CLAIMS

1. A protein, wherein the protein is a recombinant protein having a structure:

(A) (milk protein 1) – (linker peptide 1) 6– (milk protein 2), or

(B) (milk protein 1) – (linker peptide 1) – (milk protein 2) – (linker peptide 2) – (milk protein 3), or

(C) (milk protein 1) – (linker peptide 1) – (milk protein 2) – (linker peptide 2) – (milk protein 3) – (linker peptide 3) – (milk protein 4);

wherein:

(i) the milk protein 1, the milk protein 2, the milk protein 3, the milk protein 4, the linker peptide 1, the linker peptide 2, and the linker peptide 3 are linked via peptide bonds; and

(ii) at least one of the milk protein 1, the milk protein 2, the milk protein 3, and the milk protein 4 is a milk protein comprising a free thiol group.

2. The recombinant protein of claim 1, wherein

(i) the recombinant protein has a structure (A),

(ii) the milk protein 1 is a milk protein comprising a free thiol group, and

(iii) the milk protein 2 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (B),

(ii) the milk protein 1 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 2 and the milk protein 3 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (B),

(ii) the milk protein 2 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 1 and the milk protein 3 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) the milk protein 1 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 2, the milk protein 3, and the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) the milk protein 2 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 1, the milk protein 3, and the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (A), and

(ii) each of the milk protein 1 and the milk protein 2 is a milk protein comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (B),

(ii) each of the milk protein 1 and the milk protein 2 is a milk protein comprising a free thiol group, and

(iii) the milk protein 3 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (B),

(ii) each of the milk protein 1 and the milk protein 3 is a milk protein comprising a free thiol group, and

(iii) the milk protein 2 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 1 and the milk protein 2 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 3 and the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 1 and the milk protein 3 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 2 and the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 1 and the milk protein 4 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 2 and the milk protein 3 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 2 and the milk protein 3 is a milk protein comprising a free thiol group, and

(iii) each of the milk protein 1 and the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (B), and

(ii) each of the milk protein 1, the milk protein 2, and the milk protein 3 is a milk protein comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 1, the milk protein 2, and the milk protein 3 is a milk protein comprising a free thiol group, and

(iii) the milk protein 4 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C),

(ii) each of the milk protein 1, the milk protein 2, the milk protein 4 is a milk protein comprising a free thiol group, and

(iii) the milk protein 3 is a milk protein not comprising a free thiol group;

or wherein

(i) the recombinant protein has a structure (C), and

(ii) each of the milk protein 1, the milk protein 2, the milk protein 3, and the milk protein 4 is a milk protein comprising a free thiol group.

3. A recombinant expression construct consisting of a polynucleotide comprising a promoter sequence, an optional secretion signal sequence, a polynucleotide sequence encoding a recombinant protein of either of claims 1 or 2, and a termination sequence; wherein the promoter sequence is operably linked in sense orientation to the optional secretion signal sequence and the polynucleotide sequence encoding the recombinant protein, the optional secretion signal sequence is operably linked in sense orientation to the polynucleotide sequence encoding the recombinant protein, and the one or more terminator sequences are operably linked to the polynucleotide sequence encoding the recombinant protein.

4. A recombinant vector comprising the recombinant expression construct of claim 3.

5. A recombinant host cell comprising the recombinant expression construct of claim 3.

6. The recombinant host cell of claim 5
(i) comprising two or more recombinant expression constructs of claim 3; or
(ii) wherein the recombinant host cell is derived from a bacterium; or
(iii) wherein the recombinant host cell is derived from a fungus; preferably wherein the fungus is a yeast or wherein the fungus is a filamentous fungus; or
(iv) wherein the recombinant host cell is derived from a plant.

7. A method for obtaining the recombinant host cell of claim 5, wherein the method comprises obtaining a polynucleotide encoding the recombinant protein, or obtaining the recombinant expression construct of claim 3, or obtaining the recombinant vector of claim 4; and introducing the polynucleotide, recombinant expression construct, or recombinant vector into a host cell.

8. A method for producing the recombinant protein of either of claims 1 or 2, wherein the method comprises fermenting the recombinant host cell of claim 5 in a culture medium under conditions suitable for production of the recombinant protein.

9. The method of claim 8, wherein the method further comprises purifying the recombinant protein to obtain a preparation comprising the recombinant protein; preferably

wherein the preparation comprises the recombinant protein at a purity of greater than 50% by mass of total protein.

10. A method for producing a casein wherein the method comprises:

a) fermenting a recombinant host cell capable of producing a recombinant protein having a structure

(A) (milk protein 1) – (linker peptide 1) – (milk protein 2),

or

(B) (milk protein 1) – (linker peptide 1) – (milk protein 2) – (linker peptide 2) – (milk protein 3), or

(C) (milk protein 1) – (linker peptide 1) – (milk protein 2) – (linker peptide 2) – (milk protein 3) – (linker peptide 3) – (milk protein 4); wherein:

(i) the milk protein 1, the milk protein 2, the milk protein 3, the milk protein 4, the linker peptide 1, the linker peptide 2, and the linker peptide 3 are linked via peptide bonds,

(ii) at least one of the milk protein 1, the milk protein 2, the milk protein 3, and the milk protein 4 is a β-lactoglobulin,

(iii) at least one of the milk protein 1, the milk protein 2, the milk protein 3, and the milk protein 4 is the casein, and

(iv) wherein the casein is adjacent to one or more linker peptides comprising a recognition or cleavage sequence for a protease.

