4.4 to produce a second coagulum. This second coagulum is washed and dried to provide a β -casein enriched fraction.

20 [00111] In various embodiments the β -casein comprises one or more recombinant β -casein proteins.

[00112] In various embodiments the recombinant β -casein comprises a native recombinant β -casein, a variant of β -casein, or a combination thereof. In various embodiments the recombinant β -casein protein has an amino acid sequence of any one of SEQ ID Nos: 27-40. In various embodiments the variant of α_{s1} -casein or α_{s2} -casein has an amino acid sequence having at least about 70%, 75%, 80%, 85%, 90%, 95%, 96%, 98%, or 99% sequence identity to a sequence of SEQ ID Nos: 27-40.

Recombinant expression

30 [00113] One or more proteins used in the formation of the cheese or cheese-like products may be produced recombinantly. In some cases, the α_s -casein and/or β -casein is produced recombinantly.

[00114] α_{s1} -casein, α_{s2} -casein, and/or β -casein can have an amino acid sequence from any species. For example, recombinant α_s -casein and/or β -casein may have an amino acid sequence of cow, human, sheep, goat, buffalo, bison, pig, horse or camel α_s -

- casein and/or β -casein. The casein nucleotide sequence may be codon-optimized for increased efficiency of production. Exemplary α _s-casein protein sequences are provided as SEQ ID NOs: 1-26 and exemplary β -casein protein sequences are provided as SEQ ID NOs: 27-40 in Table 2 below. Recombinant α _s-casein and/or β -casein can be a non-
- 5 naturally occurring variant of an α _s-casein and/or β -casein. Such a variant can comprise one or more amino acid insertions, deletions, or substitutions relative to a native casein sequence. For example, such variants may include an amino acid sequence or peptide truncated at the N-terminus and/or C-terminus, preferably by from 1 to 10 amino acids, for example by 1, 2, 3, or about 5 amino acids, relative to a native casein sequence.
- 10 Such variants may include an amino acid sequence or peptide elongated at the N-terminus and/or C-terminus, preferably by from 1 to 10 amino acids, for example by 1, 2, 3, or about 5 amino acids, relative to a native casein sequence. In some embodiments, variants may contain from 1 to 10 amino acid insertions, deletions, and/or substitutions (collectively) with respect to the native sequence. For example, such
- 15 variants may have from 1 to about 5 amino acid insertions, deletions, and/or substitutions (collectively) with respect to the native sequence. The degree and location of glycosylation or other post-translation modifications may vary depending on the chosen host cells and the nature of the host cellular environment. Partial hydrolytic products of α _s-casein and/or β -casein are also encompassed by the term "variant".
- 20 **[00115]** Such a variant can have at least 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% sequence identity to SEQ ID NOs: 1-40. The term "sequence identity" as used herein in the context of amino acid sequences is defined as the percentage of amino acid residues in a candidate sequence that are identical with the amino acid residues in a selected sequence, after aligning the sequences and introducing gaps, if necessary, to
- 25 achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Alignment for purposes of determining percent amino acid sequence identity can be achieved in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST, BLAST-2, ALIGN, ALIGN-2 or Megalign (DNASTAR) software. Those skilled in the art can
- 30 determine appropriate parameters for measuring alignment, including any algorithms needed to achieve maximal alignment over the full-length of the sequences being compared.
- [00116]** A recombinant α _s-casein and/or β -casein is recombinantly expressed in a host cell. As used herein, a "host" or "host cell" denotes any protein production host
- 35 selected or genetically modified to produce a desired product. Exemplary hosts include fungi, such as filamentous fungi, as well as bacteria, yeast, algae, plant, insect, and mammalian cells.

[00117] Host cells comprising genetic constructs, such as expression constructs, as disclosed herein are useful in methods well known in the art (e.g. Sambrook *et al.*, Molecular Cloning : A Laboratory Manual, 2nd Ed. Cold Spring Harbor Press, 1987; Ausubel *et al.*, Current Protocols in Molecular Biology, Greene Publishing, 1987) for recombinant production of polypeptides disclosed herein. Such methods may involve the culture of host cells in an appropriate medium in conditions suitable for or conducive to expression of a polynucleotide or polypeptide disclosed herein. The expressed recombinant polypeptide, which may optionally be secreted into the culture, may then be separated from the medium, host cells or culture medium by methods well known in the art (e.g. Deutscher, Ed, 1990, Methods in Enzymology, Vol 182, Guide to Protein Purification).

[00118] In some cases, a bacterial host cell such as *Lactococcus lactis*, *Bacillus subtilis* or *Escherichia coli* may be used to produce α -, β -and/or κ -casein proteins. Other host cells include bacterial host such as, but not limited to, *Lactococci* sp., *Lactococcus lactis*, *Bacillus subtilis*, *Bacillus amyloliquefaciens*, *Bacillus licheniformis* and *Bacillus megaterium*, *Brevibacillus choshinensis*, *Mycobacterium smegmatis*, *Rhodococcus erythropolis* and *Corynebacterium glutamicum*, *Lactobacilli* sp., *Lactobacillus fermentum*, *Lactobacillus casei*, *Lactobacillus acidophilus*, *Lactobacillus plantarum* and *Synechocystis* sp. 6803.

[00119] In some embodiments, the host cell is a yeast cell selected from the list consisting of *Saccharomyces cerevisiae*, *Schizosaccharomyces pombe*, *Yarrowia lipolytica*, *Candida glabrata*, *Ashbya gossypii*, *Cyberlindnera jadinii*, *Pichia pastoris*, *Pichia methanolica*, *Kluyveromyces lactis*, *Hansenula polymorpha*, *Candida boidinii*, *Arxula adeninivorans*, *Xanthophyllomyces dendrorhous*, and *Candida albicans* species. In some embodiments, the yeast cell is a *Saccharomycete*.

[00120] In some embodiments, the host cell is a fungal cell selected from the list consisting of *Aspergillus* spp. and *Trichoderma* spp.

[00121] Expression of a target protein can be provided by an expression vector, a plasmid, a nucleic acid integrated into the host genome or other means. For example, a vector for expression can include: (a) a promoter element, (b) a signal peptide, (c) a heterologous casein sequence, and (d) a terminator element.

[00122] Methods for producing and using genetic constructs and expression vectors are well known in the art and are described generally in Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, 2nd Ed. Cold Spring Harbor Press, 1987; Ausubel *et al.*, Current Protocols in Molecular Biology, Greene Publishing, 1987).

- [00123]** Expression vectors that can be used for expression of α_s -casein and/or β -casein include those containing an expression cassette with elements (a), (b), (c) and (d). In some embodiments, the signal peptide (c) need not be included in the vector. In some cases, a signal peptide may be part of the native signal sequence of the casein protein, for instance, the protein may comprise a native signal sequence as bolded in SEQ ID NOs: 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, or 39. In some cases, the vector comprises a polynucleotide encoding a protein sequence as exemplified in SEQ ID NOs: 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, or 39. In some cases, the vector may comprise a polynucleotide encoding a mature protein sequence, as exemplified in SEQ ID NOs: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, or 40 with a heterologous signal sequence. In general, the expression cassette is designed to mediate the transcription of the transgene when integrated into the genome of a cognate host microorganism or when present on a plasmid or other replicating vector maintained in a host cell.
- [00124]** To aid in the amplification of the vector prior to transformation into the host microorganism, a replication origin (e) may be contained in the vector. To aid in the selection of microorganism stably transformed with the expression vector, the vector may also include a selection marker (f). The expression vector may also contain a restriction enzyme site (g) that allows for linearization of the expression vector prior to transformation into the host microorganism to facilitate the expression vectors stable integration into the host genome. In some embodiments the expression vector may contain any subset of the elements (b), (e), (f), and (g), including none of elements (b), (e), (f), and (g). Other expression elements and vector element known to one of skill in the art can be used in combination or substituted for the elements described herein. For example, because many microorganisms are capable of expressing multiple gene products from a polycistronic mRNA, multiple polypeptides can be expressed under the control of a single regulatory region for those microorganisms, if desired. These might include one or more α_s -casein proteins, one or more β -casein proteins, one or more different dairy proteins (e.g. one or more caseins), and/or one or more non-dairy proteins.

Table 2: Sequences

SEQ ID No.	Name	Sequence
1	Bovine α_{s1} -casein	MKLLILTCLVAVALAR PKHPIKHQGLPQEVNLNENLLRFFV APFPEVFGKEKVNELSKDIGSESTEDQAMEDIKQMEAESI SSSEEIVPNSVEQKHIQKEDVPSEYLGYLEQLLRLLKKYKV PQLEIVPNSAEERLHSMKEGIHAQQKEPMIGVNQELAYFY PELFRQFYQLDAYPSGAWYYVPLGTQYTDAPSFSDIPNPIG SENSEKTTMPLW
2	Bovine α_{s1} -casein mature protein	RPKHPIKHQGLPQEVNLNENLLRFFVAPFPEVFGKEKVNELS KDIGSESTEDQAMEDIKQMEAESISSSEEIVPNSVEQKHI QKEDVPSEYLGYLEQLLRLLKKYKVPQLEIVPNSAEERLHSM KEGIHAQQKEPMIGVNQELAYFYPELFRQFYQLDAYPSG AWYYVPLGTQYTDAPSFSDIPNPIGSENSEKTTMPLW
3	Ovine α_{s1} -casein	MKLLILTCLVAVALAR PKHPIKHQGLSSEVLNENLLRFV VAPFPEVFRKENINELSKDIGSESIEDQAMEDAKQMKAGS SSSSEEIVPNSAEQKYIQKEDVPSEYLGYLEQLLRLLKKYN VPQLEIVPKSAEEQLHSMKEGNPAHQKQPMIAVNQELAYF YPQLFRQFYQLDAYPSGAWYYLPLGTQYTDAPSFSDIPNPI GSENSGKITMPLW
4	Ovine α_{s1} -casein mature protein	RPKHPIKHQGLSSEVLNENLLRFVAPFPEVFRKENINELS KDIGSESIEDQAMEDAKQMKAGSSSSSEEIVPNSAEQKYI QKEDVPSEYLGYLEQLLRLLKKYNVPQLEIVPKSAEEQLHSM KEGNPAHQKQPMIAVNQELAYFYYPQLFRQFYQLDAYPS GAWYYLPLGTQYTDAPSFSDIPNPIGSENSGKITMPLW
5	Caprine α_{s1} -casein	MKLLILTCLVAVALAR PKHPINHRGLSPEVPNENLLRFV VAPFPEVFRKENINELSKDIGSESTEDQAMEDAKQMKAGSS SSSEEIVPNSAEQKYIQKEDVPSEYLGYLEQLLRLLKKYNV PQLEIVPKSAEEQLHSMKEGNPAHQKQPMIAVNQELAYFY PQLFRQFYQLDAYPSGAWYYLPLGTQYTDAPSFSDIPNPIG SENSGKITMPLW
6	Caprine α_{s1} -casein mature protein	RPKHHPINHRGLSPEVPNENLLRFVAPFPEVFRKENINELS KDIGSESTEDQAMEDAKQMKAGSSSSSEEIVPNSAEQKY IQKEDVPSEYLGYLEQLLRLLKKYNVPQLEIVPKSAEEQLH SMKEGNPAHQKQPMIAVNQELAYFYYPQLFRQFYQLDAYPS GAWYYLPLGTQYTDAPSFSDIPNPIGSENSGKITMPLW
7	Buffalo α_{s1} -casein	MKLLILTCLVAVALAR PKQPIKHQGLPQGVLNENLLRFF VAPFPEVFGKEKVNELSTDIGSESTEDQAMEDIKQMEAES ISSSEEIVPISVEQKHIQKEDVPSEYLGYLEQLLRLLKKYNV PQLEIVPNLAAEQHSMKEGIHAQQKEPMIGVNQELAYFY PQLFRQFYQLDAYPSGAWYYVPLGTQYTDAPSFSDIPNPI GSENSEKTTMPLW
8	Buffalo α_{s1} -casein mature protein	RPKQPIKHQGLPQGVLNENLLRFFVAPFPEVFGKEKVNELS TDIGSESTEDQAMEDIKQMEAESISSSEEIVPISVEQKHIQ KEDVPSEYLGYLEQLLRLLKKYNVPQLEIVPNLAAEQHSM KEGIHAQQKEPMIGVNQELAYFYYPQLFRQFYQLDAYPSGA WYYVPLGTQYTDAPSFSDIPNPIGSENSEKTTMPLW

