(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 September 2022 (29.09.2022)

WIPO | PCT

(10) International Publication Number
WO 2022/204166 A1

(51) International Patent Classification:
A23J 3/20 (2006.01) *C12N 1/14* (2006.01)
A23K 10/30 (2016.01) *C12L 33/195* (2006.01)
A23L 13/40 (2016.01)

(21) International Application Number:
PCT/US2022/021369

(22) International Filing Date:
22 March 2022 (22.03.2022)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/164,466 22 March 2021 (22.03.2021) US

(71) Applicant: **THE FYNDER GROUP, INC.** [US/US]; 815 West Pershing Road, Suite 4, Chicago, Illinois 60609 (US).

(72) Inventor; and
(71) Applicant: **ECKSTROM, Eleanore Brophy** [US/US]; 1614 W. Lunt Ave, Chicago, Illinois 60626 (US).

(72) Inventors: **GHOTRA, Baljit**; 815 West Pershing Road, Suite 4, Chicago, Illinois 60609 (US). **AVNIEL, Yuval**; 815 West Pershing Road, Suite 4, Chicago, Illinois 60609 (US). **KLOPF, Brian**; 815 West Pershing Road, Suite 4, Chicago, Illinois 60609 (US). **KAWABATA, Jessica**; 815 West Pershing Road, Suite 4, Chicago, Illinois 60609 (US). **CARRE, Eric**; 1486 Prairie Trail, Grayslake, Illinois 60030 (US).

(74) Agent: **BOSCHERT, Tyler J.**; Sheridan Ross P.C., 1560 Broadway, Suite 1200, Denver, Colorado 80202 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: FOOD PRODUCTS COMPRISING FILAMENTOUS FUNGAL MATERIAL

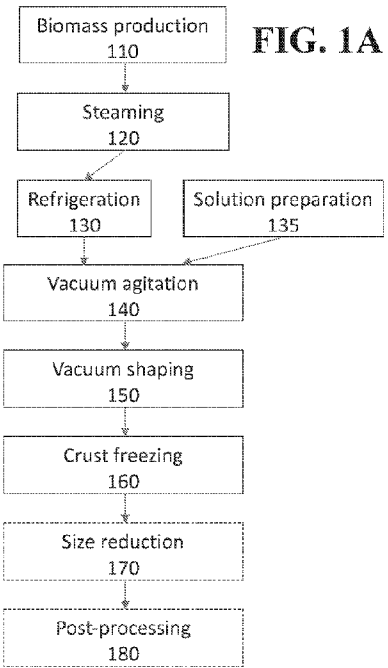


FIG. 1A

(57) Abstract: Filamentous fungal food compositions are disclosed, as are methods of making such filamentous fungal food compositions. The filamentous fungal food compositions may serve as analogs of conventional non-fungal food products, particularly meat products such as meat jerky. The methods of manufacture of the filamentous fungal food compositions may include processing of filamentous fungal biomass under sub-atmospheric pressure.

WO 2022/204166 A1

[Continued on next page]

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

FOOD PRODUCTS COMPRISING FILAMENTOUS FUNGAL MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority of U.S. Provisional Patent Application 63/164,466, filed 22 March 2021, the entirety of which is incorporated herein by reference.

FIELD OF THE INVENTION

This application relates generally to food products comprising filamentous fungal material and methods for the manufacture thereof, and particularly to food products that may serve as analogs or replicas of conventional food products but having improved properties relative thereto.

BACKGROUND OF THE INVENTION

Many conventional processed food products, such as smoked meats or dehydrated meats e.g. meat jerky, include an allergenic substance and/or a substance that is derived or obtained from animals, and may therefore be unsuitable for consumption by persons with dietary restrictions, e.g. persons wishing to reduce or eliminate animal meat intake or with allergic sensitivities. Existing hypoallergenic or vegan alternatives to conventional processed food products often suffer from poor stability and/or shelf life, unappealing taste or texture, and so on. Moreover, many of these conventional processed food products, as a result of processing conditions or requirements for attaining a particular taste, texture, or shelf life, have nutritional drawbacks; by way of non-limiting example, conventional meat jerky is often high in humectants, e.g. sugar, salt, etc. (which must be used in significant quantities during processing as a stabilizer and for its plasticizing effect to achieve jerky's characteristic tough texture), and smoked or otherwise processed conventional meat products are often high in fat (as a result of the fatty tissues from which they are obtained) and/or salt (for flavoring and extension of shelf life). Furthermore, because meat has a high moisture content and water activity, meat products either suffer from short shelf lives or must be dehydrated to a very substantial degree.

