

**BIODEGRADABLE PLANT PROTEIN HYDROGELS, USES AND
PREPARATION THEREOF**

FIELD OF THE INVENTION

[001] The invention relates generally to the field of food products. More specifically to alternative meat, eggs, fish and dairy products.

BACKGROUND

[002] Animal proteins have a unique composition and molecular structure with characteristics that determine their functional properties. Mostly, animal proteins that are used in the industry have fiber-like properties, which contribute to the textural properties of meat food. There are only a few economically viable examples of plant proteins that naturally exhibit this type of fibrous structure (e.g., gluten) and only a few numbers of mycoproteins have been used for such purposes. Using fiber-like vegetable proteins as alternatives to animal protein-based food products is highly challenging.

[003] Common plant proteins used in plant-based foods today include soy, peas, potatoes, mung beans, and rice, all distinguished with their globular structures. To adjust the functional properties of plant protein, methylcellulose or other cellulose derivatives such as CMC (carboxymethylcellulose) are used as binders between the tissues and the various components of plant-based meat, fish, dairy and eggs analogues. Although methylcellulose is considered a safe substance for the meat, fish and eggs industries as a "binding" substance, the awareness of consumers in this market has favored to use "green labeled" functional additives in food products.

[004] Biopolymers, mainly proteins and polysaccharides can produce gels that can be used to create a desired texture for food formulations in general, and for meat, eggs, and yogurts analogues, and they can bind to each other, thus creating a porous three-dimensional network of biopolymer chains that can trap water, oil/fat and other substances in it. Today, transglutaminase is mainly used to form the three-dimensional network of biopolymer chains, but several concerns have emerged regarding its use. Some of the concerns relate to bacterial contamination and inducing celiac disease and increased intestinal permeability.

Therefore, there is a need for a new method to form three-dimensional network of biopolymer chains.

SUMMARY

[005] The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods which are meant to be exemplary and illustrative, not limiting in scope.

[006] In one aspect, there is provided a food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings;

[007] wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings;

[008] and wherein a molar ratio between glutamine and glutamic acid residues within the protein is at most 1:10.

[009] In one embodiment, a dry weight percentage of the protein within the food product is between 60 and 90%.

[0010] In one embodiment, a weight ratio between the protein and the additional agent is between 10:1 and 1:10.

[0011] In one embodiment, the protein comprises a modified plant protein; and wherein the weight ratio between the protein and the additional agent is between 10:1 and 3:1.

[0012] In another aspect, there is provided a food product comprising (i) a hydrolyzed protein and (ii) an additional agent; wherein the (i) and the (ii) comprise plurality of phenol-based rings;

[0013] wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based ring;

[0014] the hydrolyzed protein is characterized by a hydrolysis degree between 5 and 40%.

[0015] In one embodiment, hydrolyzed protein is obtained via protein hydrolysis with a proteolytic enzyme

[0016] In one embodiment, hydrolyzed protein comprises a plurality of peptides characterized by alpha helix content of at least 50% and further characterized by an average

MW below 80kDa; and wherein the proteolytic enzyme comprises pepsin, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase, aminopeptidase, or any combination thereof.

[0017] In one embodiment, hydrolyzed protein comprises a hydrolyzed plant protein; and wherein the hydrolyzed plant protein is characterized by at least 50% improved water solubility compared to the same non-hydrolyzed plant protein.

[0018] In one embodiment, food product is characterized by traces of oxidase.

[0019] In one embodiment, additional agent is a phenolic lipid, or is a biopolymer comprising a polysaccharide, a polyphenol, a protein, a lignin, or a combination thereof.

[0020] In one embodiment, polysaccharide is a hydroxycinnamic acid substituted polysaccharide; and wherein the hydroxycinnamic acid substituted polysaccharide comprises a feruloylated polysaccharide, a pectic polysaccharide or both.

[0021] In one embodiment, food product is a solid at a temperature below 100°C and is characterized by a gel content of between 5 and 50%.

[0022] In one embodiment, food product is characterized by a water content between 0.1 and 70% w/w; and wherein in a hydrated state the food product is characterized by a water content between about 30 and about 70% w/w.

[0023] In one embodiment, food product is in a form of a porous matrix.

[0024] In one embodiment, food product is selected from meat substitute, fish substitute, egg substitute, dairy substitute, plant-based products, or any combination thereof.

[0025] In one embodiment, food product is shapeable, spreadable or both; and wherein the food product maintains its shape under heating at a temperature up to 250°C.

[0026] In one embodiment, food product is characterized by at least one of: a hardness between 5 and 10N, a chewiness between 1 and 3N, and a gumminess between 0.5 and 2N, determined by Texture Profile Analyzer.

[0027] In one embodiment, food product is in a denatured state and characterized by at least one of: a hardness between 5 and 50N, a chewiness between 4 and 25N, and a gumminess between 4 and 30N, determined by Texture Profile Analyzer.

[0028] In one embodiment, food product is provided in the denatured state by thermal processing.

[0029] In one embodiment, food product is low calorie food product.

- [0030] In another aspect, there is provided a method for manufacturing the food product of the invention, comprising: contacting a protein with a first enzyme having deamidase catalytic activity under conditions appropriate for converting at least glutamine residues of the protein into glutamic acid residues, thereby obtaining a glutamic acid protein (GAP); wherein a molar ratio between glutamine and glutamic acid within the GAP is at most 1:10;
- [0031] contacting the GAP with an oxidase and with an additional agent under conditions appropriate for crosslinking the GAP and the additional agent, thereby obtaining the food product;
- [0032] wherein the protein and the additional agent comprise a plurality of phenol-based rings.
- [0033] In one embodiment, the oxidase comprises any one of laccase, peroxidase, tyrosinases, or any combination thereof; and wherein the first enzyme comprises any one of: amidohydrolase, deamidase, protein glutaminase, or any combination thereof.
- [0034] In one embodiment, deamidase catalytic activity comprises glutamine to glutamate transformation activity, asparagine to aspartate transformation activity or both; optionally wherein the first enzyme further comprises a protease activity.
- [0035] In one embodiment, the method further comprising performing a termination step thereby substantially arresting enzymatic activity of the first enzyme, wherein the termination step is performed prior to the step (ii).
- [0036] In one embodiment, the step (i) further comprising contacting the protein or the GAP with a second enzyme having a proteolytic activity.
- [0037] In one embodiment, step (ii) comprises mixing at a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a crosslinking degree of at least 20-90%.
- [0038] In one embodiment, protein comprises a plant protein; and wherein the GAP is characterized by at least 50% improved water solubility compared to the plant protein.
- [0039] In another aspect, there is a method for manufacturing the food product of the invention, comprising:
- [0040] (i) contacting a protein with a proteolytic enzyme under conditions suitable for hydrolysis of the protein, thereby obtaining a composition comprising a hydrolyzed protein (HPP);

[0041] (ii) contacting the composition with an oxidase and the additional agent under conditions appropriate for crosslinking the HPP and the additional agent, thereby obtaining the food product.

[0042] In one embodiment, the HPP is characterized by a degree of hydrolysis of between about 5 and about 40%.

[0043] In one embodiment, conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C; and wherein the method further comprising performing a termination step, wherein the termination step is performed prior to the step (ii).

[0044] In one embodiment, termination step comprises any of: (i) providing the composition to a temperature of at least 90°C; (ii) adding an inhibitor of the proteolytic enzyme to the composition; (iii) exposing the composition to a pH below 4 or above 9, or a combination of (i)-(iii).

[0045] In one embodiment, conditions appropriate for crosslinking comprise providing the composition to a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a gel content of at least 5%.

[0046] In one embodiment, protein comprises a plant protein and wherein the HPP is characterized by at least 50% improved water solubility compared to the plant protein.

[0047] In one embodiment, method further comprises lyophilizing the food product.

[0048] In one embodiment, wherein the conditions appropriate for crosslinking comprise providing the composition to a temperature between 10 and 70 °C for a period of time sufficient for forming the food product characterized by a cross-linking degree of between about 20 and about 90%.

[0049] In one embodiment, the method further comprises lyophilizing the food product.

[0050] In one embodiment, the method further comprises a preliminary step of adding one or more additional food ingredient; and wherein the preliminary step is performed before the step (ii).

[0051] In one embodiment, the one or more additional food ingredient comprises any one of oil/fat, flavoring, a coloring agent, a salt, a vitamin, or a mineral, including any combination thereof.

[0052] In one embodiment, the proteolytic enzyme comprises any one of pepsin, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase, aminopeptidase, or any combination thereof.

[0053] In one embodiment, the polysaccharide is derived from psyllium husk, psyllium seeds powder, chia husk, chia seeds powder, apple, bamboo and sugar cane fibers powder, or any combination thereof.

[0054] In one embodiment, the modified plant protein is characterized by water solubility above 25%, as determined based on total nitrogen content.

[0055] In one embodiment, the modified plant protein is characterized by at least 50% improved water solubility compared to the same non-hydrolyzed plant protein.

[0056] In one embodiment, the modified plant protein is a hydrolyzed plant protein characterized by a degree of hydrolysis between 5 and 40%.

[0057] In one embodiment, the hydrolyzed plant protein is characterized by at least one of: (i) alpha helix content of at least 50%; (ii) average MW below 80kDa.

[0058] In one embodiment, the food product is characterized by a crosslinking degree cross-linking degree of between about 20 and about 90%.

[0059] In one aspect, there is provided a food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings; wherein the food product is characterized by a gel content between 5 and 50%; and wherein a molar ratio between glutamine and glutamic acid within the protein is at most 1:10.

[0060] In some embodiments, a weight percentage of the protein within the food product is between 1 and 40% mol.

[0061] In some embodiments, a weight ratio between the protein and the additional agent is between 1:10 and 10:1.

[0062] In some embodiments, the protein is a plant protein.

[0063] In one aspect, there is provided a food product comprising (i) a hydrolyzed protein and (ii) an additional agent; wherein the (i) and the (ii) comprise plurality of phenol-based rings; wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based ring; wherein the food product is characterized by a gel content of between 5 and 50%; and wherein the hydrolyzed protein is obtained via hydrolysis with a proteolytic enzyme.

[0064] In some embodiments, the hydrolyzed protein comprises a plurality of peptides characterized by alpha helix content of at least 50%.

[0065] In some embodiments, the hydrolyzed protein comprises a plurality of peptides characterized by alpha helix content of at least 50%.

[0066] In some embodiments, the hydrolyzed protein is a hydrolyzed plant protein.

[0067] In some embodiments, the food product is characterized by traces of oxidase.

[0068] In some embodiments, the additional agent comprises a polysaccharide, a polyphenol, a protein, a phenolic lipid, a lignin, or a combination thereof.

[0069] In some embodiments, the polysaccharide is or comprises a polysaccharide derived from feruloylated polysaccharide, pectic polysaccharide, psyllium husk, psyllium seeds powder, chia husk, chia seeds, powder apple, bamboo and sugar cane fibers powder, or any combination thereof.

[0070] In some embodiments, the food product is a solid at a temperature below 100°C and is characterized by a gel content of between 5 and 50%.

[0071] In some embodiments, the food product is characterized by a water content between 0.1 and 50% w/w.

[0072] In some embodiments, the food product is a porous matrix.

[0073] In some embodiments, the food product is selected from meat substitute, fish substitute, egg substitute, dairy substitute, plant-based products, or any combination thereof.

[0074] In some embodiments, the food product is shapeable, spreadable or both; and wherein the food product maintains its shape under heating at a temperature up to 200°C.

[0075] In some embodiments, the food product is characterized by at least one of: a hardness between 5 and 10N, a chewiness between 1 and 3N, and a gumminess between 0.5 and 2N, determined by Texture Profile Analyzer.

[0076] In some embodiments, the food product is in a denatured state and characterized by at least one of: a hardness between 5 and 50N, a chewiness between 4 and 25N, and a gumminess between 4 and 30N, determined by Texture Profile Analyzer.

[0077] In some embodiments, the food product is provided in the denatured state by thermal processing.

[0078] In some embodiments, the food product is low calorie food product.

[0079] In one aspect, there is provided a method for manufacturing the food product of the invention comprising: contacting a protein with an amidohydrolase under conditions appropriate for converting glutamine residues of the protein into glutamic acid residues, thereby obtaining a protein (GAP); wherein a molar ratio between glutamine and glutamic acid within the GAP is at most 1:10; contacting the GAP with an oxidase and with an additional agent under conditions appropriate for crosslinking the GAP and the additional agent, thereby obtaining the food product; wherein the protein and the additional agent comprise a plurality of phenol-based rings.

[0080] In some embodiments, the conditions appropriate for converting glutamine into glutamic acid comprise mixing at a temperature between 10 and 70°C.

[0081] In some embodiments, the method further comprising performing a termination step thereby substantially arresting enzymatic activity of the amidohydrolase, wherein the termination step is performed prior to the step (ii).

[0082] In some embodiments, the termination step comprises any one of: heating at a temperature of at least 90°C; contacting with an amidohydrolase inhibitor; or exposing to a pH below 4 or above 9.

[0083] In some embodiments, the step (ii) comprises mixing at a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a gel content of at least 5%.

[0084] In one aspect, there is provided a method for manufacturing the food product of the invention, comprising: (i) contacting a protein with a proteolytic enzyme under conditions suitable for hydrolysis of the protein, thereby obtaining a composition comprising a hydrolyzed protein (HPP); (ii) contacting the composition with an oxidase and the additional agent under conditions appropriate for crosslinking the HPP and the additional agent, thereby obtaining the food product.

[0085] In some embodiments, the conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C.

[0086] In some embodiments, the method further comprising performing a termination step, wherein the termination step is performed prior to the step (ii).

[0087] In some embodiments, the termination step comprises any of: providing the composition to a temperature of at least 90°C; adding an inhibitor of the proteolytic enzyme to the composition; exposing the composition to a pH below 4 or above 9.

[0088] In some embodiments, the conditions appropriate for crosslinking comprise providing the composition to a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a gel content of at least 5%.

[0089] In some embodiments, the additional agent comprises a polysaccharide, a protein, a phenolic lipid, or a combination thereof.