SEQ ID No.	Name	Sequence
9	Equine α_{s1} -casein	MKLLILTCLVAVALAR PKLPHRQPEIIQNEQDSREKVLKERKFPSFALEYINELNRQRELLKEKQKDEHKEYLIEDPEQQESSSTSSSEEVVPINTEQKRIPREDMLYQHTLEQLRRRLSKYNQLQLQAIHAQEQLIRMKENSQRKPMRVVNQEAYFYLEPFQPSYQLDVYPYAAWFHFAQIMQHVAISPFHDTAKLIASENSEKTDIPEW
10	Equine α_{s1} -casein mature protein	RPKLPHRQPEIIQNEQDSREKVLKERKFPSFALEYINELNRQRELLKEKQKDEHKEYLIEDPEQQESSSTSSSEEVVPINTEQKRIPREDMLYQHTLEQLRRRLSKYNQLQLQAIHAQEQLIRMKENSQRKPMRVVNQEAYFYLEPFQPSYQLDVYPYAAWFHFAQIMQHVAISPFHDTAKLIASENSEKTDIPEW
11	Camel α_{s1} -casein	MKLLILTCLVAVALAR PKYPLRYPEVFQNEPDSIEEVLNKRKILELAVVSPIQFRQENIDELKDTRNEPTEDHIMEDTERKESGSSSSSEEVVSSTTEQKDILKEDMPSQRYLEELHRLNKKLLQLEAIRDQKLIPRVKLSHPYLEQLYRINEDNHPQLGEPVKVVTQEAYFHLEPFQFFQLGASPYVAWYPPQVMQYIAHPSSYDTPEGIASEDGGKTDVMPQWW
12	Camel α_{s1} -casein mature protein	RPKYPLRYPEVFQNEPDSIEEVLNKRKILELAVVSPIQFRQENIDELKDTRNEPTEDHIMEDTERKESGSSSSSEEVVSSTTEQKDILKEDMPSQRYLEELHRLNKKLLQLEAIRDQKLIPRVKLSHPYLEQLYRINEDNHPQLGEPVKVVTQEAYFHLEPFQFFQLGASPYVAWYPPQVMQYIAHPSSYDTPEGIASEDGGKTDVMPQWW
13	Human α_{s1} -casein	MRLLILTCLVAVALAR PKLPLRYPERLQNPSESSEPIPLESREEYMNGMNRQRNIREKQTDDEIKDTRNESTQNCVVAEPEKMESSISSSSEEMSLSKCAEQFCRLNEYNQLQLQAAHAQEIQIRRMNENSHVQVPFQQLNQLAAYPYAVWYYPQIMQYVFPFSDISNPTAHENYEKNNVMLQW
14	Human α_{s1} -casein mature protein	RPKLPLRYPERLQNPSESSEPIPLESREEYMNGMNRQRNIREKQTDDEIKDTRNESTQNCVVAEPEKMESSISSSSEEMSLSKCAEQFCRLNEYNQLQLQAAHAQEIQIRRMNENSHVQVPFQQLNQLAAYPYAVWYYPQIMQYVFPFSDISNPTAHENYEKNNVMLQW
15	Bovine α_{s2} -casein	MKFFIFTCLLAVALAK NTMEHVSSEESIISQETYKQEKMAINPSKENLCSTFCKEVVRNANEEYSSIGSSSEESAIEVATEEVKITVDDKHQKALNEINQFYQKFPQYLQYLYQGPIVLNPWDQVKRNAVPITPTLNREQLSTSEENSKKTVDMESTE VFTKKTCLTEEEKNRLNFLKKISQRYQKFALPQYLKTVYQH QKAMKPWIPKTKVIPYVRYL
16	Bovine α_{s2} -casein mature protein	KNTMEHVSSEESIISQETYKQEKMAINPSKENLCSTFCKEVVRNANEEYSSIGSSSEESAIEVATEEVKITVDDKHQKALNEINQFYQKFPQYLQYLYQGPIVLNPWDQVKRNAVPITPTLNREQLSTSEENSKKTVDMESTE VFTKKTCLTEEEKNRLNFLKKISQRYQKFALPQYLKTVYQH QKAMKPWIPKTKVIPYVRYL

SEQ ID No.	Name	Sequence
17	Ovine α_{s2} -casein	MKFFIFTCLLAVALAK HKMEHVSSEEPINISQEIYKQE KNMAIHPRKEKLCTTSCEEVVRNADEEEYSIRSSSEESAE VAPEEVKITVDDKHQYKALNEINQFYQKFPQYLQYLYQGPI VLNPWDQVKRNAGPFTPTVNREQLSTSEENSKKTIDMES TEVFTKKTKLTEEEKNRLNFKKISQYYQKFAWPQYLKTV DQHQAAMKPWTQPKTNAIPYVRYL
18	Ovine α_{s2} -casein mature protein	KHKMEHVSSEEPINISQEIYKQEKMAIHPRKEKLCTTS CEEVVRNADEEEYSIRSSSEESAEVAPEEVKITVDDKHQY KALNEINQFYQKFPQYLQYLYQGPIVLNPWDQVKRNAGPF TPTVNREQLSTSEENSKKTIDMESTEVFTKKTKLTEEEKNR LNFLKKISQYYQKFAWPQYLKTV DQHQAAMKPWTQPKTN AIPYVRYL
19	Caprine α_{s2} -casein	MKFFIFTCLLAVALAK HKMEHVSSEEPINIFQEIYKQEK NMAIHPRKEKLCTTSCEEVVRNANEEYYSIRSSSEESAEV APEEIKITVDDKHQYKALNEINQFYQKFPQYLQYPYQGPIV LNPWDQVKRNAGPFTPTVNREQLSTSEENSKKTIDMEST EVFTKKTKLTEEEKNRLNFKKISQYYQKFAWPQYLKTV DQHQAAMKPWTQPKTNAIPYVRYL
20	Caprine α_{s2} -casein mature protein	KHKMEHVSSEEPINIFQEIYKQEKMAIHPRKEKLCTTS CEEVVRNANEEYYSIRSSSEESAEVAPEEIKITVDDKHQYK ALNEINQFYQKFPQYLQYPYQGPIVLNPWDQVKRNAGPFT PTVNREQLSTSEENSKKTIDMESTEVFTKKTKLTEEEKNRLN FLKKISQYYQKFAWPQYLKTV DQHQAAMKPWTQPKTNAI PYVRYL
21	Buffalo α_{s2} -casein	MKFFIFTCLLAVALAK HMTMEHVSSEESIISQETYKQEK NMAIHPSKENLCSTFCKEVIRNANEEYYSIGSSSEESAEVA TEEVKITVDDKHQYKALNEINQFYQKFPQYLQYLYQGPIV LNPWDQVKRNAGPFTPTLNREQLSTSEENSKKTIDMEST EVFTKKTKLTEEDKNRLNFKKISQHYQKFAWPQYLKTVYQ YQKAMKPWTQPKTNVIPYVRYL
22	Buffalo α_{s2} -casein mature protein	KHMTMEHVSSEESIISQETYKQEKMAIHPSKENLCSTFC KEVIRNANEEYYSIGSSSEESAEVATEEVKITVDDKHQYK ALNEINQFYQKFPQYLQYLYQGPIVLNPWDQVKRNAGPFT PTLNREQLSTSEENSKKTIDMESTEVFTKKTKLTEEDKNR LNFLKKISQHYQKFAWPQYLKTVYQYQKAMKPWTQPKTN VIPYVRYL
23	Equine α_{s2} -casein	MKFFIFTCLLAVALAK HNMMEHRSSSEDSVNISQEKFKQ EKYVVIPTSKESICSTSCCEATRNNINEMESAKFPTEREEKE VEEKHHLKQLNKINQFYKLNFLQYLQALRQPRIVLTPWD QTKTGDSFPFIPVNTQLFTSEEIPKKTVDMESTEVEVTEKT ELTEEEKNYLKLLEYEFTLPQYFKIVRQHQTMDPRSHRK TNSYQIIPVLRYP
24	Equine α_{s2} -casein mature protein	KHNMMEHRSSSEDSVNISQEKFKQEKYVVIPTSKESICST SCCEATRNNINEMESAKFPTEREEKEVEEKHHLKQLNKINQ FYKLNFLQYLQALRQPRIVLTPWDQTKTGDSFPFIPVNTQL FTSEEIPKKTVDMESTEVEVTEKTELTEEEKNYLKLLEYEFT LPQYFKIVRQHQTMDPRSHRK TNSYQIIPVLRYP

SEQ ID No.	Name	Sequence
25	Camel α_{s2} -casein	MKFFIFTCLLAVVLAK HEMDQGSSEESINVSQQKFKQ VKKVAIHPSKEDICSTFCEEAVRNIKEVESAEVPTENKISQ FYQKWKFLQYLQALHQGGQIVMNPWDQGKTRAYPFIPTVN TEQLSISEESTEVPTTEESTEVFTKKTELTEEEKDHQKFLNKI YQYYQTFLWPEYLTQYQYQKTMTPWNHIKRYF
26	Camel α_{s2} -casein mature protein	KHEMDQGSSEESINVSQQKFKQVKKVAIHPSKEDICSTF CEEAVRNIKEVESAEVPTENKISQFYQKWKFLQYLQALHQ GQIVMNPWDQGKTRAYPFIPTVNTEQLSISEESTEVPTTE STEVFTKKTELTEEEKDHQKFLNKIYQYYQTFLWPEYLTQ YQYQKTMTPWNHIKRYF
27	Bovine β -casein	MKVLILACLVALALARE EELNVPGEIVESLSSEESITRI NKKIEKFQSEEQQTDELQDKIHFAQTQSLVYFPFGPI NSLPQNIPLTQTTPVVPPFLQPEVMGVSKVKEAMAPKHK EMPFKYPVEPFTESQSLTLTDVENLHPLPLQSWMHQP HQPLPTVMFPPQSVLSLSQSKVLPVPQKAVPYPQRDMPI QAFLLYQEPVLGPVRGPFPIIV
28	Bovine β -Casein Mature protein	RELEELNVPGEIVESLSSEESITRINKKIEKFQSEEQQT DELQDKIHFAQTQSLVYFPFGPIPNLQNIPLTQTTPV VPPFLQPEVMGVSKVKEAMAPKHKEMPFKYPVEPFTESQ SLTLTDVENLHPLPLQSWMHQPHQPLPTVMFPPQSVL SLSQSKVLPVPQKAVPYPQRDMPIQAFLLYQEPVLGPVRG PFPIIV
29	Ovine β -Casein	MKVLILACLVALALARE QEELNVVGETVESLSSEESIT HINKKIEKFQSEEQQTDELQDKIHFAQAQSLVYFPFG PIPNLQNIPLTQTTPVVPPFLQPEIMGVPKVKETMVPK HKEMPFKYPVEPFTESQSLTLTDVEKLHPLPLVQSWMH QPPQPLPTVMFPPQSVLSLSQPKVLPVPQKAVPQRDMPI QAFLLYQEPVLGPVRGPFPIIV
30	Ovine β -casein mature protein	REQEELNVVGETVESLSSEESITHINKKIEKFQSEEQQT EDELQDKIHFAQAQSLVYFPFGPIPNLQNIPLTQTTPV VPPFLQPEIMGVPKVKETMVPKHKEMPFKYPVEPFTESQ SLTLTDVEKLHPLPLVQSWMHQPPQPLPTVMFPPQSVL SLSQPKVLPVPQKAVPQRDMPIQAFLLYQEPVLGPVRGPF ILV
31	Caprine β -casein	MKVLILACLVALAIARE QEELNVVGETVESLSSEESIT HINKKIEKFQSEEQQTDELQDKIHFAQAQSLVYFPFG PIPNLQNIPLTQTTPVVPPFLQPEIMGVPKVKETMVPK HKEMPFKYPVEPFTESQSLTLTDVEKLHPLPLVQSWMH QPPQPLSPTVMFPPQSVLSLSQPKVLPVPQKAVPQRDMPI QAFLLYQEPVLGPVRGPFPIIV
32	Caprine β -casein mature protein	REQEELNVVGETVESLSSEESITHINKKIEKFQSEEQQT EDELQDKIHFAQAQSLVYFPFGPIPNLQNIPLTQTTPV VPPFLQPEIMGVPKVKETMVPKHKEMPFKYPVEPFTESQ SLTLTDVEKLHPLPLVQSWMHQPPQPLSPTVMFPPQSVL SLSQPKVLPVPQKAVPQRDMPIQAFLLYQEPVLGPVRGPF ILV