There is thus a need in the art for food products that are analogous in taste, texture, and other aesthetic and sensory characteristics to conventional processed food products, but that can be provided at lower cost and/or with an improved nutritional profile. It is further advantageous for such processed food products to be optionally free of allergenic or animal-derived products to allow these products to appeal to a wider range of potential consumers, and to remain stable over extended periods to provide for a longer usable shelf life, for example by having lower activity or moisture content and/or by including a coating or

sealing layer to retain internal moisture and provide a substantially hermetic barrier while avoiding colonization by microbes, while still retaining a desired texture.

SUMMARY OF THE INVENTION

In one aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution; (b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c) treating the plurality of filamentous fungal pieces to form the food product. Steps (a) and (b) may be performed simultaneously or sequentially in any order.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of between about zero and about 101.325 kilopascals, or no more than about 0.1 pascals.

In embodiments, step (a) may be carried out under a reduced-oxygen and/or nitrogen-enriched atmosphere.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb or otherwise take up an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the total (*i.e.*, "wet" or prior to dehydration/removal of water) weight of the filamentous fungal biomass.

In embodiments, step (a) may comprise contacting at least two filamentous fungal biomasses with the solution; the method may further comprise, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate; and step (b) may comprise size-reducing the filamentous fungal aggregate. The aggregate may, but need not, comprise a casing that encases the at least two filamentous fungal biomasses. The aggregating step may, but need not, be carried out under sub-atmospheric pressure, which may, but need not, be a pressure of no more than about 0.1

pascals. The aggregating step may, but need not, comprise crust-freezing the at least two filamentous fungal biomasses.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, step (c) may comprise at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution; and (b) dehydrating the filamentous fungal biomass.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb or otherwise take up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a first filamentous fungal biomass, or portion thereof, with a first solution; (b) size-reducing the first filamentous fungal biomass, or portion thereof, to form a plurality of filamentous fungal pieces; (c) contacting a second filamentous fungal biomass, or portion thereof, with a second solution; (d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass, or portion thereof; and (e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass, or portion thereof, to form the food product.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, at least one of the first and second solutions may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, at least one of the following may be true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass, or portion thereof, prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass, or portion thereof, prior to step (c).

In embodiments, at least one of step (a) and step (c) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, at least one of the following may be true: (i) step (a) comprises the sub-step of removing water from the first filamentous fungal biomass, or portion thereof; and (ii) step (c) comprises the sub-step of removing water from the second filamentous fungal biomass, or portion thereof.

In embodiments, at least one of the following may be true: (i) step (a) is carried out by agitating the first filamentous fungal biomass, or portion thereof, together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass, or portion thereof, together with the second solution.

In embodiments, at least one of the following may be true: (i) the first filamentous fungal biomass, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%,

at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

In embodiments, at least one of the first and second solutions may be an aqueous solution.

In embodiments, at least one of the first and second solutions may be a non-aqueous solution.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as described herein.

In embodiments, the meat jerky analog food product may have a water activity of between about 0.35 and about 0.85, or less than about 0.45.

In embodiments, the meat jerky analog food product may have a shelf life of at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

In another aspect of the present invention, an intermediate food composition comprises a filamentous fungal biomass or a portion thereof; and a solution, absorbed or otherwise taken up by the filamentous fungal biomass or portion thereof.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass or portion thereof.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution comprising a food additive; (b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps (a) and (b) are carried out simultaneously or sequentially in any order.

In embodiments, the food additive may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a total mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may be carried out under super-atmospheric pressure.

In embodiments, step (a) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F.

In embodiments, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass may be no more than about 34 °F.

In embodiments, the method may further comprise, prior to step (a), removing water from the filamentous fungal biomass.

In embodiments, step (a) may comprise agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomass.

In embodiments, step (a) may comprise contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate, and wherein step (b) comprises size-reducing the filamentous fungal aggregate. The step of aggregating may, but need not, comprise encasing the at least two filamentous fungal biomasses in a casing. The aggregating step may, but need not, be carried out under sub-atmospheric pressure, which may, but need not, be a pressure of no more than about 0.1 pascals. The aggregating step may, but need not, comprise crust-freezing the at least two filamentous fungal biomasses.

In embodiments, the method may further comprise, between steps (a) and (b), crust freezing the filamentous fungal biomass. An internal temperature of the filamentous fungal biomass after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, step (c) may comprise at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in or on a fermentation medium or on a membrane associated with a fermentation medium; and inactivating the filamentous fungal biomass. The fermentation method may, but need not, be selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, and an air-medium colloid (AMC) fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat analog food product is made according to a method as described herein.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution comprising a food additive; and (b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F.

In embodiments, step (a) may be carried out at a temperature above room temperature.

In embodiments, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass may be no more than about 34 °F.

In embodiments, the method may further comprise, prior to step (a), removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the filamentous fungal biomass. The fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least

about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as disclosed herein.