[0090] In some embodiments, the method further comprises lyophilizing the food product.

[0091] In one aspect, there is provided a method for manufacturing a food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise plurality of phenol-based rings; wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based ring; wherein the food product is characterized by a gel content of between 5 and 50%; the method comprising: (i) contacting a protein bound to a polysaccharide with a saccharidase under conditions suitable for at least partial hydrolysis of the polysaccharide, and subsequently adding the additional agent, thereby obtaining a composition; (ii) contacting the composition with an oxidase under conditions appropriate for crosslinking the protein and the additional agent, thereby obtaining the food product.

[0092] In some embodiments, the conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C.

[0093] In some embodiments, the method further comprising performing a termination step, wherein the termination step is performed prior to the step (ii).

[0094] In some embodiments, the termination step comprises any one of: providing the composition to a temperature of at least 90°C; adding an inhibitor of the saccharidase to the composition; exposing the composition to a pH below 4 or above 9.

[0095] In some embodiments, the conditions appropriate for crosslinking comprise providing the composition to a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a gel content of at least 5%.

[0096] In some embodiments, the method further comprises lyophilizing the food product.

[0097] In some embodiments, the step (i) further comprises adding a food supplement comprising inter alia oil, fat, flavoring, salt, antioxidant, vitamin and mineral.

[0098] In another aspect, there is provided a method for manufacturing a food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise plurality of phenol-based rings; wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based ring; wherein the food product is characterized by a gel content of between 5 and 50%; the method comprising: (i) contacting a protein bound to a polysaccharide with a saccharidase under conditions suitable for at least partial hydrolysis of the polysaccharide, and subsequently adding the additional agent, and a food supplement thereby obtaining a composition; (ii) contacting the composition with an oxidase under conditions appropriate for crosslinking the protein and the additional agent, thereby obtaining the food product.

[0099] In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the figures and by study of the following detailed description.

[00100] Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

[00101] Further embodiments and the full scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[00102] **Figs. 1A-1B.** are bar graphs presenting integration data of **1A** C=O amide (at 1629 cm^{-1}) and **1B** carbonyl ester (at 1742 cm^{-1}) of PPI before and after treatment with protein glutaminase (PG) for 1 h.

[00103] **Figs. 2A-2B.** are graphs presenting transformation degree of glutamine to glutamic acid of a 20% wt plant protein in water after treatment with PG over time. **2A.** pea protein isolate (PPI) mixture, results are expressed as means of triplicates with standard deviation. **2B.** soy protein isolate mixture (SPI) mixture, results are expressed as means of duplicates with standard deviation.

[00104] **Figs. 3A-3B.** are graphs presenting the degree of hydrolysis of 20% wt of plant protein after treatment with papain over time. **3A.** PPI mixture, results are expressed as means of triplicates with standard deviation and **3B.** SPI mixture, results are expressed as means of duplicates with standard deviation.

[00105] **Fig. 4.** is a graph presenting FTIR of PPI before and after treatment with PG.

[00106] **Figs. 5A-5D** present an image of a 20% wt in water of plant protein before and after treatment with PG and papain at different time intervals. **5A.** PPI treated with PG **5B.** PPI treated with papain. **5C.** SPI treated with PG **5D.** SPI treated with papain.

[00107] **Figs. 6A-6B** are graphs presenting protein solubility profile of 20% wt PPI mixture in water after treatment with **6A.** PG and **6B.** papain.

[00108] **Fig. 7.** is an image presenting a visual assessment of PPI crosslinking with 3% laccase in different period of PG or papain treatments.

[00109] **Figs. 8A-8B.** are images presenting a visual assessment of SPI crosslinking with 3% laccase after 1h or 3h treatment with **8A.** papain or **8B.** PG, compared to a non-pretreated SPI.

[00110] **Figs. 9A-9B** are graphs comparing the texture profile for **9A.** hardness, gumminess and chewiness, and for **9B.** cohesiveness, springiness and resilience of SPI-based patties, pretreated with different hydrolytic enzymes, and crosslinked with laccase.

[00111] **Figs. 10A-10B** are graphs comparing the texture profile for **10A.** hardness, gumminess and chewiness, and for **10B.** cohesiveness, springiness and resilience of SPI-based patties as compared to commercial, MC-based, patties.

DETAILED DESCRIPTION

[00112] According to one aspect there is provided a food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-

based rings; wherein the protein is characterized by a molar ratio between glutamine and glutamic acid residues of at most 1:10.

[00113] In some embodiments, the food product comprises (i) a protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings; wherein a molar ratio between glutamine and glutamic acid residues within the protein is at most 1:10 and wherein the food product is characterized by a crosslinking degree between about 20 and about 90%.

[00114] In some embodiments, the food product further comprises trace amount of oxidase, a first enzyme having deamidase catalytic activity, saccharidase or any combination thereof. In some embodiments, the food product further comprises trace amount of oxidase. In some embodiments, the trace amounts encompass at most 20,000 ppm, 10,000 ppm, 5000 ppm, 1000 ppm, 250 ppm, 100 ppm, between 10 and 10000 ppm, between 10 and 5000 ppm, between 10 and 100 ppm, including any range in between. In some embodiments, the food product of the invention is a food grade product. As used herein, the term “food grade” refers to a product consisting of food-grade ingredients, generally recognized as safe and approved for human consumption by a corresponding regulatory authority (i.e., GRAS). The concentration of each of the constituents within the food grade doesn’t exceed a toxicity limit for the specific constituent as determined by the corresponding regulatory authority. In some embodiments, the concentration of oxidase within the food product of the invention doesn’t exceed oxidase toxicity limit, as determined by the corresponding regulatory authority.

[00115] In some embodiments, the molar ratio between glutamine and glutamic acid residues (and/or Asn:Asp residues) within the food product is at most 1:2, at most 1:3, at most 1:4, at most 1:5, at most 1:8, at most 1:10, at most 1:15, at 1:20 at most 1:25, at most 1:50, at most 1:100, at most 1:500, between 10:1 and 1:500, between 10:1 and 1:1, between 10:1 and 1:100, between 1:1 and 1:5, between 1:1 and 1:50, between 1:50 and 1:100, between 1:80 and 1:120, between 1:100 and 1:500, including any range in between.

[00116] The terms “deamidase catalytic activity” or “deamidase activity” are used herein interchangeably and refer to protein having activity for catalyzing deamidation reaction of (i.e. amide hydrolysis) of a glutamine and/or asparagine residue in a protein.

[00117] In some embodiments, deamidase activity further encompasses an enzyme having amidohydrolase activity. Non limiting examples for the amidohydrolase are beta-lactamase, histone deacetylase, asparaginase, urease and glutaminase, including any structural homolog, and any combination thereof.

[00118] In some embodiments, the first enzyme comprises any one of: amidohydrolase, deamidase, glutaminase, protein glutaminase, including any homolog, and any combination thereof.

[00119] In some embodiments, the first enzyme is further characterized by protease activity. In some embodiments, the first enzyme (e.g. protein glutaminase) is characterized by deamidase activity and by protease activity.

[00120] As used herein the term “homolog” refers to an enzyme with at least 70%, at least 80%, at least 85%, at least 90%, at least 95%, at least 97%, at least 99%, or 100% sequence homology to any of the enzymes disclosed herein, including any range between. Such enzymes can be used in their free form or immobilized on polymeric beads in order to facilitate their recovery in the process.

[00121] The terms “homology” or “identity”, as used interchangeably herein, refer to sequence identity between two amino acid sequences or two nucleic acid sequences, with identity being a stricter comparison. The phrases “percent identity or homology” and “% identity or homology” refer to the percentage of sequence identity found in a comparison of two or more amino acid sequences or nucleic acid sequences. Two or more sequences can be anywhere from 0-100% identical, or any value there between. Identity can be determined by comparing a position in each sequence that can be aligned for purposes of comparison to a reference sequence. When a position in the compared sequence is occupied by the same nucleotide base or amino acid, then the molecules are identical at that position. The degree of identity of amino acid sequences is a function of the number of identical amino acids at positions shared by the amino acid sequences. A degree of identity between nucleic acid sequences is a function of the number of identical or matching nucleotides at positions shared by the nucleic acid sequences. A degree of homology of amino acid sequences is a function of the number of amino acids at positions shared by the polypeptide sequences.

[00122] The following is a non-limiting example for calculating homology or sequence identity between two sequences (the terms are used interchangeably herein). The sequences

are aligned for optimal comparison purposes (e.g., gaps can be introduced in one or both of a first and a second amino acid or nucleic acid sequence for optimal alignment and non-homologous sequences can be disregarded for comparison purposes). The optimal alignment is determined as the best score using the GAP program in the GCG software package with a Blossum 62 scoring matrix with a gap penalty of 12, a gap extend penalty of 4, and a frame shift gap penalty of 5. The amino acid residues or nucleotides at corresponding amino acid positions or nucleotide positions are then compared. When a position in the first sequence is occupied by the same amino acid residue or nucleotide as the corresponding position in the second sequence, then the molecules are identical at that position. The identity percentage between the two sequences is a function of the number of identical positions shared by the sequences.

[00123] In some embodiments, % homology or identity as described herein are calculated or determined using the basic local alignment search tool (BLAST). In some embodiments, % homology or identity as described herein are calculated or determined using Blossum 62 scoring matrix.

[00124] In some embodiment, saccharidase further encompasses an enzyme capable of hydrolyzing a glycosidic bond. Non limiting examples of saccharidases are amylase (e.g., alpha- and beta-amylases), glucoamylases, glucosidase including any structural homolog, and any combination thereof. In some embodiments, saccharidase is or comprises amylase and/or glucoamylase. Such enzymes can be used in their free form or immobilized on polymeric beads in order to facilitate their recovery in the process.

[00125] In some embodiments, oxidase encompasses an enzyme having oxidase activity. Non limiting examples for the oxidase are laccase, peroxidase, tyrosinases, including any structural homolog, and any combination thereof. In some embodiments, oxidase is laccase. Such enzymes can be used in their free form or immobilized on polymeric beads in order to facilitate their recovery in the process.

[00126] In some embodiments, the protein comprises a non-animal protein. In some embodiments, the protein is from an animal origin (also referred to as animal protein). In some embodiments, the protein comprises both a non-animal protein and an animal protein. In some embodiments, the animal protein is selected from: meat (e.g., pork, lamb, beef, etc.) protein, fish protein, egg protein, and milk protein, including any combination thereof. In

some embodiments, the non-animal protein is selected from: fruit protein, vegetable protein, seed protein, algal protein, fungal protein, yeast protein, legume protein, or any combination thereof. In some embodiments, the protein consists essentially of a non-animal protein.

[00127] In some embodiments, the non-animal protein comprises a plant protein. In some embodiments, the protein consists essentially of a plant protein. In some embodiment, the plant protein comprises a legume protein, a cereal protein, a vegetable protein, or any combination thereof. In some embodiment, the plant protein is selected from: pea, soybean, chickpea, quinoa, potato, fava beans, yellow pea, rice, rye, golden lentil, chana dal, sorghum, sprouted green lentil, white lima bean, hemp, corn, rapeseed, canola, including any fraction (or hydrolysate), derivative, or any combination thereof.

[00128] In some embodiments, the protein is a plant protein isolate.

[00129] In some embodiment, the protein utilized in the instant invention is a food grade protein. In some embodiment, the protein comprises a single protein species, or a plurality of chemically distinct proteins. In some embodiment, the protein is a natural product. In some embodiment, the protein is derived from a natural product. In some embodiments, the term “derived from” encompasses any industrial processing such as purification, isolation, fractionation, chemical modification, etc. In some embodiments, the protein is a protein hydrolysate. In some embodiments, the protein is characterized by a chemical purity of between 60 and 99.9%, between 60 and 70%, between 70 and 80%, between 80 and 85%, between 85 and 90%, between 90 and 95%, between 95 and 99.9%, including any range in between.

[00130] In some embodiments, the protein is a protein isolate. In some embodiments, the protein or the protein isolate is derived from a natural product, or from a natural protein isolate, and further comprises impurities such as polysaccharides and oligosaccharides. In some embodiments the protein or the protein isolate comprises non-protein impurities (e.g. salts, non-phenolic poly-, oligo-saccharide, pigment, etc.) up to 40%, up to 30%, up to 20%, up to 10% and between 1 and 40%, between 1 and 10%, between 10 and 40%, between 10 and 20%, between 15 and 20%, between 20 and 30%, between 30 and 40%, including any range in between.

[00131] In some embodiments the content of impurities within the protein or the protein isolate 90%, up to 80%, up to 60%, up to 60%, up to 40%, up to 30%, up to 20%, up to 10%

and between 1 and 90%, between 1 and 50%, between 10 and 40%, between 10 and 20%, between 15 and 20%, between 20 and 30%, between 30 and 40%, including any range in between.

[00132] According to one aspect there is provided a food product comprising (i) a plant protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings; and wherein the food product is characterized by a gelation content of at between 5 and 50% and/or a crosslinking degree between 20 and 90%; and wherein a molar ratio between glutamine and glutamic acid (and/or Asn:Asp) residues within the plant protein is at most 1:10, or at most 1:2, or as disclosed hereinabove. In some embodiments, the food product further comprises trace amount of the oxidase and/or of the proteolytic enzyme, wherein the trace amounts are disclosed hereinabove.

[00133] In some embodiments, the food product of the invention is characterized by a reduced molar ratio between glutamine and glutamic acid residues and/or by reduced molar ratio between asparagine and aspartic acid residues within the protein as determined by FTIR, wherein reduced is by at least 10%, at least 100%, at least 500%, at least 1000%, between 0.1% and 1000%, between 0.1% and 10%, between 5 and 50%, between 10 and 100%, between 50 and 250%, between 100 and 500%, between 250% and 750%, between 750 and 1000%, including any range in between, as compared to pristine protein. In some embodiments, the reduced molar ratio is determined by a C=O peak ratio between an amide and a carbonyl ester, obtained from an FTIR spectrum. Exemplary determination of the C=O peak ratio between the amide and the carbonyl ester peak ratio is as described in Fig. 1A and Fig. 1B.