SEQ ID No.	Name	Sequence
33	Buffalo β -casein	MKVLILACLVALALARE LEELNVPGEIVESLSSESSEESITH INKKIEKFQSEEQQQMEDELQDKIHPFAQTQSLVYPFGPI PKSLPQNIPPLTQTPVVVPFLQPEIMGVSKVKEAMAPKHK EMPFKYPVEPFTESSQLTLTDVENLHLPLLLQSWMHQPP QPLPPTVMFPPQSVLSLSQSKVLPVPQKAVPYPQRDMPIQ AFLLYQEPVLGPVRGPFPIIV
34	Buffalo β -casein mature protein	RELEELNVPGEIVESLSSESSEESITHINKKIEKFQSEEQQQM EDELQDKIHPFAQTQSLVYPFGPIPKSLPQNIPPLTQTPVV VPPFLQPEIMGVSKVKEAMAPKHKEMPFKYPVEPFTESSQ SLTLTDVENLHLPLLLQSWMHQPPQPLPPTVMFPPQSVL SLSQSKVLPVPQKAVPYPQRDMPIQAFLLYQEPVLGPVRG PFPIIV
35	Equine β -casein	MKILILACLVALALARE KEELNVSSETVESLSSNEPDSS SEESITHINKEKLQKFKHEGQQQREVERQDKISRFVQPQP VVYPYAEVPYAVVPQSILPLAQPPIPLFLQPEIMEVSQAKE TILPKRKVMPLKSPIVPFSEIQILNPTNGENLRPLVHLIQP FMHQVPQSLLQTLMLPSQPVLSPPQSKVAPFPQPVVPYPQ RDTVPQAFLLYQDPRLGPTGELDPATQPIVAVHNPVIV
36	Equine β -casein mature protein	REKEELNVSSETVESLSSNEPDSSSEESITHINKEKLQKFK HEGQQQREVERQDKISRFVQPQPVVYPYAEVPYAVVPQS ILPLAQPPIPLFLQPEIMEVSQAKETILPKRKVMPLKSPIVP FSEIQILNPTNGENLRPLVHLIQPFMHQVPQSLLQTLMLPS QPVLSPPQSKVAPFPQPVVPYPQRDTVPQAFLLYQDPRLG PTGELDPATQPIVAVHNPVIV
37	Camel β -casein	MKVLILACRVALALARE KEEFKTAGEALESISSEESITH INKQKIEKFKEEQQQTEDEQDQKIYTFPQPQSLVYSHTEP IPYPILPQNFLPPLQPAVMVPFLQPKVMDVPKTKETIIPKRK EMPLLQSPVVPFTESQSLTLTDLENLHLPLLLQSLMYQIPQ PVPQTPMIPPQSLLSLSQFKVLPVPQQMVPYPQRAMPVQA VLPFQEPVDPVRGLHPVPQPLVPVIA
38	Camel β -casein mature protein	REKEEFKTAGEALESISSEESITHINKQKIEKFKEEQQQT EDEQQDKIYTFPQPQSLVYSHTEPYPYPILPQNFLPPLQPAV MVPFLQPKVMDVPKTKETIIPKRKEMPLLQSPVVPFTESQS LTLTDLENLHLPLLLQSLMYQIPQVPQTPMIPPQSLLSLS QFKVLPVPQQMVPYPQRAMPVQAVLPFQEPVDPVRGLHP VPQPLVPVIA
39	Human β -casein	MKVLILACLVALALARE TIESLSSESSEESITEYKQKVEKVK HEDQQQGEDEHQDKIYPSFQPQPLIYPFVEIPYGFPLQNI LPLAQPAVVLPVPQPEIMEVPKAKDTVYTKGRVMPVLKSPT IPFFDPQIPKLTDLLENLHLPLLLQPLMQQVPQIPQTLALP PQPLWSVPQPKVLPVPPQVVPYPQRAVPVQALLNQELLN PTHQIYPVTQPLAPVHNPIV
40	Human β -casein mature protein	RETIESLSSESSEESITEYKQKVEKVKHEDQQQGEDEHQDKI YPSFQPQPLIYPFVEIPYGFPLQNILPLAQPAVVLPVPQPEI MEVPKAKDTVYTKGRVMPVLKSPTIPFFDPQIPKLTDLLENL HLPLLLQPLMQQVPQIPQTLALPPQPLWSVPQPKVLPV QQVVPYPQRAVPVQALLNQELLNPTHQIYPVTQPLAPVH NPISV

[00125] Gram positive bacteria (such as *Lactococcus lactis* and *Bacillus subtilis*) may be used to secrete target proteins into the media, and gram-negative bacteria (such as *Escherichia coli*) may be used to secrete target proteins into periplasm or into the media. In some embodiments, the bacterially-expressed proteins expressed may not have any post-translational modifications (PTMs), which means they are not glycosylated and/or may not be phosphorylated.

[00126] Target casein proteins may be expressed and produced in *L. lactis* both in a nisin-inducible expression system (regulated by PnisA promoter), lactate-inducible expression system (regulated by P170 promoter) or other similar inducible systems, as well as a constitutively expressed system (regulated by P secA promoter), wherein both are in a food-grade selection strain, such as NZ3900 using vector pNZ8149 (lacF gene supplementation/rescue principle). The secretion of functional proteins may be enabled by the signal peptide of Usp45 (SP(usp45)), the major Sec-dependent protein secreted by *L. lactis*. For example, α_{s1} -casein and α_{s2} -casein may be co-expressed or individually expressed in *L. lactis* using a synthetic operon.

Cheese and cheese-like products

[00127] The present invention generally relates to cheese or cheese-like products comprising

- a) about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof,
 - b) at least about 5% by weight of one or more hydrocolloids, wherein the one or more hydrocolloids comprise one or more starches, and
 - c) from about 0.2 to about 20% by weight total dairy protein,
- wherein total casein in the cheese or cheese-like product comprises
- i) at least about 55% by weight α_s -casein, and/or
 - ii) at least about 40% by weight β -casein.

[00128] Also described herein are cheese and cheese-like products comprising

- a) about 0.2 to about 35% by weight α_s -casein,
- b) one or more hydrocolloids, comprising at least one of a starch or a gum.

[00129] The invention particularly reduces the total casein content required to form cheese and cheese-like products, particularly processed cheese and processed cheese-like products, while still achieving the desirable properties of such cheeses and cheese-like products.

- 5 **[00130]** The invention also may reduce or eliminate the amount of emulsifying salts needed to produce processed cheese and/or analogue type products. Processed cheese manufacture requires the use of emulsifying salts to modify casein conformation into forms that simultaneously emulsify milk fat, while creating a gel upon cooling that produces the desired body and texture. However, the use of α_s -casein and/or β -casein
10 according to the invention may both emulsify fat and form the desired body and texture upon cooling without the use of emulsifying salts.

- [00131]** The term "cheese-like product" as used herein, refers to products having one or more characteristics of a particular cheese, for example, products that, when consumed, impart the sensation of consuming cheese. In some embodiments, the
15 cheese-like products may not meet the standard for a particular cheese, for example the Codex Alimentarius standard (found at <http://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/en/>). In some embodiments the cheese-like product comprises no animal-derived ingredients. Such products are frequently referred to as "vegan cheeses". Cheese-like products may comprise proteins, fats and/or lipids
20 made by genetic engineering and/or fermentation to replicate the protein and/or fatty acid composition of milk fat.

[00132] In an exemplary embodiment the cheese-like product is a processed cheese-like product.

- [00133]** As used herein, the term "processed cheese-like product" refers to products
25 having one or more of the characteristics of a processed cheese, and includes products such as processed cheese spread or an analogue cheese. As used herein, the term "processed cheese" refers to cheeses prepared by cooking and melting cheese or a blend of cheeses, and includes processed cheeses prepared as described herein in the Examples. When the hot processed cheese is formed, it is a homogeneous pumpable,
30 fluid cheese material that may be cast or formed into sheets to produce blocks, loaves, slices or other desired forms using techniques such as rolling and/or cutting. Processed cheese is sometimes referred to as "process cheese", and the terms are synonymous.

[00134] In various embodiments the cheese-like product is a vegetarian or vegan cheese.

[00135] The invention also relates to the use of unusually low amounts of α _s-casein and/or β -casein to produce cheese and cheese-like products. Typical processed cheeses, such as those described herein in the Examples, may comprise from about 12 to 25% by weight total protein. In contrast, cheeses and cheese-like products produced according to
 5 the invention may comprise 0.2 to about 10% by weight total protein, 0.2 to about 9% by weight total protein or about 0.2 to 5% by weight total protein.

[00136] An exemplary cheese or cheese-like product of the invention may comprise:

- a) from about 0.05 to about 35% lipid,
- b) from about 15 to about 65% by weight moisture,
- 10 c) from about 0.25 to about 7.5% by weight of simple carbohydrates,
- d) from about 0 to about 45% by weight of complex carbohydrates,
- e) from about 0 to about 0.75% by weight of one or more gums,
- f) from about 0.25 to about 3.5% salt, and
- g) from about 0.15 to about 5.0% by weight of minerals, cations, and/or anions.

[00137] In some embodiments the cheese or cheese-like product may comprise at least about 0.05, 1, 2, 2.5, 3, 4, 5, 6, 7, 7.5, 8, 9, 10, 11, 12, 12.5, 13, 14, 15, 16, 17, 17.5, 18, 19, 20, 21, 22, 22.5, 23, 24, 25, 26, 27, 27.5, 28, 29, 30, 31, 32, 33, 34 or 35% by weight lipid, and useful ranges may be selected between any of these values (for example, from about 0.05 to about 35, 1% to about 30%, about 5% to about 30%,
 20 about 10% to about 30%, about 17% to about 20%, about 20% to about 30%, about 25% to about 30%, about 27% to about 30%, about 27.5% to about 30%, about 1% to about 27.5% by weight fat, about 5% to about 27.5%, about 10% to about 27.5%, about 17% to about 27.5%, about 17% to about 27%, about 20% to about 25%, about 1% to about 22% by weight fat, about 5% to about 22%, about 10% to about 22%,
 25 about 17% to about 22%, about 1% to about 20%, about 5% to about 20%, about 10% to about 20%, about 1% to about 10% or about 1% to about 5% by weight lipid).

[00138] In one embodiment the cheese or cheese-like product is a reduced fat cheese or cheese-like product. In one embodiment the reduced fat cheese or cheese-like product comprises from about 0.5% to about 10% by weight lipid.

30 **[00139]** In some embodiments cheeses and cheese-like products of the invention may have the desired flavour, body, appearance, structure, texture, firmness, fibrosity,

density, elasticity, springiness, melt, stretch, water binding capacity, creaminess and/or mouthfeel of equivalent cheeses produced by standard methods. Additionally, the proteins may perform specific physicochemical tasks such as forming desired gels, coagula, emulsions, foams, etc. The elasticity and functional properties of the gels produced by the protein blends of the invention may allow processing on processed cheese manufacturing and packaging equipment, including chill rolls, casting belts, free slice casting equipment, etc. Preferably all ingredients meet vegan/vegetarian specifications and expectations.

[00140] In one embodiment, the processed cheese or processed cheese-like product has a melt value of from about 3 to about 10, preferably from about 6 to about 7 on the Schreiber melt test. The Schreiber melt test was designed for use on processed cheese products, and especially for "slice" processed cheese products.

[00141] These techniques are described in Park, J., J. R. Rosenau, and M. Peleg. 1984. "Comparison of four procedures of cheese meltability evaluation". *J. Food Sci.* 49:1158-1162, & 1170 and Zehren, V, L., and D. D. Nusbaum, 1962. Process Cheese. Cheese Reporter Publishing Co., Inc. Madison, WI.

[00142] Briefly, the Schreiber melt test is conducted by performing the following steps:

- cut a circular disk of cheese to a 39.5 mm diameter and thickness of about 4.7 mm, that is set into a glass (100 x 20 mm thin walled) petri dish bottom,
- place the petri dish cover on the sample and place in the refrigerator for 10 minutes at 4°C,
- place prepared sample into a preheated 232°C forced draft oven and bake for 5 minutes,
- cool for 30 minutes, and
- remove petri dish lid and place dish upon Schreiber melt test chart (a chart containing a series of concentric circles starting at 39.5 mm in diameter, with the diameter of each succeeding circle 2 mm greater.
- report the Schreiber melt test score as listed on the concentric circles (i.e. sequentially 0 to 12).