In another aspect of the present invention, a meat analog food product comprises filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true: (i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product; (ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food

product; and (iii) a sugar content of the meat analog food product is no more than about 10 wt%.

In embodiments, the meat analog food product may have a shelf life of at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

In embodiments, the meat analog food product may have a water activity of between about 0.35 and about 0.85.

In embodiments, the meat analog food product may have a water activity of no more than about 0.45.

In embodiments, the meat analog food product may comprise less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per 28 grams of food product.

In embodiments, at least one of the following may be true: (i) the meat analog food product comprises no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food product; and (ii) a sugar content of the meat analog food product is no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least

about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the meat analog food product may comprise all nine essential amino acids.

In embodiments, the meat analog food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the meat analog food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the meat analog food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the meat analog food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the meat analog food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a first filamentous fungal biomass with a first solution; (b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces; (c) contacting a second filamentous fungal biomass with a second solution; (d) combining the plurality of filamentous fungal pieces and the second filamentous fungal

biomass; and (e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, at least one of the first and second solutions may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, at least one of the following may be true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass prior to step (c).

In embodiments, at least one of step (a) and step (c) is carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, at least one of step (a) and step (c) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F. During at least part of a duration of step (a), a temperature of at least one of the first filamentous fungal biomass and the second filamentous fungal biomass may, but need not, be no more than about 34 °F.

In embodiments, at least one of step (a) and step (c) may be carried out at a temperature above room temperature.

In embodiments, the method may further comprise at least one of: (i) prior to step (a), removing water from the first filamentous fungal biomass; and (ii) prior to step (c), removing water from the second filamentous fungal biomass.

In embodiments, at least one of the following may be true: (i) step (a) is carried out by agitating the first filamentous fungal biomass together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass together with the second solution.

In embodiments, at least one of the following may be true: (i) the first filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass absorbs least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

In embodiments, the method may further comprise at least one of (i) between steps (a) and (b), crust freezing the first filamentous fungal biomass, and (ii) between steps (c)

and (d), crust freezing the second filamentous fungal biomass. An internal temperature of the first filamentous fungal biomass when (i) is true, or an internal temperature of the second filamentous fungal biomass when (ii) is true, after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, at least one of the first and second solutions may be an aqueous solution.

In embodiments, at least one of the first and second solutions may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to at least one of steps (a) and (c), forming at least one of the filamentous fungal biomass and the second filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the at least one of the first filamentous fungal biomass and the second filamentous fungal biomass. The fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by at least one of dehydrating the filamentous fungal biomass, freezing the filamentous fungal biomass, pressure treating the filamentous fungal biomass, rinsing the filamentous fungal biomass, size reducing the filamentous fungal biomass, steaming the filamentous fungal biomass, and temperature cycling the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, at least one of the filamentous fungal biomass and the second filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, at least one of the first filamentous fungal biomass and the second filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as disclosed herein.

In another aspect of the present invention, an intermediate food composition comprises a filamentous fungal biomass; and a solution comprising a food additive, absorbed by the filamentous fungal biomass.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the filamentous fungal biomass may be derived from a fermentation method selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid (AMC) fermentation method, and combinations thereof.

In embodiments, the filamentous fungal biomass is inactivated.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In another aspect of the present invention, a method for preparing a food product comprises (a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; (b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c)removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive.

In embodiments, in step (a), the filamentous fungal biomass may be exposed to an absolute pressure of no more than about 0.1 pascals.

In embodiments, following step (a), the filamentous fungal biomass may have an approximately cylindrical shape.

In embodiments, the method may further comprise, between steps (a) and (b), crust freezing the filamentous fungal biomass. An internal temperature of the filamentous fungal biomass after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the filamentous fungal biomass. The

fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

The advantages of the present invention will be apparent from the disclosure contained herein.

As used herein, "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B, and C," "at least one of A, B, or C," one or more of A, B, and C," "one or more of A, B, or C," and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B, and C together.

It is to be noted that the term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more," and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising," "including," and "having" can be used interchangeably.

As used herein, unless otherwise specified, the terms "about," "approximately," etc., when used in relation to numerical limitations or ranges, mean that the recited limitation or range may vary by up to 10%. By way of non-limiting example, "about 750" can mean as little as 675 or as much as 825, or any value therebetween. When used in relation to ratios or relationships between two or more numerical limitations or ranges, the terms "about," "approximately," etc. mean that each of the limitations or ranges may vary by up to 10%; by way of non-limiting example, a statement that two quantities are "approximately equal" can mean that a ratio between the two quantities is as little as 0.9:1.1 or as much as 1.1:0.9 (or any value therebetween), and a statement that a four-way ratio is "about 5:3:1:1" can mean that the first number in the ratio can be any value of at least 4.5 and no more than 5.5, the second number in the ratio can be any value of at least 2.7 and no more than 3.3, and so on.