[00134] In some embodiments, the pristine protein is characterized by an FTIR peak at a wavelength between about 1240 and 1232 cm^{-1} , corresponding to C-C-O bond of the phenol-based rings. Wherein, the food product of the invention is characterized by an FTIR peak at a wavelength between about 1233 and 1228 cm^{-1} . Wherein, the food product of the invention is characterized by an FTIR peak corresponding to C-C-O bond of the phenol-based rings shifted by $\pm$ about 1 to 5 cm^{-1} , relative to the same peak of the pristine protein. A non-limiting FTIR spectrum of an exemplary article of the invention is demonstrated in Fig. 4.

[00135] In some embodiments, the transformation degree of glutamine to glutamic acid residues (and/or Asn to Asp residues) within the protein is between about 1 to 95%, between 1 and 5%, between 3 and 7%, between 5 and 10%, between 10 and 15%, between 15 and 25%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 65%, between 65 and 75%, between 75 and 85%, between 85 and 95%, including any range in between. The transformation degree was measured according to Church FC, Porter DH, Catignani GL, Swaisgood HE. An o-phthalaldehyde spectrophotometric assay for proteinases. *Anal Biochem.* 1985 May 1;146(2):343-8. Exemplary transformation degree graph is described in Fig. 2A and Fig. 2B.

[00136] According to one aspect there is provided a food product comprising (i) a hydrolyzed protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings; and wherein the hydrolyzed protein is characterized by a hydrolysis degree between 5 and 40%. In some embodiments, the hydrolyzed protein is obtained via hydrolysis with an enzyme having a proteolytic activity. In some embodiments, the food product further comprises trace amount of the oxidase and/or of the proteolytic enzyme, wherein the trace amounts are as disclosed hereinabove.

[00137] According to one aspect there is provided a food product comprising (i) a hydrolyzed protein and (ii) an additional agent; wherein the (i) and the (ii) comprise one or more of plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings; wherein the hydrolyzed protein is characterized by a hydrolysis degree between 5 and 40%; and wherein the food product is characterized by a crosslinking degree between 20 and 90% and/or by a gelation content of between 5 and 50%. In some embodiments, the food product further comprises trace amount of the oxidase and/or of the proteolytic enzyme, wherein the trace amounts are as disclosed hereinabove.

[00138] According to one aspect there is provided a food product comprising (i) a hydrolyzed plant protein and (ii) an additional agent; wherein the (i) and the (ii) comprise a plurality of phenol-based rings; and wherein the (i) and the (ii) are covalently cross-linked to via the plurality of phenol-based rings; and wherein the hydrolyzed plant protein is characterized by a hydrolysis degree between 5 and 40%. In some embodiments, the

hydrolyzed plant protein is obtained via hydrolysis with a proteolytic enzyme. In some embodiments, the food product further comprises trace amount of the oxidase and/or of the proteolytic enzyme, wherein the trace amounts are as disclosed hereinabove.

[00139] In some embodiments, the hydrolyzed protein is characterized by an alpha helix content of at least 50%, of at least 60%, of at least 70%, and between 50 and 100%, between 50 and 60%, between 60 and 70%, between 70 and 80%, between 80 and 90%, between 90 and 100%, including any range in between. As used herein alpha helix content refers to a ratio between alpha helix and one or more secondary structures selected from beta sheet and random structure. Alpha helix content can be measured by circular dichroism or RAMAN, FTIR, NMR, etc.

[00140] In some embodiments, the hydrolyzed protein is a protein hydrolysate comprising a plurality of peptides. In some embodiments, the plurality of peptides is a mixture of peptides characterized by a distinct sequence, and/or distinct molecular weight. In some embodiments, the plurality of peptides is characterized by an alpha helix content of at least 50%, of at least 60%, of at least 70%, and between 50 and 100%, between 50 and 60%, between 60 and 70%, between 70 and 80%, between 80 and 90%, between 90 and 100%, including any range in between. In some embodiments, the plurality of peptides comprises a chemically distinct peptides (e.g., peptides having different amino acid sequence, and/or different molecular weight). In some embodiments, the plurality of peptides is characterized by an average MW below 80kDa, below 60kDa, between 1 and 80 kDa, between 1 and 60 kDa, between 1 and 50 kDa, between 1 and 5 kDa, between 5 and 10 kDa, between 5 and 20 kDa, between 5 and 40 kDa, between 10 and 15 kDa, between 15 and 20 kDa, between 20 and 25 kDa, between 20 and 30 kDa, between 30 and 40 kDa, between 40 and 50 kDa, between 40 and 80 kDa, between 40 and 60 kDa, between 30 and 80 kDa, including any range in between. In some embodiments, the plurality of peptides is characterized by an MW distribution (PDI) of between 0.2 and 1, including any range between. In some embodiments, the plurality of peptides is characterized by an average MW below 80kDa, and by alpha helix content of above 50%.

[00141] According to another aspect, there is provided a food product comprising (i) a peptide and (ii) an additional agent; wherein the (i) and the (ii) comprise one or more phenol-based ring(s); and wherein the (i) and the (ii) are covalently cross-linked via the plurality of

phenol-based rings; and wherein the food product is characterized by a gelation content of between 5 and 50%. In some embodiments, the peptide is derived from a plant protein. In some embodiments, the peptide is derived from an animal-based protein. In some embodiments, the peptide is a protein hydrolysate obtained by enzymatic hydrolysis of a protein. In some embodiments, enzymatic hydrolysis comprises hydrolysis via a proteolytic enzyme (i.e. a protein having a protease catalytic activity).

[00142] In some embodiments, the peptide comprises a plurality of peptides. In some embodiments, the plurality of peptides comprises substantially the same peptides. In some embodiments, the plurality of peptides is a mixture of peptides characterized by a distinct sequence, and/or distinct molecular weight. In some embodiments, the plurality of peptides is characterized by an alpha helix content of at least 50%, of at least 60%, of at least 70%, and between 50 and 100%, between 50 and 60%, between 60 and 70%, between 70 and 80%, between 80 and 90%, between 90 and 100%, including any range in between. In some embodiments, the plurality of peptides comprises chemically distinct peptides (e.g., peptides having different amino acid sequence, and/or different molecular weight). In some embodiments, the plurality of peptides is characterized by an average MW below 80kDa, below 60kDa, between 1 and 80 kDa, between 1 and 60 kDa, between 1 and 50 kDa, between 1 and 5 kDa, between 5 and 10 kDa, between 5 and 20 kDa, between 5 and 40 kDa, between 10 and 15 kDa, between 15 and 20 kDa, between 20 and 25 kDa, between 20 and 30 kDa, between 30 and 40 kDa, between 40 and 50 kDa, between 40 and 80 kDa, between 40 and 60 kDa, between 30 and 80 kDa, including any range in between. In some embodiments, the plurality of peptides is characterized by an MW distribution (PDI) of between 0.2 and 1, including any range in between.

[00143] In some embodiments, the hydrolyzed protein is characterized by a degree of hydrolysis of between about 5 to 40%, between 5 and 30%, between 10 and 25%, between 10 and 30%, between 1 and 5%, between 5 and 10%, between 10 and 15%, between 15 and 20%, between 20 and 25%, between 25 and 30%, between 30 and 40%, including any range in between. In some embodiments, the hydrolyzed protein is characterized by a degree of hydrolysis of between about 0.5 to 10%, between 0.5 and 2%, between 2 and 4%, between 4 and 6%, between 6 and 8%, between 8 and 10%, including any range in between. The

degree of hydrolysis was measured using the o-phthalaldehyde (OPA) method, exemplary transformation degree graph is described in Fig. 3A and Fig. 3B.

[00144] Non limiting examples of the proteolytic enzyme are pepsin, protein deamidase, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase or aminopeptidase including any combination thereof.

[00145] In some embodiments, the proteolytic enzyme is or comprises papain.

[00146] According to another aspect, there is provided a food product comprising (i) a protein component and (ii) an additional agent; wherein the (i) and the (ii) comprise one or more phenol-based ring(s); and wherein the (i) and the (ii) are covalently cross-linked via the plurality of phenol-based rings.

[00147] In some embodiments, the protein component is a modified protein. In some embodiments, the protein component is a hydrolyzed plant protein.

[00148] As used herein, the term “protein” in conjugation with the food product of the invention, encompasses a modified protein derived from a natural protein or a natural protein isolate, wherein “modified” encompasses enzymatically catalyzed chemical modification of the natural protein. As used herein, the term “modified protein” encompasses (i) a protein characterized by reduced molar ratio between glutamine and glutamic acid residues, as disclosed herein; and further encompasses (ii) a hydrolyzed protein or peptide(s), as disclosed herein.

[00149] Accordingly, the ranges/values (i.e. ratios, concentrations, physico-chemical properties) described herein in relation to “protein” are equally applying to both “modified protein” and “hydrolyzed protein”, interchangeably.

[00150] In some embodiments, the modified protein derived from a natural protein or a natural protein isolate, wherein derived is by treatment of the natural protein or the natural protein isolate with (i) a first enzyme having deamidase catalytic activity; (ii) a proteolytic enzyme; or both (i) and (ii).

[00151] In some embodiments, the modified protein is derived from a natural chimeric protein (i.e. a protein covalently bound to a polysaccharide) is by pre-treatment of the natural protein with (iii) saccharidase, as disclosed herein. In some embodiments, the modified protein derived from a natural protein by treatment of the natural protein or the natural protein isolate with a combination of enzymes selected from (i), (ii) and (iii).

[00152] In some embodiments, the modified protein is a modified plant protein. In some embodiments, the modified protein is a hydrolyzed plant protein.

[00153] In some embodiments, the modified protein is characterized by improved water solubility and/or dispersibility, wherein improved is by at least 20%, at least 30%, at least 50%, at least 80%, at least 100%, at least 150%, at least 200% improved water solubility compared to the pristine protein.

[00154] In some embodiments, the modified protein is characterized by water solubility (i.e. a fraction of the modified protein which is dissolved in DDW without any buffer or salts) of at least 23%, at least 25%, at least 30%, at least 35%, or between 23 and 50%, between 25 and 50%, between 27 and 50%, between 30 and 50%, between 25 and 40%, between 30 and 45%, including any range between, wherein water solubility is calculated based on total nitrogen content of the aqueous composition (see Examples section).

[00155] In some embodiments, a weight of the protein related to the dry weight of the food product of the invention ranges between about 50 and about 95%, between about 60 and about 90%, between 10 and 99%, between 30 and 90%, between 60 and 80%, between 60 and 85%, between 60 and 70%, between 60 and 75%, between 60 and 90%, including any range or value therebetween.

[00156] In some embodiments, the additional agent comprises at least 2 phenolic rings (i.e. phenol based compounds). In some embodiments, the additional agent is a food grade constituent. In some embodiments, the additional agent is or comprises any one of: a biopolymer (e.g., polysaccharide, oligo saccharide, feruloylated polysaccharide and pectic polysaccharides comprising phenol based compounds, a protein, a polyphenol, a lignin, or any combination thereof), a phenolic lipid, a flavonoid, a phenolic acid and a stilbene, including any salt and any combination thereof. In some embodiment, the additional agent comprises a single compound, or a plurality of chemically distinct compounds.

[00157] The term “phenolic ring” or “phenol-based ring”, also used herein as “phenol based compound” refers to a phenol moiety bound to the protein or to the additional agent. The phenol moiety is optionally substituted (e.g., by amide, ester, carboxy, carbonyl, thioester, thioamide, alkoxy substituent, etc.). The phenol based compound bound to the additional agent encompasses a phenol moiety of a hydroxycinnamic acid such as ferulic acid, *p*-

hydroxybenzoic acid, vanillin, *p*-coumaric acid, or a phenol moiety of lignin, stilbene, etc. The phenolic ring bound to the protein encompasses a phenol ring of tyrosine.

[00158] In some embodiments, the additional agent comprises a polysaccharide comprising at least 2 phenolic rings. In some embodiments, the polysaccharide is a phenolic polysaccharide, comprising a polysaccharide backbone substituted with a plurality of phenol based compounds. The term “phenolic polysaccharide” encompasses a hydroxycinnamic acid substituted polysaccharide, thus the terms “phenolic polysaccharide” and “hydroxycinnamic acid substituted polysaccharide” are used herein interchangeably. In some embodiments, the hydroxycinnamic acid comprises ferulic acid, *p*-hydroxybenzoic acid, coumaric acid, α -Cyano-4-hydroxycinnamic acid, Caffeic acid, Cichoric acid, Cinnamic acid, Chlorogenic acid, Diferulic acids, Sinapinic acid including any combination and any salt thereof.

[00159] In some embodiments, the phenolic polysaccharide is or comprises hydroxycinnamic acid substituted (Glucurono)arabinoxylan. In some embodiments, the polysaccharide is a feruloylated polysaccharide. In some embodiments, the polysaccharide is a plant polysaccharide. In some embodiments, the additional agent is derived from a plant. In some embodiments, the additional agent is a plant extract (e.g. aqueous extract), a plant isolate, or comprises a biomass derived from a plant or a plant part (e.g. root, seed, leaf, stem, etc.). In some embodiments, the plant extract is a whole plant extract.

[00160] In some embodiments, the polysaccharide content within the additional agent is between 40 and 99%, between 50 and 99%, between 50 and 90%, between 50 and 70%, between 40 and 80%, between 40 and 90%, between 40 and 70%w/w, including any range between.

[00161] In some embodiments, the term “derived from” encompasses any industrial processing such as extraction, purification, isolation, fractionation, chemical modification, etc. In some embodiments, the additional agent further comprises of impurities (i.e. impurities which are not a phenolic polysaccharide), wherein a w/w concentration of the impurities in the additional agent is up to 40%, up to 30%, up to 20%, up to 15%, up to 10%, up to 5%, up to 1% and between 0 and 20%, between 1 and 40%, between 0 and 5%, between 5 and 10%, between 5 and 15%, between 5 and 20%, between 10 and 20%, between 15 and 20%, including any range in between.