[00143] A melt value of from about 6 to about 7 on the Schreiber melt test indicates an acceptable processed cheese performance. A melt value of greater than 6 on the Schreiber melt test indicates an unacceptable cheese performance.

[00144] In various embodiments, the cheese or cheese-like product comprises:

- 5 a) about 1 to about 3.5%, preferably about 1.5% to about 2.5% w/w α -casein,
 b) about 15 to about 30%, preferably about 18 to about 27% w/w starch,
 c) about 0.1 to about 0.24%, preferably about 0.12 to about 0.2% w/w gum,
 d) optionally one or more non-dairy proteins,
 e) optionally one or more emulsifying salts,
 f) about 45 to about 65%, preferably about 50 to about 60% w/w moisture, and
 g) about 12 to about 26%, preferably about 15 to about 22% w/w lipid.
- 10 **[00145]** An exemplary cheese or cheese-like product comprises:
 a) about 2% w/w α -casein,
 b) about 22.5% w/w starch,
 c) about 0.16% w/w carrageenan,
 d) optionally one or more non-dairy proteins,
 15 e) optionally one or more emulsifying salts,
 f) about 58% w/w moisture,
 g) about 19% w/w vegetable fat, and
 h) about 1% w/w salt.
- [00146]** In various embodiments, the cheese or cheese-like product comprises:
 20 a) about 1.0 to about 5.0% total protein,
 b) about 0.90 to about 5.0% dairy protein,
 c) about 0.5 to about 4.5%, preferably about 0.8% to about 2.5% w/w α -casein, and/or about 1.0% to about 2.0%, preferably about 1.2% to about 1.7% β -casein,
 25 d) about 15 to about 30%, preferably about 18 to about 27% w/w starch, preferably wherein the starch comprises about 65% to about 75% oxidised thin-boiling potato starch by weight of total starch, about 16% to about 22% OSA modified potato starch by weight of total starch, and about 11% to about 16% acetylated distarch phosphate modified potato starch by
 30 weight of total starch,
 e) about 0.1 to about 0.24%, preferably about 0.12 to about 0.2% w/w gum,

- f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- h) about 45 to about 65%, preferably about 50 to about 60% w/w moisture, and
- 5 i) about 12 to about 26%, preferably about 15 to about 22% w/w lipid.

[00147] An exemplary cheese or cheese-like product comprises:

- a) about 1.0% w/w total protein,
- b) about 1.0% w/w dairy protein,
- c) about 0.8% w/w α_s -casein,
- 10 d) about 18.4% w/w starch,
- e) about 0.16% w/w carrageenan,
- f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- h) about 56% w/w moisture,
- 15 i) about 19% w/w vegetable fat, and
- j) about 1% w/w salt.

[00148] Another exemplary cheese or cheese-like product comprises:

- a) about 3% w/w total protein,
- b) about 3% w/w dairy protein,
- 20 c) about 2.5% w/w α_s -casein,
- d) about 18.4% w/w starch,
- e) about 0.16% w/w carrageenan,
- f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- 25 h) about 56% w/w moisture,
- i) about 19% w/w vegetable fat, and
- j) about 1% w/w salt.

[00149] Another exemplary cheese or cheese-like product comprises:

- 5 a) about 3.0% w/w total protein,
 b) about 3.0% w/w dairy protein,
 c) about 1.3% w/w α_s -casein,
 d) about 1.3% w/w β -casein,
 e) about 18.4% w/w starch,
 f) about 0.16% w/w carrageenan,
 g) optionally one or more non-dairy proteins,
 h) optionally one or more emulsifying salts,
 i) about 56% w/w moisture,
10 j) about 19% w/w vegetable fat, and
 k) about 1% w/w salt.

[00150] Another exemplary cheese or cheese-like product comprises:

- 15 a) about 3.0% w/w total protein,
 b) about 3.0% w/w dairy protein,
 c) about 1.6% w/w β -casein,
 d) about 18.4% w/w starch,
 e) about 0.16% w/w carrageenan,
 f) optionally one or more non-dairy proteins,
 g) optionally one or more emulsifying salts,
20 h) about 56% w/w moisture,
 i) about 19% w/w vegetable fat, and
 j) about 1% w/w salt.

[00151] Another exemplary cheese or cheese-like product comprises:

- 25 a) about 5% w/w total protein,
 b) about 5% w/w dairy protein,
 c) about 4.2% w/w α_s -casein,
 d) about 18.4% w/w starch,
 e) about 0.16% w/w carrageenan,

- f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- h) about 56% w/w moisture,
- i) about 19% w/w vegetable fat, and
- 5 j) about 1% w/w salt.

[00152] In various embodiments, the cheese or cheese-like product comprises:

- a) about 1.0 to about 5.0% total protein,
- b) about 0.90 to about 5.0% dairy protein,
- 10 c) about 0.5 to about 6.0%, preferably about 0.8% to about 4.5% w/w α_s -casein,
- d) about 15 to about 30%, preferably about 18 to about 27% w/w starch, preferably wherein the starch comprises about 65% to about 75% oxidised thin-boiling potato starch by weight of total starch, about 16% to about 22% OSA modified maize starch by weight of total starch, and about 10% to about 15% hydroxypropyl distarch phosphate modified tapioca starch by weight of total starch,
- 15 e) about 0.1 to about 0.24%, preferably about 0.12 to about 0.2% w/w gum,
- f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- 20 h) about 45 to about 65%, preferably about 50 to about 60% w/w moisture, and
- i) about 12 to about 26%, preferably about 15 to about 22% w/w lipid.

[00153] An exemplary cheese or cheese-like product comprises:

- a) about 1.0% w/w total protein,
- 25 b) about 1.0% w/w dairy protein,
- c) about 0.8% w/w α_s -casein,
- d) about 18.5% w/w starch,
- e) about 0.15% w/w locust bean gum,
- f) optionally one or more non-dairy proteins,
- 30 g) optionally one or more emulsifying salts,

- h) about 56% w/w moisture,
- i) about 19% w/w vegetable fat, and
- j) about 1% w/w salt.

[00154] Another exemplary cheese or cheese-like product comprises:

- 5 a) about 5.0% w/w total protein,
- b) about 5.0% w/w dairy protein,
- c) about 4.1% w/w α_s -casein,
- d) about 18.5% w/w starch,
- e) about 0.15% w/w locust bean gum,
- 10 f) optionally one or more non-dairy proteins,
- g) optionally one or more emulsifying salts,
- h) about 56% w/w moisture,
- i) about 19% w/w vegetable fat, and
- j) about 1% w/w salt.

15 **Hydrocolloids**

[00155] Hydrocolloids are useful as thickening or gelling agents in food products.

[00156] The cheese or cheese products described herein comprise one or more hydrocolloids. In various embodiments the one or more hydrocolloids comprise one or more starches, one or more gums, or a combination thereof.

20 **[00157]** In various embodiments the one or more hydrocolloids comprise one or more starches.

[00158] In various embodiments the starch comprises potato starch, maize starch, rice starch, tapioca (cassava) starch, wheat starch, pea starch, sweet potato starch, banana starch, barley starch, oat starch, sago starch, amaranth starch, arrowroot starch, canna starch, sorghum starch, chia seed starch, fava bean starch, jackfruit starch, bamboo starch, chickpea starch, cassava starch, carrot starch, or any combination of any
25 two or more thereof. Particularly preferred starches include maize, potato, cassava, tapioca and rice starch.

[00159] In some embodiments the starch may be modified. Starches may be
30 modified by physical, chemical or enzymatic means to produce modified starches with

altered and/or enhanced properties, such as resistance to gelatinisation and/or retrogradation, improved stability, low viscosity when heated, enhanced gelling, and/or improved emulsification with fat.

5 **[00160]** In various embodiments the starch comprises a modified starch, for example, a pre-gelatinised starch, a thin-boiling starch, an oxidised starch, octenyl succinic anhydride (OSA) modified starch, or an acetylated distarch phosphate.

10 **[00161]** In various embodiments the starch comprises a modified potato starch, modified maize starch and/or a modified tapioca starch. In various embodiments the modified starch is selected from an oxidised thin boiling potato starch, an octenyl succinic anhydride (OSA) modified potato starch, an acetylated distarch phosphate modified potato starch, an octenyl succinic anhydride (OSA) modified maize starch, or a hydroxypropyl distarch phosphate modified tapioca starch, or a combination of any two or more thereof.

15 **[00162]** In various embodiments the one or more gums comprise xanthan gum, guar gum, locust bean gum, tragacanth gum, acacia gum, karaya gum, tara gum, gellan gum, konjac gum (konjac mannan), carboxymethylcellulose (CMC), tragacanth, agar, pectin, alginate, carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan), Arabic gum, pectin, alginate, flaxseed gum, guar gum, or any combination of any two or more thereof.

20 **[00163]** Other useful hydrocolloids include carboxymethylcellulose (CMC), tragacanth and plant-derived hydrocolloids, such as agar, alginate, carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan), Arabic gum, and mixtures thereof. Preferred hydrocolloids include, for example, agar, pectin, xanthan gum, carboxymethylcellulose (CMC), and carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan) and mixtures of such. A
25 particularly preferred hydrocolloid is carrageenan.

Lipid

[00164] In various embodiments the cheese or cheese-like product comprises one or more vegetable or animal lipids.

30 **[00165]** In various embodiments the one or more lipids may comprise one or more vegetable or animal lipids.

[00166] Exemplary plant oils include, for example coconut oil, corn oil, cottonseed oil, canola oil, olive oil, palm oil, ground nut oil, safflower oil, sesame oil, soybean oil, sunflower oil, nut oil, hazelnut oil, almond oil, cashew oil, macadamia oil, pecan oil,

pistachio oil, walnut oil, oils from melon and gourd seeds, bottle gourd oil, buffalo gourd oil, pumpkin seed oil, watermelon seed oil, acai oil, blackcurrant seed oil, borage seed oil, evening primrose oil, carob seed oil, amaranth oil, apricot oil, argan oil, artichoke oil, avocado oil, babassu oil, ben oil, borneo tallow nut oil, cohune oil, coriander seed oil, flax oil, flax seed oil, coriander seeds oil, grape seed oil, hemp oil, kapok seed oil, kiwi fruit oil, lallemantia oil, linseed oil, mustard oil, okra seed oil, perilla seed oil, pequi oil, pine nut oil, poppyseed oil, prune kernel oil, quinoa oil, ramtil oil, rice bran oil, tea oil, wheat germ oil, hydrogenated vegetable oil, cocoa butter, shea butter any derivative of palm kernel oil, cocoa butter or shea butter, for example a derivative obtained by

10 fractionation, partial or full hydrogenation and/or extraction, or any combination of any two or more thereof.

[00167] In various embodiments the vegetable lipid comprises one or more vegetable oils, coconut oil, one or more lecithins, or any combination thereof.

[00168] In various embodiments the vegetable oil comprises canola (rapeseed) oil, corn oil, sunflower oil, olive oil, soybean oil, or any combination of any two or more thereof.

15

[00169] In various embodiments the one or more lecithins may comprise soy lecithin.

[00170] In various embodiments the lipid source is or comprises a milk lipid. Preferably the milk lipid is selected from cream, high fat cream, plastic cream, beta serum or anhydrous milk fat.

20

[00171] In various embodiments the vegetable or animal lipid may be derived from natural sources. In other embodiments, the vegetable or animal lipid may be produced recombinantly.

Dairy proteins

[00172] The term "dairy protein" as used herein refers to any protein that is naturally present in the milk of a mammal, or any variant thereof. The term includes unpurified proteins as well as partially or completely purified or isolated proteins, and includes full-length and processed (mature) dairy proteins, as well as protein fragments. The term also includes dairy proteins that have been produced from non-milk sources, such as recombinantly expressed dairy proteins.

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30

[00173] Dairy proteins include caseins, such as α_{s1} -casein, α_{s2} -casein, β -casein, κ -casein, and p- κ -casein; and whey proteins including β -lactoglobulin, α -lactalbumin,

serum albumin, and immunoglobulins. Some examples of casein proteins are listed in Table 2.

Non-dairy proteins

5 [00174] The term "non-dairy protein" as used herein refers to any protein, excluding dairy proteins. The term "non-dairy animal protein" as used herein refers to any non-dairy protein that is naturally present in an animal. Examples of non-dairy animal proteins include gelatin (such as gelatin produced from pork) and collagen.

[00175] In various embodiments the non-dairy protein comprises algal protein, hydrolysed algal protein, plant protein or hydrolysed plant protein.