11. The method of claim 10, wherein

(i) the recombinant protein has a structure (A),

(ii) the milk protein 1 is a β-lactoglobulin,

(iii) the milk protein 2 is the casein, and

(iv) the linker peptide 1 comprises a recognition or cleavage sequence for a protease; or wherein

(v) the recombinant protein has a structure (B),

(vi) at least one of the milk protein 1 and the milk protein 2 is a β-lactoglobulin,

(vii) the milk protein 2 is the casein, and

(viii) the linker peptide 1 and the linker peptide 2 comprise a recognition or cleavage sequence for a protease;

or wherein

(i) the recombinant protein has a structure (C),

(ii) at least one of milk protein 1 and milk protein 4 is a β-lactoglobulin,

(iii) the milk protein 2 and the milk protein 3 is the casein, and

(iv) the linker peptide 1, the linker peptide 2, and the linker peptide 3 comprise a recognition or cleavage sequence for a protease;

or wherein

(i) the recombinant protein has a structure (C),

(ii) at least one of milk protein 1 and milk protein 3 is a β-lactoglobulin,

(iii) the milk protein 2 and the milk protein 4 is the casein, and

(iv) the linker peptide 1, the linker peptide 2, and the linker peptide 3 comprise a recognition or cleavage sequence for a protease;

or wherein

(i) the recombinant protein has a structure (C),

(ii) the milk protein 1 is a β-lactoglobulin,

(iii) the milk protein 2, the milk protein 3, and the milk protein 4 is the casein, and

(iv) the linker peptide 1, the linker peptide 2, and the linker peptide 3 comprise a recognition or cleavage sequence for a protease;

or

wherein the casein is k-casein; or

wherein the casein is b-casein; or

wherein the casein is a-S1-casein; or

wherein the casein is a-S2-casein; or

wherein the protease is selected from the group consisting of chymosin, trypsin, pepsin; matrix metalloproteinases, GI proteases, subtilisin, kex2 endoprotease, and TEV protease; or wherein the method further comprises cleaving the one or more linker peptides comprising the recognition or cleavage sequence for a protease with the protease, thereby releasing the casein; or

wherein the recombinant host cell is derived from a bacterium; or

wherein the recombinant host cell is derived from a fungus, preferably wherein the fungus is a yeast or wherein the fungus is a filamentous fungus; orwherein the recombinant host cell is derived from a plant, preferably wherein the plant is soybean.

12. A polymer, wherein the polymer comprises a protein polymer, wherein the protein polymer comprises protein monomers linked via disulfide bonds, and wherein the protein monomers comprise one or more recombinant proteins of either of claims 1 or 2.

13. The polymer of claim 12, wherein

(i) the protein monomers comprise one recombinant protein; or

(ii) the protein monomers comprise two or more different recombinant proteins; or

(iii) the polymer is essentially free of any milk protein other than the milk protein comprised in the recombinant protein; or

(iv) the polymer is essentially free of a component derived from petroleum.

14. A method for producing the polymer of claim 12, wherein the method comprises:

(i) obtaining the one or more recombinant proteins, and

(ii) mildly denaturing the one or more recombinant proteins such that one or more free thiol groups comprised in the one or more recombinant proteins form one or more intra- and/or inter-molecular disulfide bonds.

15. A composition comprising the recombinant protein of either of claims 1 or 2 and/or the polymer of either of claims 12 or 13.

16. The composition of claim 15, wherein the composition is

(a) a food product; or

(b) a cosmetic or personal care composition.

17. The composition of claim 16, alternative (a), wherein

(A) the food product is a supplemented food product; in particular wherein the supplemented food product is

(i) a supplemented dairy product; or

(ii) a supplemented animal meat or animal meat product; or

(iii) a supplemented egg or egg product;

or

(B) the food product is a substitute food product; in particular wherein the substitute food product is

(i) a substitute dairy product; or

(ii) a substitute animal meat or animal meat product; or

(iii) a substitute egg or egg product;

or

(C) the composition is (i) a film; or

(ii) a coating; or

(iii) a spray; or

(iv) a gel, nanogel, hydrogel, hydronanogel, or hydrogel bead; or

(v) an encapsulate; or

(vi) a microsphere, nanoparticle, nanofibril, or nanotube; or

(vii) a nano fibril; or

(viii) a hydro fibril; or

(ix) a nanotube; or

(x) a foam; or

(xi) a biological scaffold; or

(xii) an encapsulate.