[00162] In some embodiments, the impurities comprise any one of: a non-phenolic polysaccharide (e.g., water-insoluble fibers, cellulose, a glucan, a pectin which are not substituted by a phenol based compounds), a fatty acid (and/or an ester thereof), a lipid, a salt, a pigment (e.g., chlorophyll, carotenoids), a protein or any combination thereof.

[00163] In some embodiments, a w/w portion of the phenol based compounds (e.g. ferulic acid, *p*-hydroxybenzoic acid, vanillin, *p*-coumaric acid, or any combination thereof) within the polysaccharide is between 0.05 and 5%, between 0.1 and 5%, between 0.1 and 1%, between 0.05 and 2%, between 0.05 and 1%, between 0.05 and 3%, including any range between.

[00164] In some embodiments, the feruloylated polysaccharide comprises any one of: sugar beet pectin, psyllium husk powder and psyllium seeds powder, chia husk or chia seeds powder, or any combination thereof. In some embodiments, the polysaccharide is a feruloylated pectin. In some embodiments, the polysaccharide is or comprises a psyllium or chia derived material. In some embodiments, psyllium derived materials are derived from a plant or a plant part of genus *Plantago*. In some embodiments, psyllium derived materials are derived from seeds or stems of the plant of genus *Plantago*. In some embodiments, psyllium derived material is in a form of a powder, a granule or a capsule. In some embodiments, psyllium derived material is or comprises psyllium husk and/or psyllium seeds.

[00165] In some embodiments, a weight ratio between the protein and the additional agent with the food product of the invention is between 20:1 and 1:1, between 15:1 and 1:1, between 10:1 and 2:1, between 8:1 and 2:1, between 8:1 and 3:1, between 6:1 and 2:1, between 6:1 and 3:1, including any range in between.

[00166] In some embodiments, a weight ratio between the protein and the additional agent with the food product of the invention is between 1:100 and 100:1, between 1:5 and 100:1, between 1:1 and 100:1, between 1:50 and 1:1, between 1:100 and 1:1, between 1:50 and 50:1, between 1:100 and 1:5, between 1:5 and 5:1, between 1:5 and 1:1, between 1:1 and 5:1, between 10:1 and 1:1, between 1:1 and 10:1, between 1:1 and 50:1, including any range in between.

[00167] In some embodiments, the food product of the invention is characterized by a gelation content of at least 5%, at least 10%, at least 15%, at least 20%, between 5 and 50%,

between 5 and 15%, between 10 and 20%, between 20 and 30%, between 23 and 27%, between 15 and 25%, between 25 and 35%, between 30 and 40%, between 40 and 50%, including any range in between.

[00168] In some embodiments, the food product further comprises water, wherein the w/w percentage of the water within the food product of the invention is between 0.1 and 80% w/w, between 0.1 and 5%, between 0.1 and 10%, between 5 and 25%, between 10 and 20%, between 25 and 50%, between 20 and 30%, between 30 and 40%, between 40 and 50%, between 50 and 60%, between 60 and 70%, between 70 and 80%, including any range in between.

[00169] In some embodiments, the food product consists essentially of the protein, water, and the additional agent of the invention (and optionally of the additional food ingredient), wherein the protein and the additional agent are crosslinked as disclosed herein. In some embodiments, at least 70%, at least 80%, at least 90%, at least 95% by weight of the food product consists of the protein, water and the additional agent. In some embodiments, the food product consists of the protein, water and the additional agent by weight of between 70 and 95%, between 70 and 75%, between 75 and 80%, between 80 and 85%, between 85 and 90%, between 90 and 95%, including any range in between. In some embodiments, the water is bonded by physical interactions (e.g., hydrogen bonding, dipole-dipole interactions, electrostatic interactions, etc.) to the plant protein, and/or to the additional agent.

[00170] In some embodiments, the food product of the invention is swellable (i.e. water absorption capacity) by at least 20%, at least 50%, at least 100%, between 30 and 300%, between 50 and 250% weight increase after water absorption, including any range between.

[00171] In some embodiments, the food product of the invention is solid at a temperature below 100°C, and between 20 and 100°C, between 20 and 30°C, between 30 and 40°C, between 40 and 50°C, between 50 and 60°C, between 60 and 70°C, between 70 and 80°C, between 80 and 90°C, between 90 and 100°C, including any range in between.

[00172] In some embodiments, the food product is a hydrated-solid (is also referred to herein as “moist food product”). In some embodiments, the moist food product comprises water, wherein the water is bonded by physical interactions (e.g., hydrogen bonding, dipole-dipole interactions, electrostatic interactions, etc.) to the plant protein, and/or to the additional agent. In some embodiments, the food product is a hydrogel. In some

embodiments, the food product is characterized by water retention ability (of at least 30%, at least 40%, at least 50%, at least 70%, or between 30 and 90%, between 30 and 80%, between 30 and 70%, between 30 and 60%, including any range between) when exposed (e.g. by cooking, frying, baking, etc.) to a temperature up to 230C, or up to 200C.

[00173] In some embodiments, the w/w percentage of the water within the moist food product (i.e. hydrated food product) of the invention is between 30 and 80%, between 5 and 80% w/w, between 10 and 80%, between 10 and 70%, between 10 and 75%, between 20 and 80%, between 20 and 75%, between 30 and 80%, between 30 and 75%, between 40 and 80%, between 40 and 75%, between 40 and 70%, between 40 and 60%, between 50 and 80%, between 50 and 75%, between 50 and 70%, between 10 and 20%, between 5 and 15%, between 10 and 20%, between 20 and 30%, between 30 and 40%, between 40 and 50%, including any range in between.

[00174] As used herein, the term “hydrogel” refers to a solid comprising the plant protein, the additional agent, and the water. In some embodiments, the plant protein molecules are in a form of a three-dimensional network of protein molecules. In some embodiments, the protein molecules are homogeneously distributed (e.g., dispersed) within the hydrogel, and are substantially devoid of precipitation or phase separation. In some embodiments, the hydrogel is a polymeric matrix (i.e., a matrix formed by protein chains) stably bound to the water molecules. In some embodiments, the protein molecules are substantially devoid of clusters or precipitations. In some embodiments, the protein molecules within the hydrogel of the invention are substantially in a form of distinct molecules, so that the hydrogel is devoid of protein precipitation.

[00175] In some embodiments, the food product is a dehydrated-solid (is also referred to herein as “dry food product”), comprises at most 10%, at most 5% water, at most 2, at most 0.5% water, between 0.01 and 10%, between 0.01 and 0.1%, between 0.1 and 1%, between 1 and 2%, between 1 and 5%, between 3 and 7%, between 5 and 10%, including any range in between.

[00176] In some embodiments, the dry food product consists essentially of the porous matrix formed by the crosslinked protein and the additional agent of the invention. In some embodiments, the dry food product is a solid, or a porous solid matrix (e.g., a sponge). In

some embodiments, the dry food product is a powder. In some embodiments. The dry product is lyophilized.

[00177] In some embodiments, the dry product is a porous matrix. In some embodiments, the porous matrix is characterized by a porosity of between 40 and 90%, between 40 and 50%, between 45 and 55%, between 50 and 60%, between 60 and 70%, between 70 and 80%, between 80 and 90%, including any range in between.

[00178] In some embodiments, the dry food product is a low density matrix. In some embodiments, the dry food product is characterized by a density of less than 1.0 g/cm^3 , less than 0.98 g/cm^3 , less than 0.95 g/cm^3 , less than 0.93 g/cm^3 , and between 0.85 and 1.0 g/cm^3 , between 0.85 and 0.88 g/cm^3 , between 0.88 and 0.91 g/cm^3 , between 0.91 and 0.93 g/cm^3 , between 0.93 and 0.95 g/cm^3 , between 0.95 and 0.97 g/cm^3 , and between 0.97 and 0.99 g/cm^3 , between 0.99 and 1.0 g/cm^3 including any range in between.

[00179] In some embodiments, the dry food product has at least one dimension; a length, width, height or depth of between 1 cm and 1 m, between 1 cm and 0.1m, between 1 and 25 cm, between 10 and 50 cm between 0.1 and 0.2m. between 0.2 and 0.3m, between 0.3 and 0.4m, between 0.4 and 0.5m, between 0.5 and 0.6m, between 0.6 and 0.7m, between 0.7 and 0.8m, between 0.8 and 0.9m, between 0.9 and 1m including any range in between.

[00180] In some embodiments, the food product is a homogenous solid (i.e. is devoid of a visible phase separation, and substantially retains its shape) at a temperature below 230°C , below 200°C , below 190°C , below 180°C , below 170°C , below 160°C , below 150°C , below 130°C , below 100°C , and between 20 and 230°C , between 20 and 200°C , between 30 and 200°C , between 40 and 200°C , between 50 and 230°C , between 60 and 200°C , between 70 and 200°C , between 20 and 100°C , between 20 and 150°C , between 20 and 180°C , between 20 and 190°C , including any range in between.

[00181] As used herein, the term “matrix” refers to one or more porous continuous layers of cross-linked chains, wherein each chain comprises the protein/peptide, and/or the additional agent. The term “layer” refers to a substantially homogeneous substance of substantially uniform-thickness which maintains its physico-chemical properties (e.g., glass transition temperature, Young’s modulus, elongation) within the entire dimensions (lengths and width dimensions) thereof. In some embodiments, each layer has a different physical

structure and/or a different chemical composition. In some embodiments, each layer has the same physical structure and/or the same chemical composition.

[00182] In some embodiments, the protein/peptide chains are randomly, and/or under certain order or control, distributed therewithin. Matrix may further include any materials incorporated within and/or interposed between the layers or within the pores. In some embodiments, the matrix comprises randomly oriented chains. In some embodiments, each chain within the matrix is in contact with at least one additional chain. In some embodiments, the chains are randomly distributed within the matrix, to obtain a three-dimensional mesh structure comprising a void space between the chains. In some embodiments, the chains are randomly distributed within the matrix thus forming a plurality of pores (or void space). In some embodiments, the matrix comprises the plant polymer, as described herein. In some embodiments, the chains are randomly distributed within the matrix. In some embodiments, the matrix is substantially devoid of aligned or oriented chains. In some embodiments, the matrix is substantially devoid of chains aligned or oriented in a specific direction.

[00183] In some embodiments, the protein (or peptide) chains within the food product (or within the matrix) are cross-linked. The term “cross-linking” as used herein refers to the formation of a chemical bond between two phenol-based rings, wherein the phenol-based rings stem from the protein(s) and/or from the additional agent. In some embodiments, cross linking comprises a chemical bond between two phenol-based rings, wherein the two phenol-based rings are located within (i) the same protein (or peptide) chain or in distinct protein (or peptide) chains. In some embodiments, cross linking comprises a chemical bond between two phenol-based rings, wherein the two phenol-based rings are located within (i) the same additional agent chain or in distinct additional agent chains. In some embodiments, cross linking comprises a chemical bond between two phenol-based rings, wherein the first phenol-based ring stems from the protein (or peptide) and the second phenol-based ring stems from the additional agent. In some embodiments, cross-linking comprises inter cross-linking between two protein (or peptide) chains, wherein the inter cross-linking is via an additional agent bound to the first protein (or peptide) chain and to the second protein (or peptide) chain.

[00184] The crosslinking degree of the food product of the invention refers to a percentage of phenolic rings involved in crosslinking, relative to a total amount of phenolic rings (i.e.

crosslinked and non-crosslinked) in the food product. Alternatively, the crosslinking degree of the food product of the invention refers to a percentage of polysaccharide bound phenolic rings involved in crosslinking, relative to a total amount of polysaccharide bound phenolic rings in the food product. Alternatively, the crosslinking degree of the food product of the invention refers to a percentage of protein bound phenolic rings involved in crosslinking, relative to a total amount of protein bound phenolic rings in the food product.

[00185] The amount of crosslinked and non-crosslinked phenolic rings (and consequently, the crosslinking degree of the food product can be determined by NMR, FTIR, or RAMAN spectroscopy).

[00186] In some embodiments, the food product of the invention is characterized by a crosslinking degree of at least 10%, at least 15%, at least 20%, between 20 and 95% between 20 and 90%, between 50 and 90%, between 50 and 95%, between 50 and 80%, between 60 and 80%, between 10 and 20%, between 20 and 30%, between 23 and 27%, between 15 and 25%, between 25 and 35%, between 30 and 40%, between 40 and 50%, including any range in between. In some embodiments, the food product of the invention is characterized by a crosslinking degree of at least 10%, at least 15%, at least 20%, between 20 and 95% between 20 and 90%, between 50 and 90%, between 50 and 95%, between 50 and 80%, between 60 and 80%, between 10 and 20%, between 20 and 30%, between 23 and 27%, between 15 and 25%, between 25 and 35%, between 30 and 40%, between 40 and 50%, including any range in between, wherein the crosslinking degree refers to a percentage of polysaccharide bound phenolic rings involved in crosslinking relative to a total amount of polysaccharide bound phenolic rings.

[00187] In some embodiments, the food product further comprises an additional food ingredient (e.g. a dietary supplement) such as oil or fat with different solid fat content (SFC) and optionally characterized by a melting point between 35 and 45C, unsaturated fatty acids in their ethyl ester, glyceride and phospholipid forms (such as Omega 3), dietary fiber, non-phenolic polysaccharide, an amino acid, aroma, a flavoring agent, a vitamin, a coloring agent, a mineral (e.g. a metal salt), preservative. In some embodiments, the dietary supplements weight concentration within the food product (e.g. hydrated food product) is up to 30% and between 0.1 and 30%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 3%, between 3 and 4%, between 4 and 5%, between 5 and 6%,

between 6 and 7%, between 7 and 8%, between 8 and 9%, between 9 and 10%, between 10 and 20%, between 15 and 25%, between 1 and 25%, between 20 and 30%w/w, including any range in between. In some embodiments, the food product of the invention consists essentially of food-grade (e.g. GRAS) constituents, suitable for human consumption.