10 [00176] In various embodiments the plant protein may comprise, for example, canola (rapeseed), legume, cereal, nut, or seed protein or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is a hydrolysed plant protein. In various embodiments the legume protein comprises pea, chickpea, bean, lupin, lentil or soy protein, or any combination of any two or more thereof, optionally
15 wherein any one or more of the plant proteins is a hydrolysed plant protein. In various embodiments the cereal protein comprises rice, wheat, sorghum, maize, corn, or barley protein, or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is hydrolysed plant protein. In various embodiments the nut protein comprises almond, or cashew protein, or any combination thereof, optionally
20 wherein any one or more of the plant proteins is a hydrolysed plant protein. In various embodiments the seed protein comprises chia, hemp or flax (linseed) protein, or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is hydrolysed plant protein.

[00177] In various embodiments the non-dairy protein comprises a soy protein
25 material, for example soy protein flour, soy protein concentrate, soy protein isolate, and mixtures thereof.

[00178] In various embodiments the cheese or cheese-like product comprises at least about 0, 0.01, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19 or at least about 20 % w/w non-dairy protein, and various ranges can be selected from between these
30 values, for example, from about 0 to about 17, about 0 to about 15, about 0 to about 10, about 0 to about 8, about 0 to about 5, about 0.01 to about 17, about 0.01 to about 15, about 0.01 to about 10, about 0.01 to about 8, about 0.01 to about 5, about 0.1 to about 17, about 0.1 to about 15, 0.1 to about 10, 0.1 to about 8, 1 to about 8, 1 to about 5, or 5 to about 8% w/w of the non-dairy protein. Preferably the cheese or cheese-like product
35 comprises about 0, 0.01, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, or at about 8 % w/w non-dairy

protein, and suitable ranges may be selected from any of these values. In one embodiment, the cheese or cheese-like product contains essentially no non-dairy protein.

[00179] In various embodiments the non-dairy protein may be derived from natural sources. In other embodiments, the non-dairy protein may be produced recombinantly.

5 ***Emulsifying salts***

[00180] In various embodiments the cheese or cheese-like product comprises one or more emulsifying salts. In various embodiments the emulsifying salt comprises one or more sodium emulsifying salts, one or more potassium emulsifying salts, one or more calcium emulsifying salts, or any combination thereof. For example, the emulsifying salt
10 may comprise sodium, potassium and/or calcium salts of the mono, di, and polyphosphoric acids, sodium, potassium and/or calcium salts of citric acid, citric acid and/or phosphoric acid with sodium hydrogen carbonate and/or calcium carbonate.

[00181] In various embodiments the potassium emulsifying salt comprises potassium citrate, tripotassium citrate, potassium dihydrogen orthophosphate, dipotassium
15 phosphate, dipotassium dihydrogen orthophosphate, dipotassium dihydrogen orthophosphate-3-hydrate, dipotassium dihydrogen orthophosphate-6-hydrate, dipotassium dihydrogen diphosphate, tripotassium orthophosphate and tripotassium orthophosphate-3-hydrate and tripotassium orthophosphate-6-hydrate, tetrapotassium diphosphate, tetrapotassium diphosphate-3-hydrate, tetrapotassium pyrophosphate,
20 pentapotassium triphosphate, Kurroll's salt ((KPO₃)_n), or any combination of any two or more thereof.

[00182] In various embodiments the sodium emulsifying salt comprises monosodium phosphate, disodium phosphate, trisodium phosphate, sodium metaphosphate (sodium hexametaphosphate), sodium acid pyrophosphate, tetrasodium pyrophosphate, sodium
25 aluminium phosphate, sodium citrate, sodium tartrate, sodium potassium tartrate, and any combination of any two or more thereof.

[00183] In various embodiments the cheese or cheese-like product may comprise a calcium salt. The calcium salt may be selected from monocalcium phosphate, dicalcium phosphate, tricalcium phosphate, calcium chloride, calcium carbonate, calcium citrate,
30 calcium gluconate, calcium lactate, calcium gluconate, calcium acetate, equivalents thereof and/or combinations thereof.

[00184] In various embodiments the concentration of calcium in the cheese or cheese-like product may be from about 0 mM to about 260 mM. In some embodiments the concentration of calcium in the cheese or cheese-like product may be from about 10

mM to about 55 mM. In some embodiments the concentration of calcium in the cheese or cheese-like product may be at least 10 mM or at most 50 mM. In some embodiments, the concentration of calcium in the cheese or cheese-like product may be 28 mM or no more than 28 mM or may be 55 mM or no more than 55 mM. The concentration of

5 calcium in the cheese or cheese-like product may be 10 mM to 15 mM, 10 mM to 20 mM, 10 mM to 25 mM, 10 mM to 30 mM, 10 mM to 35 mM, 10 mM to 40 mM, 10 mM to 45 mM, 10 mM to 50 mM, 10 mM to 55 mM, 15 mM to 20 mM, 15 mM to 25 mM, 15 mM to 30 mM, 15 mM to 35 mM, 15 mM to 40 mM, 15 mM to 45 mM, 15 mM to 50 mM, 15 mM to 55 mM, 20 mM to 25 mM, 20 mM to 30 mM, 20 mM to 35 mM, 20 mM to 40 mM, 20

10 mM to 45 mM, 20 mM to 50 mM, 20 mM to 55 mM, 25 mM to 30 mM, 25 mM to 35 mM, 25 mM to 40 mM, 25 mM to 45 mM, 25 mM to 50 mM, 25 mM to 55 mM, 30 mM to 35 mM, 30 mM to 40 mM, 30 mM to 45 mM, 30 mM to 50 mM, 30 mM to 55 mM, 35 mM to 40 mM, 35 mM to 45 mM, 35 mM to 50 mM, 35 mM to 55 mM, 40 mM to 45 mM, 40 mM to 50 mM, 40 mM to 55 mM, 45 mM to 50 mM, 45 mM to 55 mM, or 50 mM to 55 mM.

15 The concentration of calcium in the cheese or cheese-like product may be 10 mM, 15 mM, 20 mM, 25 mM, 30 mM, 35 mM, 40 mM, 45 mM, 50 mM, or 55 mM. The concentration of calcium in the cheese or cheese-like product may be at least 10 mM, 15 mM, 20 mM, 25 mM, 30 mM, 35 mM, 40 mM, 45 mM or 50 mM. The concentration of calcium in the cheese or cheese-like product may be at most 15 mM, 20 mM, 25 mM, 30

20 mM, 35 mM, 40 mM, 45 mM, 50 mM or 55 mM.

Other ingredients

[00185] In various embodiments the cheese or cheese-like product may comprise one or more additional ingredients.

[00186] In various embodiments the cheese or cheese-like product may comprise a

25 source of milk protein.

[00187] In various embodiments the source of milk protein may be selected from

- a) whole fat milk, whole milk retentate/concentrate, semi skimmed milk, skimmed milk, skimmed retentate/concentrate, butter milk, butter milk retentate/concentrate and whey protein retentate/concentrate; or
- 30 b) one or more powders, such as whole milk powder, skimmed milk powder, milk protein concentrate powder, micellar milk protein powder, milk protein isolate powder, whey protein concentrate powder, whey protein isolate powder and buttermilk powder or other powders made from milk, reconstituted or dry, singularly or in combination. In various embodiments the source of milk protein
- 35 may comprise cheese or curd.

[00188] In alternative embodiments the cheese or cheese-like product does not comprise a source of milk protein. In some embodiments, the cheese or cheese-like product does not comprise caseinate (such as sodium caseinate), a milk protein concentrate (MPC), lactic casein and/or rennet casein.

5 **[00189]** In various embodiments the cheese or cheese-like product may comprise

- a) one or more complex carbohydrates, such as one or more maltodextrins, corn syrup, and corn syrup solids,
- b) one or more GRAS cationic compounds including one or more monovalent, divalent or multivalent cations such as potassium, sodium, calcium, magnesium,
10 manganese and/or iron compounds,
- c) one or more GRAS anionic compounds such as citrate, propionate, phosphate, and/or carbonate,
- d) one or more mineral salts,
- e) one or more GRAS acids, including one or more of lactic acid, (L+) lactic acid,
15 acetic acid, citric acid, malic acid, tartaric acid, propionic acid, phosphoric acid, sulfuric acid, and/or hydrochloric acid, and
- f) one or more other GRAS ingredients including preservatives (such as sorbates, for example, potassium sorbate), acidity regulators, colours and/or colouring agents such as pigments, flavours, and flow agents.

20 **[00190]** In various embodiments the cheese or cheese-like product comprises from about 0.25 to about 7.5% by weight simple carbohydrate and from about 0 to about 45% by weight complex carbohydrate.

[00191] In various embodiments the cheese or cheese-like product may comprise one or more lipid replacers. Lipid replacers are useful for reduced fat or no fat cheeses or
25 cheese-like products. In some embodiments, the lipid replacers may comprise one or more polyols, for example, glycerine, sorbitol, allulose, erythritol, xylitol, and/or maltitol. In some embodiments, the lipid replacers comprise one or more long chain carbohydrates/fibres, for example inulin, galacto-oligosaccharides (GOS), fructo-oligosaccharides (FOS), oligo-fructose, and/or polydextrose. In some embodiments, the
30 lipid replacers comprise both polyols and long chain carbohydrates/fibres.

Manufacturing methods

[00192] The invention also relates to a method for preparing a cheese or cheese-like product, the method comprising

- a) providing a cheese composition comprising
 - 5 i. α_s -casein, β -casein, or a combination thereof,
 - ii. one or more hydrocolloids, comprising one or more starches,
 - iii. optionally one or more lipids, and
 - iv. optionally one or more additional ingredients,
- 10 b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- 15 i. about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof, and
- ii. at least about 5% by weight of one or more hydrocolloids, and
- iii. from about 0.2 to about 20% by weight total dairy protein,

wherein total casein in the cheese or cheese-like product comprises

- 1. at least about 55% by weight α_s -casein, and/or
- 20 2. at least about 40% by weight β -casein.

[00193] Also described herein is a method for preparing a cheese or cheese-like product, the method comprising

- a) providing a composition comprising
 - 25 i. α_s -casein, the α_s -casein comprising α_{s1} -casein, α_{s2} -casein, or a combination thereof,

- ii. one or more hydrocolloids, comprising at least one of a starch or a gum,
 - iii. optionally one or more lipids
 - iv. optionally one or more non-dairy proteins,
 - 5 v. optionally one or more emulsifying salts, and
 - vi. optionally one or more additional ingredients,
- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- 10 c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

wherein the cheese or cheese-like product comprises

- 1. about 0.2 to about 35% by weight α_s -casein,
 - 2. optionally about 15 to about 65% by weight moisture, and
 - 3. optionally about 0.05 to about 35% by weight lipid.
- 15 **[00194]** In one embodiment the invention relates to a method for producing a processed cheese or processed cheese product. Exemplary embodiments of the method for producing the processed cheese or processed cheese according to the invention are described as follows. Other suitable variations or alternatives to the embodiments described herein will be apparent to those skilled in the art.
- 20 **[00195]** In various embodiments the α_s -casein comprises or is provided by an ingredient or composition comprising an α_s -casein enriched fraction described herein or lyophilised recombinant α_s -casein proteins. In various embodiments the β -casein comprises or is provided by an ingredient or composition comprising an β -casein enriched fraction described herein or lyophilised recombinant β -casein proteins.
- 25 **[00196]** In various embodiments the method comprises dispersing the α_s -casein and/or β -casein in water, preferably at a temperature of about 15 to about 55°C, more preferably about 50°C, to substantially completely dissolve the α_s -casein and/or β -casein. In various embodiments, the method comprises dispersing the α_s -casein in water at a temperature of about 40 to about 55°C, preferably about 50°C. In various embodiments,

the method comprises dispersing the β -casein in water at a temperature of about 15 to about 30°C, preferably about 20°C.

5 **[00197]** In one embodiment the water is adjusted to a pH of about 8.5 before adding the α_s -casein and/or β -casein. In another embodiment, the α_s -casein and/or β -casein is added to water and the pH subsequently adjusted to a pH of about 8.0. In one embodiment a salt such as trisodium citrate is added with the α_s -casein and/or β -casein.

10 **[00198]** In one embodiment the α_s -casein and/or β -casein may be dispersed in water and then added to a mixture of the remaining ingredients or added with other dry ingredients to lipid. In another embodiment the α_s -casein and/or β -casein is combined directly with other dry ingredients or is added directly to the lipid. In some embodiments the lipid is mixed with water to form an emulsion before addition of the dry ingredients.

