CLAIMS

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

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

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

(~~F~~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

~~3. The recombinant protein of claim 1,~~ 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

~~4. The recombinant protein of claim 1,~~ 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;

~~.5. The recombinant protein of claim 1,~~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

~~6. The recombinant protein of claim 1, ~~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

~~7. The recombinant protein of claim 1, ~~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

~~8. The recombinant protein of claim 1, ~~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

~~9. The recombinant protein of claim 1, ~~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

~~10. The recombinant protein of claim 1, ~~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

~~11. The recombinant protein of claim 1,~~ 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

~~12. The recombinant protein of claim 1,~~ 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

~~13. The recombinant protein of claim 1,~~ 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

~~14. The recombinant protein of claim 1,~~ 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

~~15. The recombinant protein of claim 1,~~ 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

~~16. The recombinant protein of claim 1,~~ 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

~~17. The recombinant protein of claim 1,~~ 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.

~~18~~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 ~~through 17~~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.

~~19~~4. A recombinant vector comprising the recombinant expression construct of claim ~~18~~3.

~~20~~5. A recombinant host cell comprising the recombinant expression construct of claim ~~18~~3.

~~21~~6. The recombinant host cell of claim ~~20~~ 5 ~~comprising~~

(i) comprising two or more recombinant expression constructs of claim ~~18~~3; or.

(ii)

~~22. The recombinant host cell of claim 20,~~ wherein the recombinant host cell is derived from a bacterium; or.

(iii) ~~23. The recombinant host cell of claim 20,~~ wherein the recombinant host cell is derived from a fungus; preferably ~~.~~

~~24. The recombinant host cell of claim 23,~~ wherein the fungus is a yeast or ~~.~~

~~25. The recombinant host cell of claim 23,~~ wherein the fungus is a filamentous fungus; or~~.~~

(iv)

~~26. The recombinant host cell of claim 20,~~ wherein the recombinant host cell is derived from a plant.

~~27~~7. A method for obtaining the recombinant host cell of claim ~~20~~5, wherein the method comprises obtaining a polynucleotide encoding the recombinant protein, or obtaining the recombinant expression construct of claim ~~18~~3, or obtaining the recombinant vector of claim ~~19~~4; and introducing the polynucleotide, recombinant expression construct, or recombinant vector into a host cell.

~~28~~8. A method for producing the recombinant protein of either ~~any~~ of claims 1 ~~through 17~~or 2, wherein the method comprises fermenting the recombinant host cell of claim ~~20~~ 5 in a culture medium under conditions suitable for production of the recombinant protein.

~~29~~9. The method of claim ~~2~~8, wherein the method further comprises purifying the recombinant protein to obtain a preparation comprising the recombinant protein; preferably~~.~~

~~30. The method of claim 29,~~ wherein the preparation comprises the recombinant protein at a purity of greater than 50% by mass of total protein.

~~31~~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

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

or

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

(~~F~~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.

~~32~~11. The method of claim ~~31~~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

~~33. The method of claim 31,~~ 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

~~34. The method of claim 31,~~ 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 35. The method of claim 31, 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

36. The method of claim 31, 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 .

37. The method of claim 31, wherein the casein is k-casein; or.

38. The method of claim 31, wherein the casein is b-casein; or.

39. The method of claim 31, wherein the casein is a-S1-casein; or.

40. The method of claim 31, wherein the casein is a-S2-casein; or.

41. The method of claim 31, wherein the protease is selected from the group consisting of chymosin, trypsin, pepsin; matrix metalloproteinases, GI proteases, subtilisin, kex2 endoprotease, and TEV protease;.

or 42.The method of claim 31, 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.

~~43. The method of claim 31,~~ wherein the recombinant host cell is derived from a bacterium; or~~.~~

~~44. The method of claim 31,~~ wherein the recombinant host cell is derived from a fungus, preferably ~~.~~

~~45. The method of claim 31,~~ wherein the fungus is a yeast or ~~.~~

~~46. The method of claim 31,~~ wherein the fungus is a filamentous fungus; or~~.~~

~~47. The method of claim 31,~~ wherein the recombinant host cell is derived from a plant, preferably ~~.~~

~~48. The method of claim 47,~~ wherein the plant is soybean.

~~49~~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 ~~any~~ either of claims 1 ~~through 17~~or 2.

~~50~~13. The polymer of claim ~~49~~12, wherein ~~the protein monomers comprise~~

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

(ii) the protein monomers comprise

~~51. The polymer of claim 49, wherein the protein monomers comprise~~ two or more different recombinant proteins; or~~.~~

(iii)

~~52. The polymer of claim 49, wherein~~ the polymer is essentially free of any milk protein other than the milk protein comprised in the recombinant protein; or~~.~~

(iv)

~~53. The polymer of claim 49, wherein~~ the polymer is essentially free of a component derived from petroleum.

~~54~~14. A method for producing the polymer of claim ~~49~~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.

~~55~~15. A composition comprising the recombinant protein of ~~any~~ either of claims 1 ~~through 17~~or 2 and/or the polymer of ~~any~~ either of claims ~~49~~ 12 ~~through 53~~or 13.

~~56~~16. The composition of claim ~~55~~15, wherein the composition is

(a) a food product; or

(b) a cosmetic or personal care composition. ~~.~~

~~57. The composition of claim 56, wherein the food product is a supplemented food product.~~

~~58. The composition of claim 57, wherein the supplemented food product is a supplemented dairy product.~~

~~59. The composition of claim 57, wherein the supplemented food product is a supplemented animal meat or animal meat product.~~

~~60. The composition of claim 57, wherein the supplemented food product is a supplemented egg or egg product.~~

~~61. The composition of claim 56, wherein the food product is a substitute food product.~~

~~62. The composition of claim 61, wherein the substitute food product is a substitute dairy product.~~

~~63. The composition of claim 61, wherein the substitute food product is a substitute animal meat or animal meat product.~~

~~64. The composition of claim 61, wherein the substitute food product is a substitute egg or egg product.~~

~~65. The composition of claim 55, wherein the composition is a cosmetic or personal care composition.~~

~~66~~17. The composition of claim ~~56~~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) ~~67. The composition of claim 56, wherein the composition is~~ a coating; or~~.~~

(iii)

~~68. The composition of claim 56, wherein the composition is~~ a spray; or~~.~~

(iv)

~~69. The composition of claim 56, wherein the composition is~~ a gel, nanogel, hydrogel, hydronanogel, or hydrogel bead; or~~.~~

(v)

~~70. The composition of claim 56, wherein the composition is~~ an encapsulate; or~~.~~

(vi)

~~71. The composition of claim 56, wherein the composition is~~ a microsphere, nanoparticle, nanofibril, or nanotube; or~~.~~

(vii)

~~72. The composition of claim 56, wherein the composition is~~ a nano fibril; or~~.~~

(viii)

~~73. The composition of claim 56, wherein the composition is~~ a hydro fibril; or~~.~~

(ix)

~~74. The composition of claim 56, wherein the composition is~~ a nanotube~~.~~; or

(x)

~~75. The composition of claim 56, wherein the composition is~~ a foam; or~~.~~

(xi)

~~76. The composition of claim 56, wherein the composition is~~ a biological scaffold; or~~.~~

(xii)

~~77. The composition of claim 56, wherein the composition is~~ an encapsulate.