[00188] In some embodiments, the food product of the invention, is shapeable, spreadable or both. In some embodiments, the food product of the invention is characterized by a predetermined shape. In some embodiments, the predetermined shape is any of a sphere, a hemisphere, a hollow sphere, a cylinder, a hollow cylinder, a hollow hemisphere, a cone, a pyramid, a horseshoe, or any other 3-D shape. In some embodiments, the predetermined shape is an irregular shape. The food product of the invention can be generally shaped as a sphere, incomplete-sphere, a rod, cube, a cylinder, a ribbon, a sponge, and any other shape, or can be in a form of a cluster of any of these shapes or can comprise a mixture of one or more shapes.

[00189] In some embodiments, non-limiting examples of shaped food products are sphere (meat ball), disc-like shape (e.g., burger), chunk (cube), cylinder (sausage), slices, strips, etc.

[00190] In some embodiments, the food product substantially maintains its shape under heating at a temperature up to 270°C, or up to 250°C and between -20 and 270°C, between -20 and 250°C, between -20 and 0°C, between -20 and 10°C, between 0 and 25°C, between 20 and 50°C, between 25 and 200°C, between 25 and 100°C, between 50 and 150°C, between 100 and 200°C, between 100 and 270°C, between 100 and 250°C, including any range in between. In some embodiments, the food product is shapeable, spreadable or both; and wherein the food product maintain its shape under heating at a temperature up to 200°C.

[00191] In some embodiments, as used herein the term “spreadable” refers to expansion or deformation of the food product at an end-use temperature.

[00192] In some embodiments, the food product is contained in a suitable package, such as plastic packaging, foil packaging, airtight packaging, moist tight packaging, aseptic packaging, but not limited to.

[00193] In some embodiments, the food product is selected from: chunk, flakes, powder, beverage, protein bar, jelly, burger, sausage, dip, spread, but not limited to.

[00194] In some embodiments the food product is selected from: raw, fried, baked, dried (e.g. thermally dried or vacuum dried), boiled, cooked, poached, but not limited to.

[00195] In some embodiments, the food product of the invention is a low-calorie food product. As used herein, the term “low-calorie” refers to the food product having reduced calorie content compared to food analog products.

[00196] In some embodiments, the food product is selected from meat substitute, fat substitute, dairy substitute, plant-based products, fish substitute, egg substitute, or any combination thereof. In some embodiments, the food product is vegetarian food product. In some embodiments, the food is a vegan food product. In some embodiments, the food product devoid of animal product or any component of an animal product.

[00197] In some embodiments, the food product is characterized by a hardness between 5 and 10N, between 5 and 5.5N, between 5.5 and 6, between 6 and 6.5, between 6.5 and 7N, between 7 and 7.5N, between 7.5 and 8N, between 8 and 8.5N, between 8.5 and 9N, between 9 and 9.5N, between 9.5 and 10N, including any range in between. Hardness is determined by Texture Profile Analyzer (TPA, Lloyd).

[00198] In some embodiments, the food product is characterized by a chewiness between 1 and 3N, between 1 and 1.25N, between 1.25 and 1.5, between 1.5 and 1.75, between 1.75 and 2N, between 2.25 and 2.5N, between 2.5 and 2.75N, between 2.75 and 3N, including any range in between. Chewiness is determined by Texture Profile Analyzer (TPA, Lloyd).

[00199] In some embodiments, the food product is characterized by a gumminess between 0.5 and 2N, between 0.5 and 0.7N, between 0.6 and 0.8, between 0.8 and 1.0, between 1 and 1.2N, between 1.2 and 1.4N, between 1.4 and 1.6N, between 1.6 and 1.8N, between 1.8 and 2N, including any range in between. Gumminess is determined by Texture Profile Analyzer (TPA, Lloyd). In some embodiments, the food product of the invention is characterized with higher hardness and gumminess compared to a control (wherein “higher” is by at least 10%, at least 20%, at least 50%). As used herein, the term “control” refers to a food product cross linked in the presence of transglutaminase, an enzyme greatly used in the industry for cross-linking proteins with polysaccharides.

[00200] In some embodiments, the food product (e.g., the moist or the dry food product) is in a denatured state (is also referred to herein as “denatured food product”). In some embodiments, denaturation of the food product is by thermal processing. In some embodiments, thermal processing disrupts hydrogen bonds and non-polar interactions within

the protein chain, destroying the secondary structures within the protein. In some embodiments, the denatured protein chains aggregate.

[00201] In some embodiments, the denatured food product is characterized by a hardness between 5 and 50N, between 5 and 10N, between 10 and 15, between 15 and 20, between 20 and 25N, between 25 and 30N, between 30 and 35N, between 35 and 40N, between 40 and 45N, between 45 and 50N, including any range in between. Hardness is determined by Texture Profile Analyzer (TPA, Lloyd).

[00202] In some embodiments, the denatured food product is characterized by a chewiness between 4 and 25N, between 4 and 7N, between 7 and 10, between 10 and 13, between 13 and 16N, between 16 and 19N, between 19 and 22N, between 22 and 25N, including any range in between. Chewiness is determined by Texture Profile Analyzer (TPA, Lloyd).

[00203] In some embodiments, the denatured food product is characterized by a gumminess between 4 and 30N, between 4 and 7N, between 7 and 10, between 10 and 13, between 13 and 16N, between 16 and 19N, between 19 and 22N, between 22 and 25N, between 25 and 28N, between 27 and 30N, including any range in between. Gumminess is determined by Texture Profile Analyzer (TPA, Lloyd).

Method 1

[00204] In another aspect, there is provided a method for manufacturing the food product of the invention, the method comprises (i) contacting a protein with a first enzyme having deamidase catalytic activity, thereby obtaining a protein (glutamic acid protein GAP) with a molar ratio between glutamine and glutamic acid residues (and/or Asn:Asp residues) within is at most 1:10, or at most 1:2, (ii) contacting the GAP with an oxidase and with an additional agent under conditions appropriate for crosslinking the GAP and the additional agent, thereby obtaining the food product.

[00205] In some embodiments, the protein is or comprises a plant protein.

[00206] In some embodiments, the first enzyme is configured to catalyze a transformation or conversion of a glutamine residue into a glutamic acid residue.

[00207] In some embodiments, the step (i) further comprises contacting the GAP with a second enzyme having a proteolytic activity (i.e. proteolytic enzyme), thereby obtaining a hydrolyzed GAP, wherein the hydrolyzed GAP is characterized by reduced Gln:Glu molar

ratio and degree of hydrolysis as described above. In some embodiments, step (i) comprises contacting the protein with the first enzyme and with the second enzyme simultaneously or consequently.

[00208] In some embodiments, the first enzyme is further characterized by a proteolytic activity, resulting in the formation of hydrolyzed GAP in one step (i.e. doesn't require an additional treatment by the second enzyme).

[00209] In some embodiments, hydrolyzed GAP is derived from a natural plant protein or a natural plant protein isolate, wherein derived is by treatment of the natural protein or the natural protein isolate with (i) a first enzyme having deamidase catalytic activity; (ii) a proteolytic enzyme; or both (i) and (ii).

[00210] In some embodiments, the step (i) is performed in an aqueous composition comprising the protein at least partially dissolved and/or dispersed therewithin.

[00211] In some embodiments, step (i) is performed at a temperature between 10 and 70°C between 10 to 20°C, between 20 to 30°C, between 30 to 40°C, between 40 to 50°C, between 50 to 60°C, between 60 and 70°C, including any range in between. In some embodiments, the plant protein is suspended, dispersed, or solubilized in a water solution. In some embodiments, the solution is mixed for a period of time sufficient for achieving the desired transformation degree (converting the glutamine into glutamic acid within the plant protein). In some embodiments, the transformation degree is determined by FTIR, or by Nessler reagent, or any other analytical method suitable for detection of ammonia.

[00212] In some embodiments, at a concentration of the protein within the aqueous composition of about 20%w/w the aqueous composition prior to performing the step (i) is a non-flowable composition, and wherein after completion of step (i) the aqueous composition is a flowable liquid.

[00213] In some embodiments, the modified protein (e.g. GAP) is characterized by improved water solubility, wherein improved is by at least 20%, at least 30%, at least 50%, at least 80%, at least 100%, at least 150%, at least 200% improved water solubility compared to the pristine protein.

[00214] In some embodiments, the modified protein (e.g. GAP) is characterized by water solubility (i.e. a fraction of the modified protein which is dissolved in DDW without any buffer or salts) of at least 23%, at least 25%, at least 30%, at least 35%, or between 23 and

50%, between 25 and 50%, between 27 and 50%, between 30 and 50%, between 25 and 40%, between 30 and 45%, including any range between, wherein water solubility is calculated based on total nitrogen content of the aqueous composition (see Examples section).

[00215] In some embodiments, the aqueous composition in step (i) is mixed for a period of time sufficient for achieving the desired water solubility of the modified protein (e.g. GAP).

[00216] In some embodiments, the first enzyme comprises any one of: amidohydrolase, deamidase, protein glutaminase, or any combination thereof.

[00217] In some embodiments, the weight concentration of the protein in the aqueous composition is at least 5% and between 5 and 85%, between 5 and 15%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 65%, between 65 and 75%, between 75 and 85%, including any range in between.

[00218] In some embodiments, a weight concentration of the first enzyme relative to a weight of the protein in the aqueous composition is at most 10%, and between 0.01 and 10%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00219] In some embodiments, the method further comprising performing a termination step thereby substantially arresting enzymatic activity of the first enzyme, wherein the termination step is performed prior to step (ii). In some embodiments, the termination step comprises any of: (a) heating the aqueous composition at a temperature of at least 90°C, (b) contacting the aqueous composition with an inhibitor of the first enzyme, or (c) exposing the aqueous composition to a pH below 4 or above 9.

[00220] In some embodiments, termination is performed after the desired transformation degree was obtained.

[00221] In some embodiments, step (ii) is performed in an aqueous composition.

[00222] In some embodiments, step (ii) comprises contacting the GAP protein and the additional agent at a temperature between 10 and 70 °C for a period of time sufficient for forming the food product with a gel content of at least 5%. In some embodiments, the period

of time sufficient for forming the food product is at least 10 min, at least 30 min, at least 1h, at least 2h, at least 3h, at least 4h, at least 8h, at least 16h, including any range in between.

[00223] In some embodiments, the step (ii) is performed at a temperature between 10 and 70°C between 10 to 20 °C, between 20 to 30 °C, between 30 to 40 °C, between 40 to 50 °C, between 50 to 60 °C, between 60 and 70°C, including any range in between.

[00224] In some embodiments, the weight concentration of the GAP with the aqueous composition is at least 5% and between 5 and 85%, between 5 and 15%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 65%, between 65 and 75%, between 75 and 85%, including any range in between.

[00225] In some embodiments, a weight concentration of the oxidase relative to a weight of GAP in the aqueous composition is at most 10%, and between 0.01 and 10%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00226] In some embodiments, the first enzyme, the oxidase or both are immobilized (i.e., bound to a solid support). In some embodiments, the immobilized enzyme is insoluble in water. In some embodiments, the enzyme is non-immobilized. In some embodiments, the enzyme is soluble in water.

Method 2

[00227] In another aspect, there is provided a method for manufacturing the food product of the invention, the method comprises (i) contacting a protein with a proteolytic enzyme under conditions suitable for hydrolysis of the protein, thereby obtaining a composition comprising a hydrolyzed protein (HPP); (ii) contacting the composition with an oxidase and the additional agent under conditions appropriate for crosslinking the HPP and the additional agent, thereby obtaining the food product. In some embodiments, the protein is or comprises a plant protein. In some embodiments, the step (i) and the step (ii) comprises mixing. In some embodiments, the step (i) and the step (ii) is performed by incubation (i.e. is substantially devoid of mixing). In some embodiments, step (ii) and (i) are performed in an aqueous solvent.

[00228] In some embodiments, the HPP comprises a plurality of proteins characterized by molecular weight (MW), degree of hydrolysis and by a secondary structure as disclosed hereinabove.

[00229] In some embodiments, the conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C, between 10 to 20°C, between 20 to 30°C, between 30 to 40°C, between 40 to 50°C, between 50 to 60°C, between 60 and 70°C, including any range in between.

[00230] In some embodiments, the protein is suspended, dispersed, or solubilized in an aqueous solvent. In some embodiments the solution is mixed for a period of time sufficient for obtaining the desired hydrolyzation degree (determined by OPA). In some embodiments, the step (i) is performed in an aqueous composition comprising the protein at least partially dissolved and/or dispersed therewithin.

[00231] In some embodiments, the weight concentration of the protein in the aqueous composition is at least 5% and between 5 and 30%, between 5 and 85%, between 5 and 15%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 65%, between 65 and 75%, between 75 and 85%, including any range in between.

[00232] In some embodiments, a weight concentration of the proteolytic enzyme relative to a weight of the protein in the aqueous composition is at most 10%, and between 0.01 and 10%, between 0.01 and 3%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00233] In some embodiments, at a concentration of the protein within the aqueous composition of about 20%w/w the aqueous composition prior to performing the step (i) is a non-flowable composition, and wherein after completion of step (i) the aqueous composition is a flowable liquid.

[00234] In some embodiments, the modified protein (e.g. HPP) is characterized by improved water solubility, wherein improved is by at least 20%, at least 30%, at least 50%, at least 80%, at least 100%, at least 150%, at least 200% improved water solubility compared to the pristine protein.

[00235] In some embodiments, the modified protein (e.g. HPP) is characterized by water solubility (i.e. a fraction of the modified protein which is dissolved in DDW without any buffer or salts) of at least 23%, at least 25%, at least 30%, at least 35%, or between 23 and 50%, between 25 and 50%, between 27 and 50%, between 30 and 50%, between 25 and 40%, between 30 and 45%, including any range between, wherein water solubility is calculated based on total nitrogen content of the aqueous composition (see Examples section).

[00236] In some embodiments, the method further comprising performing a termination step thereby substantially arresting enzymatic activity of the proteolytic enzyme, wherein the termination step is performed prior to step (ii). In some embodiments, the termination step comprises any of: (a) heating the aqueous composition at a temperature of at least 90°C, (b) contacting the aqueous composition with proteolytic enzyme inhibitor, or (c) exposing the aqueous composition to a pH below 4 or above 9.