15 **[00199]** The ingredients may be combined to produce a composition using any mixer or cheese cooker typically used for cheese preparation. Suitable equipment will be well known to those in the art. Suitable cookers include a Vorwerk Thermomix, and processed cheese cookers. Preferably the ingredients are combined under agitation to ensure even mixing.

20 **[00200]** The composition is then heated (cooked) for a period at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass. In a preferred embodiment the composition is heated for at least about 3 to about 15 minutes at a temperature of at least about 70°C, preferably about 80 to about 85°C to produce a heated cheese or cheese-like product. Preferably the composition is heated under agitation.

[00201] The pH may be adjusted at suitable stages, for example, before, during or after cooking.

25 **[00202]** In one embodiment the heated cheese mass or cheese-like mass is immediately cooled and packed. In other embodiments the heated cheese is rolled and cast into slices, for example, to form a slice-on-slice (SOS) processed cheese or processed cheese-like product.

30 **[00203]** The above methods should be considered in no way limiting and suitable variations or alternatives will be apparent to those skilled in the art.

EXAMPLES**EXAMPLE 1**

[00204] This example describes the preparation of casein proteins for use in preparing the cheese and cheese-like products of the invention.

- 5 [00205] Casein was fractionated as described in WO 2009/108074, which is incorporated herein by reference.

- [00206] Raw whole milk was separated to produce fresh raw skim milk that was subsequently pasteurized at 72.5°C. The temperature was adjusted to about 18°C and the skim milk inoculated with a blend of standard dairy starter cultures including
10 *Lactobacillus subsp. lactis* and *Lactobacillus lactis subsp. cremoris*. The skim milk was then incubated until microbial fermentation reduced the pH to about 4.6 to produce an acid casein curd. The curd was cut, cooked, separated from the whey, washed, and dried to produce a bulk supply of lactic casein by standard procedures. The composition of the lactic casein is shown below in Table 3.

- 15 [00207] Approximately 4.5 kg of lactic casein was dispersed into deionized water using sufficient shear to produce 100 L of a solubilized lactic casein slurry comprising 4% total solids. The temperature of the solubilized lactic casein was adjusted to < 7°C and then the pH adjusted to 10.2 by the addition of sodium hydroxide (1 Mol NaOH). Calcium chloride (dihydrate) was blended and dissolved into the prepared slurry to produce a
20 uniform concentration of 0.272 kg CaCl₂/kg lactic casein. The treated casein sat quiescently overnight (≈ 14 hours) to produce a coagulum in which syneresis created a curd suspended within a liquid portion. The curd and liquid were separated using a decanting centrifuge and both the curd and liquid were reserved.

- [00208] The curd received an initial wash with a hydrochloric acid solution to remove
25 residual calcium, which was followed by an additional acid wash (H₂SO₄). The curd was then dried to produce an α_s-casein enriched fraction.

- [00209] The pH of the reserved liquid was adjusted to 4.3 – 4.4 by the addition of 1.0 Mol hydrochloric acid. The acidified mixture sat quiescently until another coagulum formed, which was subsequently separated from the second liquid mixture using a
30 decanter, washed by two acid wash treatments (H₂SO₄), and dried to produce the β-casein enriched fraction.

[00210] The dried casein fractions were each packaged separately and stored at ambient temperature until use.

[00211] Table 3 below shows the compositions of the dried α_s -casein enriched and β -casein enriched fractions.

Table 3. Composition of lactic casein, α_s -casein enriched fraction, and β -casein enriched fraction.

Component	Lactic casein measured (-%-)	α_s -casein enriched	β -casein enriched
Moisture (g/100g)	9.31	9.33	10.1
Total solids (g/100g)	90.69	90.67	89.90
Fat (g/100g)	1.15	0.49	0.41
Total protein (g/100g)	88.87	89.38	88.24
Total casein (g/100g)	NA	89.38	88.24
α_s -Casein (g/100g)	35.59 ^a	74.55 ^b	27.58 ^b
β -Casein (g/100g)	30.91	7.69	47.89
κ -Casein (g/100g)	11.28 ^c	7.14	12.77
CHO	>0.1	0.02	0.02
Ash (g/100g)	1.87	2.5	1.6
Calcium (mg/100g)	0.02 (mg/100g)	175	34.1
Sodium (mg/100g)	>0.1 (mg/100g)	2.81	4.3
pH	4.38	5.27	3.73

5 ^a α_{s1} -casein only

^b α_{s1} - and α_{s2} -casein

^c κ -casein was calculated based on ratio in Table 1

EXAMPLE 2

10 [00212] This example describes the preparation of a standard slice-on-slice (SOS) processed cheddar cheese for comparison with the cheese and cheese-like products of the invention.

[00213] SOS processed cheddar cheese was prepared using the following method.

- 15 a) Temper cheeses to 4 to 6°C as required to ensure that all cheese is completely thawed.
- b) Grind cheese.

- c) Weigh citric acid and water (at ambient temperature), and dissolve citric acid into the water.
- d) Weigh cheeses and add weighed cheeses to the processed cheese cooker.
- e) Start low speed agitation in the selected processed cheese cooker, (most trials
5 conducted using Thermomix, Vorwerk, Wuppertal, Germany, using speed setting 1). Suitable agitation in a standard twin screw, laydown processed cheese cooker is approximately 10 to 15 rpm.
- f) Uniformly disperse water/citric acid mixture into the cheese in the cooker.
- g) Weigh and combine all remaining dry ingredients.
- 10 h) Slowly add the combined dry ingredients to the cheese/water/citric acid mixture in the cooker, uniformly distributing the dry ingredients into the cheese mixture.
- i) Moderately increase cooker agitation speed to produce a uniformly mixed blend, such as to speed setting 2 in a Thermomix or about 40 rpm in a twin screw cooker.
- 15 j) Increase agitation and initiate cooking, such as to speed setting 4 in a Thermomix or about 120 rpm in a twin screw cooker.
- k) Cook at a constant rate, increasing the cheese/ingredient blend temperature from about 17-22°C to about 85°C within $\approx$ 5 minutes.
- 20 l) Adjust the agitation speed profile beginning at a moderate speed and increasing to the final agitation speed within about 2.5 min.
- m) Maintain final agitation speed throughout remainder of cooking.
- n) Halt heat application when cheese blend temperature reaches 85°C and hold the cooked cheese blend at final agitation speed for 6 min.
- 25 o) Discharge molten cheese into cooling and packaging system, roll molten blend with cooling to produce slices of desired thickness (usually 2 mm), cut slices, and wrap in a suitable packaging material.
- p) Cool and package wrapped SOS cheese further as required.
- q) Hold at refrigerated temperatures (4 - 6°C) until evaluation.

[00214] Table 4 shows the formulation of the comparative SOS processed cheese.

Table 5 shows the calculated composition of the final processed cheese.

Table 4. Formulation of comparative SOS processed cheddar cheese.

Component	%
Cheddar cheese blend	76.7
Skim milk powder	2.0
Trisodium citrate (dihydrate)	3.6
Salt	0.2
Citric acid (crystallized)	0.2
Sorbic acid	0.2
Water	17.1
Total	100.0

5 **Table 5. Calculated composition of comparative SOS cheddar cheese.**

Component	Amount
Total solids	58.5 w/w
Moisture	41.5 w/w
Fat	29.65 w/w
Fat-in-dry matter	50.65 w/w
Total protein	20.0 w/w
Casein	19.8 w/w
Whey protein/NPN	0.2 w/w
Lactose	1.1 w/w
Non-lactose carbohydrate	0.5 w/w
Ash	2.5 w/w
Emulsifying salt	3.2 w/w
Salt	1.6 w/w
Sorbate	0.2 w/w
Calcium (mg/100g)	625
Sodium (mg/100g)	1475

EXAMPLE 3

[00215] This example describes the preparation of processed cheese-like products of the invention comprising potato starch, carrageenan gum and α_s -casein. The example also investigates the effect of varying pH in the products of the invention and compares the properties of the products of the invention with those of a control cheese lacking α_s -casein.

[00216] The applicant acknowledges Emsland-Stärke GmbH as a supplier of some of the base formulations that may be used in the invention.

Method of manufacture

- 10 [00217] The processed cheese-like products of the invention were prepared as follows:
- a) An α_s -casein enriched fraction prepared according to Example 1 was dispersed into water by
- 15 i) Weighing half the water required by the formulation and adjusting to ambient temperature,
- ii) Adding trisodium phosphate (TSP) to the water with constant agitation to increase the pH to 8.5 (continuously measuring the solution pH during TSP addition, which is halted immediately when pH 8.5 is reached),
- 20 iii) Increasing the temperature of the high pH water/TSP solution to 50°C with low shear, low speed mixing, and
- iv) Adding the α_s -casein enriched fraction to the 50°C high pH water and mixing for 5 minutes to ensure that the powder is dispersed and dissolved;
- v) Adjust the pH to 8.0, while maintaining agitation and hold for 5 minutes to ensure the casein dissolves.
- 25 b) A fat and powdered ingredient mixture was prepared by
- i) Heating coconut fat to 60°C, allowing the fat to melt,
- ii) Separately combining modified potato starch, salt, carrageenan and potassium sorbate to produce a dry blend mixture; and

- iii) Gently mixing the dry blended ingredients into the molten fat for 1 minute to produce a smooth uniform blend;
- c) The ingredients were combined and cooked by
- 5 i) Combining the remaining water, dissolved α_s -casein enriched fraction, and the fat-dry ingredient blend in processed cheese cooker,
- ii) Heating the blended ingredients to 85°C at a low shear rate (speed setting 2 on the Thermomix),
- iii) Increasing the mixing speed immediately when the temperature reached 85°C (speed setting 4.0 on the Thermomix) and mixing for 5 minutes, and
- 10 d) The pH of the cooked product was adjusted by
- i) Removing a subsample of product and allowing the subsample to cool, while continuing to mix blend in cooker at low shear,
- ii) Measuring the pH when the subsample temperature was $\leq 65^\circ\text{C}$,
- 15 iii) Reducing the cooker blend sample to target pH by adding citric acid, or increasing the cooker blend pH by adding trisodium phosphate,
- iv) Total cook time including pH adjustment was 10 minutes in total.
- e) Pouring hot cooked product (85°C) into suitable plastic containers,
- f) Sealing the containers, and
- g) Refrigerating the product until further use in testing, cutting into slices as
- 20 required.

Formulation and composition of processed cheese-like products

[00218] Table 6 shows the formulations of the processed cheese-like products and a standard processed cheese prepared according to the method of Example 2, while Table 7 shows the calculated final product composition.

25 **Table 6. Formulations of processed cheese-like products.**

Component	Control product (-%-)	Inventive product (-%-)
Water	54.8	54.8
Coconut fat	19.0	19.0

Modified potato starch – oxidized thin boiling (e1404)	15.1	15.1
Modified potato starch – OSA (e1450)	4.23	4.23
Modified potato starch – acetylated distarch phosphate (e1414)	3.12	3.12
Pea protein isolate	2.0	0
α_s -Casein enriched fraction	0	2.0
Salt	1.0	1.0
Potassium sorbate	0.24	0.24
Carrageenan	0.16	0.16
Lactic acid	0.1	0.1
Citric acid	0.1	As Needed
Trisodium phosphate (TSP)	0	As Needed
Total	100% by weight	100% by weight

Table 7. Calculated composition of processed cheese-like products.

Component	Control product	Inventive product (at all pH)	Processed cheese of Example 2
Total solids (% by weight)	41.2	41.7	58.5
Moisture (% by weight)	58.8	58.3	41.5
Fat (% by weight)	19.2	19.1	29.6
Fat-in-dry matter (% by weight)	46.6	46.1	50.65
Total protein (% by weight)	1.6	2.0	20.0
Total casein (% by weight)	0	1.96	19.8
α_s -Casein (% by weight)	0	1.67	NA
β -Casein (% by weight)	0	0.17	NA
κ -Casein (% by weight)	0	0.16	NA
Carbohydrate (% by weight)	18.5	18.8	1.6
Ash (% by weight)	1.23	1.32	2.5
Emulsifying salt (% by weight)	0	0.27	3.2
Salt (% by weight)	1	1	1.6
Sodium (mg/100g)	390	500	1475

Melt properties and firmness

[00219] The meltability of the products was assessed using the Schreiber melt test described herein, upon duplicate samples.