[00237] In some embodiments, termination is performed after the desired hydrolyzation degree was achieved.

[00238] In some embodiments, step (ii) comprises contacting the HPP and the additional agent at a temperature between 10 and 70°C for a period of time sufficient for forming the food product with a gel content of at least 5%. In some embodiments, the period of time sufficient for forming the food product is at least 10 min, at least 30 min, at least 1h, at least 2h, at least 3h, at least 4h, at least 8h, at least 16h, including any range in between. In some embodiments, the temperature of step (ii) is between 10 and 70°C between 10 to 20°C, between 20 to 30°C, between 30 to 40°C, between 40 to 50°C, between 50 to 60°C, between 60 and 70°C, including any range in between.

[00239] In some embodiments, the weight concentration of the HPP within the aqueous composition is at least 5% and between 5 and 85%, between 5 and 15%, between 5 and 30%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 65%, between 65 and 75%, between 75 and 85%, including any range in between.

[00240] In some embodiments, a weight concentration of the oxidase relative to a weight of the HPP in the aqueous composition is at most 10%, and between 0.01 and 10%, between 0.01 and 3%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%,

between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00241] In some embodiments, the proteolytic enzyme and/or the oxidase are immobilized. In some embodiments, the proteolytic enzyme is insoluble in water. In some embodiments, the proteolytic enzyme is non-immobilized. In some embodiments, the proteolytic enzyme is soluble in water.

[00242] The term “proteolytic enzyme” and the term “protease” are used herein interchangeably. In some embodiments, the protease comprises any one of pepsin, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase, aminopeptidase, or any combination thereof.

Method 3

[00243] In another aspect, there is provided a method for manufacturing the food product of the invention, wherein the method comprises (i) contacting a protein (i.e., a natural chimeric protein, or an isolate thereof) comprising a polysaccharide bound thereto, with a saccharidase under conditions suitable for at least partial hydrolysis of the polysaccharide portion of the chimeric protein, thereby obtaining a composition comprising a modified protein; (ii) contacting the composition with an oxidase and with the additional agent under conditions appropriate for crosslinking the additional agent and the modified protein, thereby obtaining the food product. In some embodiments, the protein portion of the modified protein is GAP, and is obtained as described herein. In some embodiments, the protein portion of the modified protein is HPP, and is obtained as described herein. In some embodiments, the step (i) is performed so as to obtain the modified protein consisting essentially of the protein portion and being substantially devoid of the polysaccharide portion.

[00244] In another aspect, there is provided a method for manufacturing the food product of the invention, wherein the method comprises (i) contacting a protein i.e., a natural chimeric protein, or an isolate thereof) comprising a polysaccharide bound thereto, with a saccharidase under conditions suitable for at least partial hydrolysis of the polysaccharide portion of the chimeric protein, thereby obtaining a modified protein; and further adding the psyllium derived material thereby obtaining a composition; (ii) contacting the composition with an oxidase under conditions appropriate for crosslinking the psyllium derived material and the modified protein, thereby obtaining the food product. In some embodiments, the

protein portion of the modified protein is GAP, and is obtained as described herein. In some embodiments, the protein portion of the modified protein is HPP, and is obtained as described herein. In some embodiments, the step (i) is performed so as to obtain the modified protein consisting essentially of the protein portion and being substantially devoid of the polysaccharide portion.

[00245] In some embodiments, the appropriate conditions of step (i) comprise contacting the chimeric protein with the saccharidase, such as alpha-amylase, beta-amylase and glucoamylase, at a temperature between 10 and 90°C between 10 to 20°C, between 20 to 30°C, between 30 to 40°C, between 40 to 50°C, between 50 to 60°C, between 60 and 70°C, between 70 and 80°C, between 80 and 90°C, including any range in between. In some embodiments, step (i) comprises one or more distinct saccharidase species. In some embodiments, contacting the chimeric protein with a plurality of distinct saccharidase species can be performed simultaneously or sequentially.

[00246] In some embodiments, the chimeric protein in step (i) is suspended, dispersed, or solubilized in an aqueous solvent to obtain a composition (aqueous composition), wherein the composition is selected from solution, dispersion and suspension. In some embodiments, the step (i) and the step (ii) are performed in an aqueous composition.

[00247] In some embodiments, contacting of step (i) comprises mixing the composition for a period of time sufficient for obtaining the predetermined hydrolysis degree of the polysaccharide portion of the chimeric protein. In some embodiments, the hydrolysis degree is determined by measuring the concentration of water-soluble sugars comprising mono-, di-, tri-, and/or oligosaccharides.

[00248] In some embodiments, the modified protein is characterized by improved water solubility, wherein improved is by at least 20%, at least 30%, at least 50%, at least 80%, at least 100%, at least 150%, at least 200% improved water solubility compared to the pristine chimeric protein.

[00249] In some embodiments, the modified protein is characterized by water solubility (i.e. a fraction of the modified protein which is dissolved in DDW without any buffer or salts) of at least 23%, at least 25%, at least 30%, at least 35%, or between 23 and 50%, between 25 and 50%, between 27 and 50%, between 30 and 50%, between 25 and 40%,

between 30 and 45%, including any range between, wherein water solubility is calculated based on total nitrogen content of the aqueous composition (see Examples section).

[00250] In some embodiments, the weight concentration of the chimeric protein within the composition of step (i) is at least 5% and between 5 and 60%, between 5 and 15%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 50%, between 55 and 60%, including any range in between.

[00251] In some embodiments, at a concentration of the chimeric protein within the aqueous composition of about 20%w/w the aqueous composition prior to performing the step (i) is a non-flowable composition, and wherein after completion of step (i) the aqueous composition is a flowable liquid.

[00252] In some embodiments, a weight concentration of the saccharidase relative to a weight of the chimeric protein in the composition of step (i) is at most 10%, and between 0.01 and 10%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00253] In some embodiments, the method further comprises performing a termination step thereby substantially arresting enzymatic activity of the saccharidase, wherein the termination step is performed prior to step (ii). In some embodiments, the termination step comprises any of: (a) heating the composition of step (i) at a temperature of at least 90°C, (b) contacting the composition of step (i) with saccharidase inhibitor, or (c) exposing the composition of step (i) to a pH below 3 or above 9.

[00254] In some embodiments, termination is performed after the desired hydrolyzation degree was obtained. In some embodiments, step (ii) comprises obtaining a composition (e.g. solution) comprising the modified protein, an enzyme having an oxidase activity (e.g. oxidase), and the additional agent; and subjecting the composition to a temperature between 10 and 70°C for a period of time sufficient for forming the food product of the invention. In some embodiments, the period of time sufficient for forming the food product is at least 10 min, at least 30 min, at least 1h, at least 2h, at least 3h, at least 4h, at least 8h, at least 16h, including any range in between. In some embodiments, the temperature for performing step (ii) is between 10 and 70°C between 10 to 20°C, between 20 to 30°C, between 30 to 40°C,

between 40 to 50°C, between 50 to 60°C, between 60 and 70°C, including any range in between.

[00255] In some embodiments, the weight concentration of the modified protein within the composition of step (ii) is at least 5% and between 5 and 60%, between 5 and 15%, between 15 and 25%, between 17 and 23%, between 25 and 35%, between 35 and 45%, between 45 and 55%, between 55 and 60%, including any range in between.

[00256] In some embodiments, a weight concentration of the enzyme having oxidase activity relative to a weight of the modified protein within with the composition of step (ii) is at most 10%, and between 0.01 and 10%, between 0.01 and 0.05%, between 0.05 and 0.1%, between 0.1 and 0.5%, between 0.5 and 1%, between 1 and 2%, between 2 and 5%, between 5 and 10%, including any range in between.

[00257] In some embodiments, the method of the invention comprises an additional step performed before or during the step (ii), the additional step comprises adding one or more of the additional food ingredient to the GAP or to the composition obtained after performing the step (i). In some embodiments, the additional step comprises adding the additional food ingredient in an amount ranging between 0.1 and 20%, between 0.1 and 1%, between 0.1 and 5%, between 0.1 and 10%, between 0.5 and 10%, between 0.5 and 5%, w/w from the weight of GAP or of the composition, including any range between.

[00258] In some embodiments, the saccharidase, the oxidase or both enzymes are immobilized (i.e., bound to a solid support). In some embodiments, the immobilized enzyme is insoluble in water. In some embodiments, the enzyme is non-immobilized. In some embodiments, the enzyme is soluble in water.

[00259] The food products disclosed herein can be characterized by instruments such as texture profile analyzer (TPA, Lloyd, equipped with 100N load cell). Test setup: a food product with diameter of 5.6cm x 2cm (height) was compressed by 40% between two parallel plates at a speed of 100mm/min, in two compression cycles, with a 0.1 second delay between cycles.

General

[00260] As used herein the term “about” refers to $\pm 10\%$. Further, all numerical values, e.g., when referring the amounts or ranges of the elements constituting the formulation are approximations which are varied (+) or (-) by up to 10% of from the stated values. It is to be

understood, even if not always explicitly stated that all numerical designations are preceded by the term "about".

[00261] The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

[00262] In the description and claims of the present application, each of the verbs, "comprise", "include" and "have" and conjugates thereof, are used to indicate that the object or objects of the verb are not necessarily a complete listing of components, elements or parts of the subject or subjects of the verb.

[00263] The term "consisting of" means "including and limited to".

[00264] The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure. Alternatively, the term "consisting essentially of" in some embodiments thereof is used to define food products which include the recited essential elements (e.g. the modified protein and the additional agent, as disclosed herein) but exclude other elements (e.g. additional food ingredients, such as nutrients, flavorings, coloring agents, preservatives, etc.) that are not essential to the structure, as well as physico-chemical and/or organoleptic properties of the food product.

[00265] The word "exemplary" is used herein to mean "serving as an example, instance or illustration". Any embodiment described as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments and/or to exclude the incorporation of features from other embodiments.

[00266] The word "optionally" is used herein to mean "is provided in some embodiments and not provided in other embodiments". Any particular embodiment of the invention may include a plurality of "optional" features unless such features conflict. The word "optionally" and the word "further" are used herein interchangeably.

[00267] As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

[00268] Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is

merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[00269] Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases “ranging/ranges between” a first indicate number and a second indicate number and “ranging/ranges from” a first indicate number “to” a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numerals therebetween.

[00270] As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical and medical arts.

[00271] Other terms as used herein are meant to be defined by their well-known meanings in the art.

[00272] It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub combination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

[00273] Various embodiments and aspects of the present invention as delineated hereinabove and as claimed in the claims section below find experimental support in the following examples.

EXAMPLES

[00274] The inventors successfully utilized common oxidases (e.g., laccase, peroxidase, tyrosinase) as for catalyzing a reaction between proteins/protein fragments/peptides and polysaccharides comprising phenol-based rings, in addition to the side reactions between protein and protein (or protein fragments/peptides) molecules and between polysaccharide comprising phenol-based rings and polysaccharide comprising phenol-based rings to yield the food product of the invention.

EXAMPLE 1

Preparation and characterization of the food product by method 1

[00275] Pretreatment of 20% w/w plant protein in water (pea protein isolate (PPI) or soy protein isolate (SPI)) with protein with the first enzyme having deamidase catalytic activity (e.g. glutaminase (PG) or protein deamidase). PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate (inhibitor of microbial growth) and PG or glutaminase at a temperature between 40 and 60°C. The transformation degree of glutamine residue to glutamic acid residue in different reaction time intervals was examined, presented in Fig. 2A for PPI and Fig 2B for SPI (determined by the OPA). In addition, the solubility of the treated protein was visually seen (Fig. 5A and Fig. 5C) and measured over time (Fig. 6A), results correlated with the degree of transformation. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container in a water bath and reach 90°C for 15min. The transformed protein solution into deamidated protein and/or deamidated protein fragments was mixed with sugar beet pectin (25% wt. of the protein) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm.

[00276] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2hours, to obtain a shaped product (Fig. 7 and Fig. 8). Texture profile analysis (TPA, Lloyd) of the food product was tested, results are summarized in Tables 1 and 2.

Table 1: Texture profile analysis of PPI based patties pretreated with PG, before and after cooking.

	Sample	Hardness (N)	Cohesiveness	Springiness Index	Chewiness(N)	Gumminess(N)	Resilience	Adhesiveness (Nmm)
Before cooking	Without enzymes	3.45	0.47	1.00	1.62	1.62	0.96	11.40
	PG + Laccase, 1h	7.80	0.25	0.74	2.57	1.91	0.26	1.52
	PG + Laccase, 3h	5.74	0.29	0.77	2.16	1.66	0.35	2.07
Cooked with NINJA grill 15min, low heat	With Laccase only	67.93	0.39	0.83	22.18	26.66	0.33	0.08
	PG + Laccase 1h	39.36	0.50	0.87	17.07	19.66	0.45	0.03
	PG + Laccase 3h	27.79	0.57	0.88	13.81	15.71	0.51	0.04

Table 2: Texture profile analysis of SPI based patties pretreated with PG, before and after cooking.

	Sample	Hardness (N)	Cohesiveness	Springiness Index	Chewiness (N)	Gumminess (N)	Resilience	Adhesiveness (Nmm)
Before cooking	Without enzymes	3.45	0.47	1.00	1.62	1.62	0.96	11.40
	with Laccase only	12.00	0.18	0.71	3.09	2.21	0.22	1.61
	Papain + Laccase 1h	9.38	0.24	0.72	3.09	2.21	0.23	0.90
	Papain+ Laccase 3h	9.62	0.20	0.71	2.78	1.97	0.29	0.78
Cooked with NINJA grill 15min,	with Laccase only	67.93	0.39	0.83	22.18	26.66	0.33	0.08
	Papain +	44.45	0.60	0.87	23.26	26.78	0.58	0.02

low heat	Laccase 1h Papain + Laccase 3h	44.72	0.63	0.89	25.14	28.24	0.54	0.01
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EXAMPLE 2

Preparation and characterization of the food product by method 2

[00277] A mixture of 20% w/w PPI or SPI in distilled water (DDW) containing 500 ppm sodium benzoate was pretreated with papain at a temperature between 40 and 60°C. The degree of protein hydrolysis in different reaction time intervals are examined, presented in Fig. 3A for PPI and 3B for SPI (determined by OPA). In addition, the effect of the degree of hydrolysis on the solubility of the treated protein was examined, an increase in solubility was observed visually (Fig. 5B and Fig. 5D) as well as measured (Fig. 6B) based on total nitrogen content, an increase in solubility was observed with an increase in the degree of hydrolysis.