- 5 [00220] The pH of each product was measured at the time the melt test was conducted.

- [00221] The following penetrometer procedure measures firmness of cheeses and cheese-like products by determining the amount of force (measured as Newtons) required to push a cylindrical probe through a prepared sample at a constant speed. The
10 force is measured by a load cell on a texture analyser. The maximum force is determined.

[00222] Penetrometer firmness was measured using by a TA HD*plus* Texture Analyzer (Stable Micro Systems, Ltd. Godalming, Surrey, UK) at 13°C using a 6.3 mm cylindrical probe, with the following settings:

- 15
- Pre-Test speed 1.0 mm/s
 - Test speed 1.0 mm/s
 - Post-Test speed 1.0 mm/s
 - Distance 10.0 mm
 - Force 0.1 N

20

 - Load cell 50 kg
 - Trigger: auto

[00223] The product temperature was tested at 13°C. Each product was either packaged as a suitable block or consisted of a stack of 25 individual slices.

- 25 [00224] The data was collected on a computer and analysed by a commercial computer program. The results are shown in Table 8.

Table 8. Sample pH and mean Schreiber melt test results.

	Control product	Processed cheese of Example 2	Inventive product	Inventive product	Inventive product
pH measured at time of analysis	4.71	5.65	4.79	5.51	5.92
Melt	11.8	8.0	6.2	11.3	10.5

Penetrometer firmness (N)	6.0	12.3	8.4	8.1	8.8
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Viscoelasticity

[00225] The viscoelastic properties of the products were assessed by rheology according to the following method.

- 5 **[00226]** Oscillatory measurements (mechanical spectra) for each sample were performed in a frequency range of 0.1-50 rad/s, using strain values compromised in the linear viscoelastic region for each sample (0.5%). Data were collected using a Modular Compact Rheometer (MCR 300, Anton Paar). The attachment used was a 20 mm smooth parallel plate geometry. Gap was modified based on the thickness of each sample
- 10 (ensuring the normal force was less than 0.5 N). Experiments were done at 25°C. The recorded data included the components of shear modulus G' (storage modulus) and the viscous component G'' (loss modulus). The component $\tan(\delta)$ were calculated at frequency 1.2 rad/s by dividing G'' to G' .

[00227] The results are shown in Table 9.

15 **Table 9. Rheological analysis.**

	Control product	Dairy SOS control	Inventive product	Inventive product	Inventive product
Measured pH (at time of analysis)	4.71	5.85	4.79	5.51	5.62
Storage modulus G' (Pa at 1.2 rad/s)	67721	42676	35648	21958	53116
Loss modulus G'' (Pa at 1.2 rad/s)	5915	13775	5330	4626	10598
Tan δ (at freq 1.2 rad/s)	0.087	0.323	0.15	0.211	0.20

Sensory properties

[00228] The sensory properties of the prepared samples were evaluated by a team of 8 judges experienced in grading pasteurized processed cheese slices. The judges evaluated all samples for flavour including salt, acid, bitter, sweet, intensity of starch
 5 flavour, and any noticeable defects, such as oxidized flavours. Additionally, the judges evaluated the cheese samples for firmness and mouthfeel.

[00229] The judges generally found the sensory properties of the inventive products to be similar.

[00230] Other observations included that:

- 10 a) the flavour of the inventive samples was less "powdery" with a reduced starch flavour compared with the control product;
- b) the fracturability and mouthfeel of the inventive samples more closely resembled a typical cheddar SOS cheese than the control sample; and
- c) the firmness and elasticity of the inventive samples more closely resembled a
 15 typical cheddar SOS cheese than the control sample.

EXAMPLE 4

[00231] This example describes the preparation of processed cheese-like products of the invention.

20 **Protein sources**

[00232] α_s -Casein enriched and β -casein enriched fractions were obtained as described in Example 1. The total protein, total casein and casein fraction content for these fractions are provided in Table 3.

Formulations

- 25 [00233] Table 10 shows the formulations of the processed cheese-like products prepared according to the method outlined below, while Table 11 shows the calculated final product composition.

Table 10. Formulations of processed cheese-like samples made from α_s -casein enriched and β -casein enriched fractions

Component	0% Protein	1% Protein	3% Protein	3% Protein 1:1	3% Protein	5% Protein
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		high alpha-Cn	high alpha-Cn	alpha:beta- Cn	high beta-Cn	high alpha-Cn
Water	51.61	43.05	25.46	26.50	26.80	7.87
Coconut fat	19.13	19.13	19.13	19.13	19.13	19.13
Modified potato starch - oxidized, thin boiling (e1404)	15.10	15.10	15.10	15.10	15.10	15.10
Modified Potato starch – OSA (e1450)	4.23	4.23	4.23	4.23	4.23	4.23
Modified potato starch – acetylated distarch phosphate (e1414)	3.12	3.12	3.12	3.12	3.12	3.12
α -Casein enriched fraction solution (10.3% protein)		9.60	29.33	6.90		49.05
β -Casein enriched fraction solution (10.8% protein)				21.40	28.00	
Salt	1.01	1.01	1.01	1.01	1.01	1.01
Potassium sorbate	0.25	0.25	0.25	0.25	0.25	0.25
Carrageenan	0.16	0.16	0.16	0.16	0.16	0.16
Lactose	5.38	4.34	2.20	2.19	2.19	0.07
Citric acid		As required	As required	As required	As required	As required
Trisodium phosphate (TSP)		As required	As required	As required	As required	As required
Total	100% by weight	100% by weight	100% by weight	100% by weight	100% by weight	100% by weight

Table 11. Compositional analysis of processed cheese-like samples made from α_s -casein enriched and β -casein enriched fractions – Base 1 (potato starch)

Component	0% Protein	1% Protein high α -Cn	3% Protein high α -Cn	3% Protein 1:1 α : β -Cn	3% Protein high β -Cn	5% Protein high α -Cn
	Dairy protein free	α -Enriched fraction	α -Enriched fraction	α -Enriched & β - enriched fractions	β -Enriched fraction	α -Enriched fraction
Moisture (g/100g)	55.59	55.59	55.59	55.59	55.59	55.59
Total solids (g/100g)	44.41	44.41	44.41	44.41	44.41	44.41
Fat (g/100g)	19.15	19.16	19.17	19.16	19.15	19.18
Total protein (g/100g)	0.03	1.00	3.00	3.00	3.00	5.00
α_s -Casein (g/100g)	0.00	0.81	2.48	1.29	0.93	4.15
β -Casein g/100g)	0.00	0.08	0.26	1.29	1.61	0.43
κ -Casein (g/100g)	0.00	0.08	0.24	0.38	0.43	0.40
Total casein (g/100g)	0.00	0.97	2.97	2.97	2.97	4.97
Whey protein (g/100g)	0.00	0.00	0.00	0.00	0.00	0.00
Carbohydrate (total)(g/100g)	23.85	22.81	20.67	20.66	20.66	18.54
Starch solids (g/100g)	18.39	18.39	18.39	18.39	18.39	18.39
Carrageenan (%)	0.16	0.16	0.16	0.16	0.16	0.16
Lactose (g/100g)	5.11	4.12	2.09	2.08	2.08	0.07

Fibre (g/100g)	0.07	0.07	0.07	0.07	0.07	0.07
Sugars (g/100g)	5.39	4.35	2.21	2.20	2.20	0.08
Ash (g/100g)	0.64	0.64	0.64	0.64	0.64	0.64
Potassium sorbate^a (%)	0.25	0.25	0.25	0.25	0.25	0.25
Salt (%)	1.01	1.01	1.01	1.01	1.01	1.01
pH (Lab)	5.06	5.08	5.12	5.18	5.24	5.19
Ca (mg/100g)	1.56	3.44	7.29	2.97	1.65	11.14
Na (mg/100g)	433.00	432.85	432.52	432.52	432.52	432.20

^a Potassium sorbate is also included in the ash content.

Method of manufacture

[00234] Processed cheese manufacture proceeded as follows:

- a) Hydrating each individual protein source by
 - 5 i) dispersing each protein into water at an appropriate temperature with sufficient agitation to create separate solutions with about 89.5% moisture, and about 10.5% solids:
 - ii) The α_s -casein enriched casein source solution was made by heating it to 50°C, and adjusting to pH 8 with TSP.
 - 10 iii) The β -casein enriched protein source solution was made by heating it to 20°C, adjusting to pH 8 with TSP.
 - iv) each solution was held quiescently overnight at refrigeration temperatures from 4 to 5°C.
- b) Processed cheese manufacture continued the following day by
 - 15 i) heating hydrogenated coconut fat (Confat 92) to 60°C until completely melted,
 - ii) transferring the required amount of protein solution to a Thermomix cooker/mixer, and heating up to 60°C,
 - iii) adding the required amount of the molten coconut fat into the protein solution, then uniformly blending the mixture to produce a uniform blend. Add the remaining water and mix until temperature reaches 60°C,
 - 20 iv) adding all of the remaining ingredients including starches, carrageenan, salt, lactose and potassium sorbate and blend to a uniform paste at 60°C,
 - v) heating the blended ingredients to 85°C at a low shear rate (speed setting 2 on the Thermomix), and
 - 25 vi) increasing the mixing speed immediately when the temperature reached 85°C (speed setting 4.0 on the Thermomix) and mixing for 5 minutes,
- c) The pH of the cooked product was adjusted by

- 5
- i) removing a subsample of product and allowing the subsample to cool, while continuing to mix blend in cooker at low shear,
 - ii) measuring the pH when the subsample temperature was $\leq 65^{\circ}\text{C}$,
 - iii) reducing the cooker blend sample to target inprocess pH of 5.2 by adding citric acid, or increasing the cooker blend pH by adding trisodium phosphate,
 - iv) total cook time including pH adjustment was 10 minutes in total.
- d) Pouring hot cooked product (85°C) into suitable plastic containers,
- e) Sealing the containers, and
- 10 f) Refrigerating the product until further use in testing, cutting into slices as required.

Properties of processed cheese-like products of the invention

[00235] Table 12 shows the melt, firmness, and viscosity of the processed cheese-like product.

15 **Table 12. Melt, Firmness and Viscosity of processed cheese-like products of the invention (Base 1)**

	0% Protein	1% Protein high alpha-Cn	3% Protein high alpha-Cn	3% Protein 1:1 alpha:beta-Cn	3% Protein high beta-Cn	5% Protein high alpha-Cn
Melt (Sch test units)	11.5	9.3	6.4	6.9	5.9	1.4
Penetrometer firmness (N)	6.3	7.3	9.7	11.4	11.0	14.2
η_{Hot} (mPas)^a	781	841	1143	1277	1162	1203

^a η_{Hot} = cheese viscosity measured at 85°C in a Rapid Visco Analyser RVA4 (Newport Scientific, Warriewood, NSW).

20 **EXAMPLE 5**

[00236] This example describes the preparation of processed cheese-like products of the invention.

Protein sources

[00237] α _s-Casein enriched and β -casein enriched fractions were obtained as described in Example 1. The total protein, total casein, casein fraction content, and lactose content for these fractions are provided in Table 3.

5 **Method of manufacture**

[00238] Processed cheese was manufactured as described in Example 4.

Formulation and composition of processed cheese-like products

[00239] Formulations of processed cheese-like products of the invention are presented in Table 13.

10 **Table 13. Formulations of processed cheese-like samples made from α _s-casein enriched fractions**

Component	0% Protein	1% Protein high alpha-Cn	5% Protein high alpha-Cn
Water	51.95	43.39	8.21
Coconut fat	19.13	19.13	19.13
Modified potato starch – oxidised, thin boiling (e1404)	15.10	15.10	15.10
Modified maize starch – OSA (e1450)	4.32	4.32	4.32
Modified tapioca starch – hydroxypropyl distarch phosphate (e1442)	2.71	2.71	2.71
α _s -Casein enriched fraction solution (10.3% protein)		9.60	49.05
Salt	1.01	1.01	1.01
Potassium sorbate	0.25	0.25	0.25
Locust bean gum	0.15	0.15	0.15
Lactose	5.38	4.34	0.07
Citric acid		As required	As required
Trisodium phosphate (TSP)		As required	As required
Total	100% by weight	100% by weight	100% by weight

[00240] Table 14 shows the target compositions of processed cheese-like products made by the above method.

15 **Table 14. Composition of processed cheese-like products (Base 2)**

	0% Protein	1% Protein high alpha-Cn	5% Protein high alpha-Cn
Component	Dairy protein free	α -Enriched fraction	α -Enriched fraction
Moisture (g/100g)	55.59	55.59	55.59
Total solids (g/100g)	44.41	44.41	44.41
Fat (g/100g)	19.16	19.16	19.18
Total protein (g/100g)	0.03	1.00	5.00
α _s -Casein (g/100g)	0.000	0.812	4.147
β -Casein g/100g)	0.000	0.084	0.428
κ -Casein (g/100g)	0.000	0.078	0.397
p - κ -Casein (g/100g)	0.000	0.000	0.000
Total Casein (g/100g)	0.000	0.973	4.974
Whey protein (g/100g)	0.00	0.00	0.00
Carbohydrate (total) (g/100g)	23.98	22.94	18.67
Starch solids (g/100g)	18.46	18.46	18.46
Locust bean gum (%)	0.15	0.15	0.15
Lactose (g/100g)	5.11	4.12	0.07
Fibre (g/100g)	0.14	0.14	0.14
Sugars (g/100g)	5.38	4.34	0.07
Ash (g/100g)	0.52	0.52	0.52
Potassium sorbate ^a (%)	0.25	0.25	0.25
Salt (%)	1.01	1.01	1.01
pH (target)	5.10	5.10	5.10
pH (lab)	5.22	5.07	5.21
Ca (mg/100g)	1.56	3.16	9.76
Na (mg/100g)	424	424	423

^a Potassium sorbate is also included in the ash content.

Properties of processed cheese-like products of the invention

[00241] Firmness was measured by penetrometry as outlined in previous examples. Melt was measured using the Schreiber Test method as outlined above.

Table 15. Melt, Firmness and viscosity of processed cheese-like products of the invention (Base 2)

	0% Protein	1% Protein high alpha-Cn	5% Protein high alpha-Cn
Melt (Sch test units)	9.3	9.3	9.8
Penetrometer firmness (N)	4.8	7.2	10.2
η_{Hot} (mPas)^a	463	510	836

^a η_{Hot} = cheese viscosity measured at 85°C in a Rapid Visco Analyser RVA4 (Newport Scientific, Warriewood, NSW).

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Sensory properties

[00242] The sensory properties of the prepared samples were evaluated by a team of 6 judges experienced in grading pasteurized processed cheese slices. The judges evaluated all samples for flavour including salt, acid, bitter, sweet, intensity of starch
10 flavour, and any noticeable defects, such as oxidized flavours. Additionally, the judges evaluated the cheese samples for firmness and mouthfeel.

[00243] The judges generally found the products containing 1% protein were the most similar to a dairy SOS control. Higher levels of protein provided higher firmness, but these products tended to be slower to melt in the mouth and have a drier mouthfeel.

15 **[00244]** Any documents referred to herein including, but not limited to, patents, patent applications, journal articles, books, and the like, are incorporated herein by reference in their entirety. Any section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

20 **[00245]** Although the invention has been described by way of example and with reference to particular embodiments, it is to be understood that modifications and/or improvements may be made without departing from the scope or spirit of the invention.

CLAIMS

1. A cheese or cheese-like product comprising
 - a) about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof,
 - 5 b) at least about 5% by weight of one or more hydrocolloids, wherein the one or more hydrocolloids comprises one or more starches, and
 - c) about 0.2 to about 20% by weight total dairy protein,
 wherein total casein in the cheese or cheese-like product comprises
 - i) at least about 55% by weight α_s -casein, and/or
 - 10 ii) at least about 40% by weight β -casein.
2. The cheese or cheese-like product according to claim 1, comprising 0.2 to about 6% by weight α_s -casein, wherein the total casein in the cheese or cheese-like product comprises at least about 55% by weight α_s -casein.
3. The cheese or cheese-like product according to claim 1 or 2, further
 - 15 comprising β -casein, κ -casein, p- κ -casein, or any combination of any two or more thereof.
4. The cheese or cheese-like product according to any one of claims 1 to 3, comprising 0.2 to about 6% by weight β -casein, wherein the total casein in the cheese or cheese-like product comprises at least about 40% by weight β -casein.
5. The cheese or cheese-like product according to claim 1 or 4, further
 - 20 comprising α_s -casein, κ -casein, p- κ -casein, or any combination of any two or more thereof.
6. The cheese or cheese-like product according to any one of claims 1 to 5, wherein the α_s -casein comprises α_{s1} -casein, α_{s2} -casein, or a combination thereof.
7. The cheese or cheese-like product according to any one of claims 1 to 6,
 - 25 comprising from about 0.2 to about 15% or about 0.2 to about 10% by weight total dairy protein.

8. The cheese or cheese-like product according to any one of claims 1 to 7, comprising from about 0.2 to about 20%, about 0.2 to about 15% or about 0.2 to about 10% by weight total casein.
- 5 9. The cheese or cheese-like product according to any one of claims 1 to 8, wherein the α_s -casein and/or β -casein is provided by a protein ingredient comprising an α_s -casein enriched fraction, a β -casein enriched fraction, recombinant α_{s1} -casein, recombinant α_{s2} -casein, recombinant β -casein, or any combination of any two or more thereof.
- 10 10. The cheese or cheese-like product of any one of claim 1 to 9, wherein the cheese or cheese-like product comprises at least about 10%, 15% or 20% by weight of one or more hydrocolloids.
11. The cheese or cheese-like product of any one of claims 1 to 10, wherein the cheese or cheese-like product comprises
- 15 a) at least about 10% by weight starch,
- b) at least about 15% by weight starch, or
- c) about 5% to about 30% by weight starch.
- 20 12. The cheese or cheese-like product of any one of claims 1 to 11, wherein the one or more starches are selected from the group comprising potato starch, maize starch, rice starch, tapioca (cassava) starch, wheat starch, pea starch, sweet potato starch, banana starch, barley starch, oat starch, sago starch, amaranth starch, arrowroot starch, canna starch, sorghum starch, chia seed starch, fava bean starch, jackfruit starch, bamboo starch, chickpea starch, cassava starch, carrot starch, and any combination of any two or more thereof.
- 25 13. The cheese or cheese-like product of claim 12, wherein the one or more starches comprises one or more modified starches.
14. The cheese or cheese-like product of claim 13, wherein the one or more modified starches are selected from the group comprising pre-gelatinised starch, thin-boiling starch, oxidised starch, octenyl succinic anhydride (OSA) modified starch, or a combination of any two or more thereof.
- 30 15. The cheese or cheese-like product of any one of claims 1 to 14, wherein the one or more hydrocolloids further comprises one or more gums.

16. The cheese or cheese-like product of claim 15, wherein the one or more gums is selected from the group comprising xanthan gum, guar gum, locust bean gum, tragacanth gum, acacia gum, karaya gum, tara gum, gellan gum, konjac gum (konjac mannan), carboxymethylcellulose (CMC), tragacanth, agar, pectin, alginate, carrageenan (κ -carrageenan, ι -carrageenan, λ -carrageenan), Arabic gum, pectin, alginate, flaxseed gum, guar gum, or any combination of any two or more thereof.
17. The cheese or cheese-like product of any one of claims 1 to 16, wherein the cheese or cheese-like product comprises from about 0.2 to about 10%, about 0.2 to about 6%, about 0.2 to about 5%, or about 0.2 to about 3% by weight total protein.
18. The cheese or cheese-like product of any one of claims 1 to 17, wherein the cheese or cheese-like product comprises one or more non-dairy proteins.
19. The cheese or cheese-like product of claim 18, wherein the one or more non-dairy proteins comprises or consists of one or more plant proteins or hydrolysed plant proteins.
20. The cheese or cheese-like product of any one of claims 1 to 19, wherein the cheese or cheese-like product comprises
- a) one or more emulsifying salts,
 - b) about 15 to about 65% by weight moisture,
 - c) about 0.05 to about 35% by weight lipid, or
 - d) any combination of any two or more of a)-c).
21. A method for preparing a cheese or cheese-like product, the method comprising
- a) providing a cheese composition comprising
 - i) α_s -casein, β -casein, or a combination thereof,
 - ii) one or more hydrocolloids, comprising one or more starches,
 - iii) optionally one or more lipids, and
 - iv) optionally one or more additional ingredients,

- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,
- 5 wherein the cheese or cheese-like product comprises
- i) about 0.2 to about 6% by weight of α_s -casein, β -casein, or a combination thereof, and
- ii) at least about 5% by weight of one or more hydrocolloids, and
- iii) about 0.2 to about 20% by weight total dairy protein,
- 10 wherein total casein in the cheese or cheese-like product comprises
1. at least about 55% by weight α_s -casein, and/or
2. at least about 40% by weight β -casein.
22. The method of claim 21, comprising
- a) providing an aqueous composition comprising α_s -casein, β -casein, or a combination thereof,
- 15 b) adding the one or more hydrocolloids, lipid and, optionally, the one or more additional ingredients, to the aqueous composition to produce a cheese composition,
- c) heating the cheese composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- 20 d) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product.
23. The method of claim 21, comprising
- a) providing an aqueous composition comprising α_s -casein, β -casein, or a combination thereof,
- 25 b) adding lipid to the aqueous composition and mixing to form an emulsion,

- 5 c) adding the emulsion to a second aqueous composition comprising the one or more hydrocolloids and, optionally, the one or more additional ingredients, to produce a cheese,
- d) heating the cheese composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- e) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product.
- 10 24. The method of any one of claims 21 to 23, comprising dispersing the α_s -casein and/or β -casein in water at a temperature of from about 20 to about 50°C to substantially completely dissolve the α_s -casein and/or β -casein to produce the aqueous composition.
25. The method of claim 24, comprising dispersing α_s -casein in water at a temperature of from about 40 to about 55°C to substantially completely dissolve the α_s -casein to produce the aqueous composition.
- 15 26. The method of claim 24, comprising dispersing β -casein in water at a temperature of from about 15 to about 30°C, or at ambient temperature, to substantially completely dissolve the β -casein to produce the aqueous composition.
- 20 27. The method of any one of claims 21 to 26, comprising providing an aqueous composition comprising a protein ingredient comprising an α_s -casein enriched fraction, a β -casein enriched fraction, recombinant α_{s1} -casein, recombinant α_{s2} -casein, recombinant β -casein, or any combination of any two or more thereof.
- 25 28. The cheese or cheese-like product of any one of claims 9 to 19 or the method of claim 26, wherein the protein ingredient comprises an α_s -casein enriched fraction, and wherein:
- a) total casein in the protein ingredient comprises at least about 50% or at least about 75% by weight α_s -casein, and/or
- 30 b) the protein ingredient comprises α_s -casein and β -casein in a weight ratio of at least about 50:50, preferably at least about 80:20.

29. The cheese or cheese-like product of any one of claims 9 to 28 or the method of claim 26, wherein the protein ingredient comprises a β -casein enriched fraction, and wherein:
- 5 a) total casein in the β -casein enriched fraction comprises at least about 50% by weight β -casein, and/or
- b) the β -casein enriched fraction comprises β -casein and α_s -casein in a weight ratio of at least about 50:50.
30. The cheese or cheese-like product or method of any one of claims 1 to 29, wherein the cheese or cheese-like product is a processed cheese or processed
- 10 cheese-like product.
31. A cheese or cheese-like product comprising
- a) about 0.2 to about 6% by weight α_s -casein,
- b) at least about 5% by weight of one or more hydrocolloids, comprising at least one starch,
- 15 c) about 0.5 to about 20% by weight total protein;
- wherein the α_s -casein comprises
- i) at least about 60% of the casein in the cheese or cheese-like product, and/or
- ii) at least about 55% by weight of the total protein in the cheese or
- 20 cheese-like product.
32. A method for preparing a cheese or cheese-like product, the method comprising
- a) providing a cheese composition comprising
- i) α_s -casein,
- 25 ii) one or more hydrocolloids, comprising at least one starch,
- iii) optionally one or more lipids, and
- iv) optionally one or more additional ingredients,

- b) heating the composition at a temperature and for a time sufficient to produce a heated cheese mass or cheese-like mass, and
- c) cooling the heated cheese mass or cheese-like mass to produce the cheese or cheese-like product,

5 wherein the cheese or cheese-like product comprises

- i) about 0.2 to about 6% by weight of α_s -casein,
- ii) at least about 5% by weight of one or more hydrocolloids, and
- iii) about 0.5 to about 20% by weight total protein,

and wherein the α_s -casein comprises

- 10 c. at least about 60% of the casein in the cheese or cheese-like product, and/or
- d. at least about 55% by weight of the total protein in the cheese or cheese-like product.

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