[00278] Furthermore, upon hydrolysis of the pristine plant protein (as well as upon treatment of the pristine plant protein with deamidase, such as PG) a dramatic increase in flowability of the aqueous protein composition has been observed. Before performing the enzymatic modification (i.e. hydrolysis and/or deamidation) the aqueous composition containing about 20%w/w of the plant protein (e.g. PPI or SPI) in DDW was characterized by a paste-like appearance a was non-flowable upon shaking thereof (using a standard laboratory shaker). After completion of the enzymatic modification step, the resulting aqueous composition was a flowable liquid. This observation indicates a significantly improved water solubility/dispersibility of the modified plant protein, as compared to pristine plant protein.

[00279] Protein solubility presented in Figures 6A-B has been calculated based on total nitrogen content as follows.

[00280] Total nitrogen content (TN) in the aqueous composition (aqueous suspension) containing the protein was measured by TOC-TN analyzer. The aqueous composition containing 20%w/w of the plant protein (PPI) was treated with PG or papain, respectively.

Samples were taken at different time points after enzyme addition. Samples were filtered using 0.45µm PVDF syringe filter before analysis.

[00281] TN of PPI has been converted to protein solubility value using a nitrogen/protein conversion factor. For pea protein the factor is 5.36 (average value, see Mariotti, F., Tomé, D. & Mirand, P. P., Crit Rev Food Sci Nutr. 2008 Feb; 48(2):177-8 “Converting nitrogen into protein-beyond 6.25 and Jones’ factors”). The solubility profile after hydrolysis with PG and papain are shown in Figures 6A and 6B.

[00282] Pristine PPI water solubility ranges between 15-20%, and it increases with the hydrolysis treatment time. PG treatment increased the solubility to 36% and 38% (about 200% increase) after 3 and 5h, respectively (Figure 6A). The results presented in Figure 6B show that treatment with papain increased the solubility of PPI to 46% (more than 200% increase) after 3 h of reaction time.

[00283] At the end of the reaction the hydrolytic enzyme was inactivated by heat by immersing the reaction medium container in a water bath and reach 90°C for 15min. The hydrolyzed protein solution was mixed with sugar beet pectin (25% wt. of the protein) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm.

Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2hours, to obtain a shaped product (Fig. 7 and Fig. 8). Texture profile analysis (TPA, Lloyd) of the food product was tested, before and after cooking at Ninja Grill for 15 min, results are summarized in Tables 3 and 4.

Table 3: Texture profile analysis of PPI based patties pretreated with papain, before and after cooking.

	Sample	Hardness (N)	Cohesiveness	Gumminess (N)	Adhesiveness (Nmm)	Chewiness (N)	Resilience	Springiness Index
Before cooking	Without enzymes	2.92	0.46	1.33	13.12	1.37	1.01	1.03
	with Laccase only	12.23	0.17	0.63	3.23	2.04	0.22	0.37

	PG + Laccase 1h	7.67	0.25	0.69	2.82	1.97	0.32	0.50
	PG+ Laccase 3h	6.20	0.27	0.74	2.28	1.68	0.23	1.18
Cooked with NINJA grill 15min, low heat	with Laccase only	28.96	0.44	12.57	0.02	18.94	0.37	0.74
	PG+ Laccase 1h	18.53	0.59	10.99	-0.04	12.82	0.65	0.86
	PG + Laccase 3h	12.65	0.61	7.67	0.06	9.38	0.58	0.82

Table 4: Texture profile analysis of SPI based patties pretreated with papain, before and after cooking.

	Sample	Hard Ness (N)	Cohesi veness	Gummi ness (N)	Adhesive Ness (Nmm)	Chewi Ness (N)	Resili ence	Springiness Index
Before cooking	Without enzymes	2.92	0.46	1.33	13.12	1.37	1.01	1.03
	with Laccase only	12.23	0.17	0.63	3.23	2.04	0.22	0.37
	Papain +	5.75	0.27	0.74	2.08	1.53	0.29	1.67
	Laccase, 1h Papain+ Laccase, 3h	8.30	0.26	0.73	3.02	2.19	0.32	1.27
Cooked with NINJA grill 15min, low heat	with Laccase only	28.96	0.44	12.57	0.02	18.94	0.37	0.74
	Papain+ Laccase, 3h	5.63	0.69	0.89	-0.02	3.9	0.71	0.89

EXAMPLE 3

Preparation and characterization of the food product by method 1

[00284] Texture profile analysis (TPA) of uncooked patties comprised of 15% wt. PPI in water produced by treatments with different enzymes has also been conducted and the results are presented in Table 5. The results show that the hardness values for PPI-based patties crosslinked directly with Laccase without pretreatment with PG are higher than those values for PG-pretreated PPI-based patties. Furthermore, the results show that pretreatment of PPI-based patties with PG and then crosslinking with Laccase, results in significant increase in the adhesiveness and a moderate increase in resilience while decreasing gumminess and chewiness.

[00285] PPI (15% wt.)-based patties treated with either Laccase or transglutaminase as crosslinking agents were compared with respect to their mechanical properties. Table 5 shows the TPA results for PPI-based (15%wt.) patties pretreated with PG for 3h and then crosslinked with Laccase, as compared to PPI-based patties (15% wt.) treated with transglutaminase under the same conditions. Both patties treated with different crosslinking enzymes were kept at RT overnight and then stored at -18°C until analysis. The hardness of Laccase-treated patties was statistically higher than the transglutaminase -treated PPI-based patties. However, the cohesiveness for transglutaminase-treated patties was higher than the cohesiveness of the same patties crosslinked with Laccase.

[00286] TPA results presented in Table 5 show also that the different parameters of PPI-based patties, including hardness, gumminess, chewiness, resilience, and springiness are time-dependent, therefore such parameters can be predetermined as a function of time and concentration of enzymes.

[00287] For summary, the results presented in Table 5 demonstrate the use of Laccase in combination with PG and sugar beet pectin or other ferule- or activated aromatic ring-containing complex fiber/polysaccharide as a potential alternative instead of transglutaminase for crosslinking (binding) of proteins comprising food formulations.

Table 5. TPA results of PPI-based (15% wt.) patties with different treatments before and after cooking

Table 5. TPA results of PPI-based (15% wt.) patties with different treatments before and after cooking

	Sample	Hardness (N)	Cohesiveness	Adhesiveness (Nmm)
Before cooking	with Laccase	8.12 ± 0.05	0.21 ± 0.00	1.00 ± 0.13
	PG + Laccase, for 1h	3.60 ± 0.06	0.23 ± 0.02	1.64 ± 0.18
	PG + Laccase, for 3h	3.09 ± 0.34	0.22 ± 0.04	1.73 ± 0.29
	PG + Laccase, for 3h stored at RT over night	15.18 ± 0.49	0.23 ± 0.02	0.75 ± 0.06
	Transglutaminase treatment at RT over night	6.88 ± 0.48	0.44 ± 0.03	0.46 ± 0.01
Cooked with NINJA grill 15min, low heat	With Laccase	35.68	0.24	1
	PG + Laccase, for 1h	20.18	0.37	1.28
	PG + Laccase, for 3h	24.13	0.44	1.34

	Gumminess (N)	Chewiness (N)	Resilience	Springiness Index
Before cooking	1.73 ± 0.04	1.18 ± 0.04	0.17 ± 0.01	0.68 ± 0.01
	0.84 ± 0.07	0.56 ± 0.04	0.21 ± 0.01	0.57 ± 0.01
	0.69 ± 0.21	0.47 ± 0.15	0.22 ± 0.07	0.68 ± 0.01
	3.48 ± 0.15	1.11 ± 0.07	0.25 ± 0.01	0.72 ± 0.01
	3.04 ± 0.40	2.70 ± 0.35	0.38 ± 0.02	0.89 ± 0.00
Cooked with NINJA grill 15min, low heat	8.42	6.16	0.21	0.73
	7.45	5.37	0.32	0.72
	10.5	8.15	0.39	0.78

EXAMPLE 4

[00288] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution into deamidated protein and/or deamidated protein fragments was mixed with sugar beet pectin (25% wt. of the protein) and modified starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container in a water bath to reach 90°C for 15min.

[00289] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 5

[00290] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with sugar beet pectin (25% wt. of the protein) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme The first enzyme was inactivated by heat by immersing the mixture to 90°C for 15min. Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 6

[00291] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with psyllium husk powder (25% wt. of the protein) as a source for polysaccharides containing polyphenolic compounds and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00292] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 7

[00293] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with protein glutaminase (PG) or glutaminase. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with psyllium husk powder and sugar beet pectin (wt. ratio of 1:1, 25% wt. of the protein) and native starch (3%

wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00294] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 8

[00295] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C.

[00296] The transformed protein solution was mixed with psyllium husk powder and sugar beet pectin (wt. ratio of 2:1, 25% wt. of the protein) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00297] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 9

[00298] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with psyllium husk powder and sugar beet pectin (wt. ratio of 1:2, 25% wt. of the protein) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00299] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction

medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 10

[00300] PPI or SPI 20% wt. with no pretreatment with the first enzyme The first enzyme was mixed in distilled water containing 500 ppm sodium benzoate. Psyllium husk powder and sugar beet pectin (wt. ratio of 1:1, 25% wt. of the protein) and native starch (3% wt. of the total wt.) were added to the protein mixture. The mixture was homogenized at 15,000 rpm. Laccase (1% wt. of protein) was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product. The food product was crispy/flexible/bending as compared to the brittle control product which did not contain psyllium husk.

EXAMPLE 11

[00301] PPI or SPI 20% wt. with no pretreatment with the first enzyme were mixed in distilled water containing 500 ppm sodium benzoate. Psyllium husk powder (25% wt. of the protein) and native starch (3% wt. of the total wt.) were added to the protein mixture. The mixture was homogenized at 15,000 rpm. Laccase (1% wt. of protein) was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product. The food product was crispy/flexible/bending as compared to the brittle control product which did not contain psyllium husk.

EXAMPLE 12

[00302] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with apple fiber (25% wt. of the protein as source of polysaccharide containing phenol-based rings and lignin) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first

enzyme was The first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00303] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 13

[00304] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. The transformed protein solution was mixed with apple fiber and sugar beet pectin (wt. ratio of 1:1, 25% wt. of the protein) and native starch (3% wt. of the total wt.) and homogenized at 15,000 rpm. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00305] Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 14

[00306] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 20 and 60°C. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min.

[00307] Then, the mixture was cooled to 60°C and Tyrosinase (as an oxidase) was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 15

[00308] PPI or SPI were mixed in distilled water (20%wt/wt.) containing 500 ppm sodium benzoate. The mixture was homogenized at 15,000 rpm with psyllium husk (25% wt. of protein) in the presence of tyrosinase for 5 minutes. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 16

[00309] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with α -amylase. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and α -amylase at a temperature between 20 and 70°C for 2 hours. The transformed protein solution was mixed with sugar beet pectin (25% wt. of the protein) and homogenized at 15,000 rpm.

Laccase was added to the mixture and homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 17

[00310] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with amyloglucosidase. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and amyloglucosidase at a temperature between 20 and 70°C for 2 hours. The transformed protein solution was mixed with sugar beet pectin (25% wt. of the protein) and homogenized at 15,000 rpm.

[00311] Laccase was added to the mixture and homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 18

[00312] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with α -amylase and glucoamylase, consecutively. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and α -amylase at a temperature between 20 and 70°C for 2 hours. Then, amyloglucosidase was added to the mixture at a temperature between 20 and 70°C for 2 hours mixing. The transformed protein

solution was mixed with sugar beet pectin (25% wt. of the protein) and homogenized at 15,000 rpm.

[00313] Laccase was added to the mixture and homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 19

[00314] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with α -amylase and glucoamylase, simultaneously. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and α -amylase at a temperature between 20 and 70°C for 2 hours. The transformed protein solution was mixed with sugar beet pectin (25% wt. of the protein) and homogenized at 15,000 rpm.

Laccase was added to the mixture and homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 20

[00315] Pretreatment of 20% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in water with the first enzyme. PPI or SPI were mixed in distilled water containing 500 ppm sodium benzoate and the first enzyme at a temperature between 40 and 60°C. At the end of the reaction the first enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min. The transformed protein solution was mixed with psyllium husk powder (10% wt. of the protein) as a source for polysaccharides containing polyphenolic compounds, and sunflower oil (ratio of 1:0.5 wt. protein:oil), and homogenized at 15,000 rpm.

Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium. The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 21

[00316] PPI or SPI with no pretreatment in distilled water (17% wt.) were mixed with psyllium husk powder (10% wt. of the protein) as a source for polysaccharides containing polyphenolic compounds, and palm stearin (of melting point of 40°C) at ratio protein:fat of 1:0.7, and homogenized at 15,000 rpm.

Then, the mixture was cooled to 60°C and Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium.

The formed dough was placed into a cylindrical silicone mold with a diameter of 10cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 22

[00317] 10% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in distilled water, containing 500ppm sodium benzoate) were mixed with the first enzyme, or papain, or other proteolytic enzyme, or any combination thereof, or without any enzyme, at a temperature between 40 and 60°C. At the end of the reaction the enzyme was inactivated by heat by immersing the reaction mixture container at 90°C for 15min. The transformed protein solution was cooled to 60°C and homogenized at 15,000 rpm with gellan gum (2% wt. of the total wt.), psyllium husk powder and sugar beet pectin (wt. ratio of 1:2, 25% wt. of the protein), as a source for polysaccharides containing polyphenolic compounds, and canola oil (10% wt. of the total wt.).

[00318] Then, a cross-linking enzyme (laccase, LC) was added to the mixture (for reference samples, no cross-linking enzyme was added). The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium.

[00319] Then, texturized vegetable protein (TVP, 19% wt. of the total wt.) was gently mixed into the laccase-containing mixture. The formed dough was placed into a cylindrical metal mold with a diameter of 5.6cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 23

[00320] 10% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in distilled water, containing 500ppm sodium benzoate) were incubated at a temperature between 40 and 60°C. Then, the reaction mixture container was immersed at 90°C for 15min. The transformed protein solution was cooled to 60°C and homogenized at 15,000 rpm with methylcellulose (2% wt. of the total wt.), gellan gum (2% wt. of the total wt.), psyllium husk

powder and sugar beet pectin (wt. ratio of 1:2, 25% wt. of the protein), as a source for polysaccharides containing polyphenolic compounds, and canola oil (10% wt. of the total wt.).

[00321] Then, texturized vegetable protein (TVP, 19% wt. of the total wt.) was gently mixed into the mixture. The formed dough was placed into a cylindrical metal mold with a diameter of 5.6cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

[00322] Texture profile analysis (TPA, Lloyd) results of the food products from example 22-23, before and after cooking (grilling using Ninja Grill, low heat for 10 min), are presented in Figure 9 and Figure 10.

[00323] Out of all hydrolytic enzymes used for protein pretreatment, as presented in Figure 9, the highest textural parameters values were obtained when using PG-pretreated SPI.

[00324] The results presented in Figure 10 show that the lowest hardness, gumminess, chewiness, cohesiveness, springiness and resilience values were obtained for non-pretreated SPI-based patties, that were not crosslinked. With addition of either PG-pretreatment, or crosslinking by laccase, all values increased. Moreover, the highest values were obtained for PG-pretreated SPI-based patties, that were also crosslinked by laccase, demonstrating the synergistic effect of both enzymatical treatments and the technological advantage of their combination.

[00325] The combined enzymatic process resulted in textural parameters values within the range of those of commercially available patties, based on methylcellulose.

[00326] For summary, the results presented in Figures 10 and 11 demonstrate the use of Laccase in combination with PG and sugar beet pectin or other ferule- or activated aromatic ring-containing complex fiber/polysaccharide as a potential alternative for methylcellulose and transglutaminase for crosslinking (binding) of proteins comprising food formulations.

EXAMPLE 24

[00327] 10% w/w plant protein (pea protein concentrate, or soy protein concentrate, Tofu produced from soybeans) in distilled water, containing 500ppm sodium benzoate) were mixed with protein glutaminase (PG) or protein deamidase, or papain, or other proteolytic enzyme, or any combination thereof, at a temperature between 40 and 60°C. At the end of the reaction the enzyme was inactivated by heat by immersing the reaction mixture container

at 90°C for 15min. The transformed protein solution was cooled to 60°C and homogenized at 15,000 rpm with gellan gum (2% wt. of the total wt.), psyllium husk powder and sugar beet pectin (wt. ratio of 1:2, 25% wt. of the protein), as a source for polysaccharides containing polyphenolic compounds, and canola oil (10% wt. of the total wt.).

[00328] Then, a cross-linking enzyme (laccase, LC) was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium.

[00329] Then, texturized vegetable protein (TVP, 19% wt. of the total wt.) was gently mixed into the laccase-containing mixture. The formed dough was placed into a cylindrical metal mold with a diameter of 5.6cm x 2cm (height) and kept at room temperature for 2h, to obtain a shaped food product.

EXAMPLE 25

[00330] 10% w/w plant protein (pea protein isolate (PPI) or soy protein isolate (SPI)) in distilled water, containing 500ppm sodium benzoate) were mixed with the first enzyme, or papain, or other proteolytic enzyme, at a temperature between 40 and 60°C. At the end of the reaction the proteolytic enzymes were inactivated by heat by immersing the reaction mixture container at 90°C for 15min and the transformed protein solution was lyophilized. The transformed protein powder was hydrated with distilled water (to constitute 4% wt. of total wt.) and homogenized at 15,000 rpm and 85°C, for 5 minutes, with texturized vegetable protein (TVP, 14% wt. of the total wt.), sugar beet pectin (5% wt. of total weight), as a source for polysaccharides containing polyphenolic compounds, starch (3% wt. of total weight), and coconut oil (5% wt. of the total wt.).

[00331] Then, Laccase was added to the mixture. The mixture was homogenized at 15,000 rpm, which incorporated air bubbles in the reaction medium.

[00332] The formed dough was shaped into a cylinder and kept at room temperature for 2h, to obtain a shaped food product.

CLAIMS

What is claimed is:

1. A food product comprising (i) a protein and (ii) an additional agent; wherein the (i) and said (ii) comprise a plurality of phenol-based rings;
wherein said (i) and said (ii) are covalently cross-linked via said plurality of phenol-based rings;
and wherein a molar ratio between glutamine and glutamic acid residues within said protein is at most 1:10.
2. The food product of claim 1, wherein a dry weight percentage of said protein within said food product is between 60 and 90%.
3. The food product of claim 1 or 2, wherein a weight ratio between the protein and said additional agent is between 10:1 and 1:10.
4. The food product of claim 3, wherein the protein comprises a modified plant protein;
and wherein the weight ratio between the protein and said additional agent is between 10:1 and 3:1.
5. A food product comprising (i) a hydrolyzed protein and (ii) an additional agent;
wherein said (i) and said (ii) comprise plurality of phenol-based rings;
wherein said (i) and said (ii) are covalently cross-linked via said plurality of phenol-based ring;
said hydrolyzed protein is characterized by a hydrolysis degree between 5 and 40%.
6. The food product of claim 5, and wherein said hydrolyzed protein is obtained via protein hydrolysis with a proteolytic enzyme.
7. The food product of claim 6, wherein said hydrolyzed protein comprises a plurality of peptides characterized by alpha helix content of at least 50% and further characterized by an average MW below 80kDa; and wherein the proteolytic enzyme comprises pepsin, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase, aminopeptidase, or any combination thereof.

8. The food product of any one of claims 5 to 7, wherein said hydrolyzed protein comprises a hydrolyzed plant protein; and wherein the hydrolyzed plant protein is characterized by at least 50% improved water solubility compared to the same non-hydrolyzed plant protein.
9. The food product of any one of claims 1 to 8, wherein said food product is characterized by traces of oxidase.
10. The food product of any one of claims 1 to 9, wherein said additional agent is a phenolic lipid, or is a biopolymer comprising a polysaccharide, a polyphenol, a protein, a lignin, or a combination thereof.
11. The food product of claim 10, wherein said polysaccharide is a hydroxycinnamic acid substituted polysaccharide; and wherein the hydroxycinnamic acid substituted polysaccharide comprises a feruloylated polysaccharide, a pectic polysaccharide or both.
12. The food product of any one of claims 1 to 11, wherein said food product is a solid at a temperature below 100°C and is characterized by a gel content of between 5 and 50%.
13. The food product of any one of claims 1 to 12, wherein said food product is characterized by a water content between 0.1 and 70% w/w; and wherein in a hydrated state said food product is characterized by a water content between about 30 and about 70% w/w.
14. The food product of any one of claims 1 to 13, wherein said food product is in a form of a porous matrix.
15. The food product of any one of claims 1 to 14, wherein said food product is selected from meat substitute, fish substitute, egg substitute, dairy substitute, plant-based products, or any combination thereof.

16. The food product of any of claims 1 to 15, wherein said food product is shapeable, spreadable or both; and wherein said food product maintains its shape under heating at a temperature up to 250°C.
17. The food product of any of claims 1 to 16, wherein said food product is characterized by at least one of: a hardness between 5 and 10N, a chewiness between 1 and 3N, and a gumminess between 0.5 and 2N, determined by Texture Profile Analyzer.
18. The food product of any of claims 1 to 17, wherein said food product is in a denatured state and characterized by at least one of: a hardness between 5 and 50N, a chewiness between 4 and 25N, and a gumminess between 4 and 30N, determined by Texture Profile Analyzer.
19. The food product of claim 18, wherein said food product is provided in the denatured state by thermal processing.
20. The food product of any of claims 1 to 19, wherein said food product is low calorie food product.
21. A method for manufacturing said food product of any one of claims 1 to 4, comprising:
 - (i) contacting a protein with a first enzyme having deamidase catalytic activity under conditions appropriate for converting at least glutamine residues of said protein into glutamic acid residues, thereby obtaining a glutamic acid protein (GAP); wherein a molar ratio between glutamine and glutamic acid within said GAP is at most 1:10;
 - (ii) contacting said GAP with an oxidase and with an additional agent under conditions appropriate for crosslinking said GAP and said additional agent, thereby obtaining said food product;

wherein the protein and the additional agent comprise a plurality of phenol-based rings.

22. The composition of the food product of claim 21, wherein the oxidase comprises any one of laccase, peroxidase, tyrosinases, or any combination thereof; and wherein the first enzyme comprises any one of: amidohydrolase, deamidase, protein glutaminase, or any combination thereof.
23. The method of claim 21 or 22, wherein said deamidase catalytic activity comprises glutamine to glutamate transformation activity, asparagine to aspartate transformation activity or both; optionally wherein the first enzyme further comprises s protease activity.
24. The method of any one of claims 21 to 23, further comprising performing a termination step thereby substantially arresting enzymatic activity of said first enzyme, wherein said termination step is performed prior to said step (ii).
25. The method of any one of claims 21 to 23, wherein the step (i) further comprising contacting the protein or the GAP with a second enzyme having a proteolytic activity.
26. The method of any one of claims 21 to 25, wherein said step (ii) comprises mixing at a temperature between 10 and 70 °C for a period of time sufficient for forming said food product with a crosslinking degree of at least 20-90%.
27. The method of any one of claims 21 to 26, wherein said protein comprises a plant protein; and wherein the GAP is characterized by at least 50% improved water solubility compared to the plant protein.
28. A method for manufacturing said food product of any one of claims 5 to 20, comprising:
- (i) contacting a protein with a proteolytic enzyme under conditions suitable for hydrolysis of said protein, thereby obtaining a composition comprising a hydrolyzed protein (HPP);
 - (ii) contacting said composition with an oxidase and the additional agent under conditions appropriate for crosslinking said HPP and said additional agent, thereby obtaining said food product.

29. The method of claim 28, wherein the HPP is characterized by a degree of hydrolysis of between about 5 and about 40%.
30. The method of claim 28 or 29, wherein said conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C; and wherein the method further comprising performing a termination step, wherein said termination step is performed prior to said step (ii).
31. The method of claim 30, wherein said termination step comprises any of: (i) providing said composition to a temperature of at least 90°C; (ii) adding an inhibitor of said proteolytic enzyme to said composition; (iii) exposing said composition to a pH below 4 or above 9, or a combination of (i)-(iii).
32. The method of any claims 28 to 31, wherein said conditions appropriate for crosslinking comprise providing said composition to a temperature between 10 and 70 °C for a period of time sufficient for forming said food product with a gel content of at least 5%.
33. The method of any one of claims 28 to 32, wherein said protein comprises a plant protein and wherein the HPP is characterized by at least 50% improved water solubility compared to the plant protein.
34. The method of any one of claims 21 to 33, wherein said method further comprises lyophilizing said food product.
35. A method for manufacturing a food product comprising (i) a protein and (ii) an additional agent; wherein said (i) and said (ii) comprise plurality of phenol-based rings; wherein said (i) and said (ii) are covalently cross-linked via said plurality of phenol-based ring; the method comprising:
- (i) contacting a protein bound to a polysaccharide with a saccharidase under conditions suitable for at least partial hydrolysis of the polysaccharide, thereby obtaining a composition comprising a protein and hydrolyzed saccharide (PHAS);

- (ii) contacting the composition with an oxidase and with an additional agent under conditions appropriate for crosslinking the protein and the additional agent, thereby obtaining the food product.
36. The method of claim 35, wherein said conditions suitable for hydrolysis comprise mixing at a temperature between 10 and 70°C.
37. The method of claim 35 or 36, further comprising performing a termination step, wherein said termination step is performed prior to said step (ii).
38. The method of claim 37, wherein said termination step comprises any of: (i) providing said composition to a temperature of at least 90°C; (ii) adding an inhibitor of said saccharidase to said composition; (iii) exposing said composition to a pH below 4 or above 9, or any combination of (i)-(iii).
39. The method of any one of claims 35 to 38, wherein said conditions appropriate for crosslinking comprise providing said composition to a temperature between 10 and 70 °C for a period of time sufficient for forming said food product characterized by a cross-linking degree of between about 20 and about 90%.
40. The method of any one of claims 35 to 39, wherein said method further comprises lyophilizing said food product.
41. The method of any one of claims 21 to 40, wherein the method further comprises a preliminary step of adding one or more additional food ingredient; and wherein said preliminary step is performed before the step (ii).
42. The method of claim 41, wherein said one or more additional food ingredient comprises any one of oil/fat, flavoring, a coloring agent, a salt, a vitamin, or a mineral, including any combination thereof.
43. The method of any one of claims 28 to 34, wherein the proteolytic enzyme comprises any one of pepsin, trypsin, chymotrypsin, papain, endoprotease, exoprotease, carboxypeptidase, aminopeptidase, or any combination thereof.

44. The food product of any one of claims 10 to 20, wherein said polysaccharide is derived from psyllium husk, psyllium seeds powder, chia husk, chia seeds powder, apple, bamboo and sugar cane fibers powder, or any combination thereof.
45. The food product of claim 4, wherein said modified plant protein is characterized by water solubility above 25%, as determined based on total nitrogen content.
46. The food product of claim 45, wherein said modified plant protein is characterized by at least 50% improved water solubility compared to the same non-hydrolyzed plant protein.
47. The food product of any one of claims 4 and 45-46, wherein said modified plant protein is a hydrolyzed plant protein characterized by a degree of hydrolysis between 5 and 40%.
48. The food product of claim 47, wherein the hydrolyzed plant protein is characterized by at least one of: (i) alpha helix content of at least 50%; (ii) average MW below 80kDa.
49. The food product of any one of claims 1 to 20 and 44 to 48, wherein said food product is characterized by a crosslinking degree cross-linking degree of between about 20 and about 90%.