The embodiments and configurations described herein are neither complete nor exhaustive. As will be appreciated, other embodiments of the invention are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B are flowcharts depicting embodiments of a method for processing filamentous fungal material into a food product or material for use in a food product, according to embodiments of the present disclosure.

Figures 2A and 2B are flowcharts depicting embodiments of a method for processing a filamentous fungal food material, derived from a fungal biomat and processed according to the method depicted in Figure 1A, into a meat jerky analog food product, according to embodiments of the present disclosure.

Figures 3A, 3B, and 3C are images of pieces of three jerky analog food products, according to embodiments of the present invention.

Figures 4A and 4B are microscopic images of a hydrophilic side of a jerky analog food product, according to embodiments of the present invention.

Figure 5A and 5B are microscopic images of a hydrophobic side and a hydrophilic side, respectively, of a jerky analog food product, according to embodiments of the present invention.

Figures 6A and 6B are images of fractured tensile strength testing specimens of jerky analog food products, according to embodiments of the present invention.

Figure 7 is a graph of tensile strength testing results of the specimens illustrated in Figures 6A and 6B.

DETAILED DESCRIPTION OF THE INVENTION

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art. If there is a plurality of definitions for a term herein, the definition provided in the Summary of the Invention prevails unless otherwise stated.

As used herein, unless otherwise specified, the term “analog” or “analog food product” refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to an identified non-fungal food product. By way of non-limiting example, a “meat analog food product,” as that term is used herein, refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to animal meat, and a “jerky food analog product,” as that term is used herein, refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to conventional jerky made from animal meats.

As used herein, the term "biomass," unless otherwise specified, refers to a mass of a living or formerly living organism. By way of non-limiting example, the phrase "filamentous fungal biomass" as used herein refers to a mass of a living or formerly living filamentous fungus. Filamentous fungal biomasses may include biomats (as that term is used herein), as well as filamentous fungus produced by submerged fermentation, such as (but not limited to) a mycoprotein paste as described in U.S. Patent 7,635,492 to Finnigan *et al.*.

As used herein, the term "biomat," unless otherwise specified, refers to a cohesive mass of filamentous fungal tissue comprising a network of interwoven hyphae filaments. Biomats as that term is used herein may, but need not, be characterized by one or more of a density of between about 50 and about 200 grams per liter, a solids content of between about 5 wt% and about 20 wt%, and sufficient tensile strength to be lifted substantially intact from the surface of a growth substrate (*e.g.*, a liquid growth medium, a solid fungal composite, or a solid membrane or mesh). Biomats, as that term is used herein, may be produced by any one or more fungal fermentation methods known in the art, such as, by way of non-limiting example, methods described in PCT Application Publications 2020/176758, 2019/099474, and 2018/014004.

As used herein, unless otherwise specified, the term "free water" refers to water molecules within a mass of material that are not chemically or physically hindered from being removed from the mass of material.

As used herein, unless otherwise specified, the term "inactivated" refers to a filamentous fungal biomass in which the fungal cells have been rendered nonviable, or enzymes capable of degrading or causing biochemical transformations within the biomass have been deactivated, or both. By extension, the term "inactivation" refers to any method or process by which a filamentous fungal biomass may be inactivated, such as, by way of non-limiting example, dehydration, freezing, pressure treatment, rinsing, size reduction, steaming, and temperature cycling.

As used herein, unless otherwise specified, the term "physically bound water" refers to water molecules within a mass of material that are in physical contact with molecules of the material but are not chemically bound to the material.

As used herein, unless otherwise specified, the term "tightly bound water" refers to water molecules within a mass of material that are chemically bound by intermolecular forces, e.g. hydrogen bonding, ionic bonding, ion-dipole forces, van der Waals forces, etc., to molecules of the material.

As used herein, unless otherwise specified, the term "vegan" refers to a food product that is substantially free of food components or ingredients, such as protein, derived from animals. Specific examples of non-vegan food ingredients or products include blood, eggs, isinglass, meat (and components thereof, e.g. animal proteins or fats), milk, rennet, and foods made using any one or more of these ingredients (e.g. ice cream, mayonnaise, etc.). As disclosed herein, some vegan food products may be analogs of non-vegan food products.

As used herein, unless otherwise specified, the term "vegetarian" refers to a food product that is substantially free of meat and components thereof. "Vegetarian" food products, as that term is used herein, may (but need not) include food components or ingredients other than meat that are derived from animals (e.g. eggs, milk, etc.). Thus, as the terms are used herein, all "vegan" food products are "vegetarian," but not all "vegetarian" food products are necessarily "vegan."

Embodiments of the present invention include compositions comprising filamentous fungi, typically compositions comprising edible filamentous fungi, and most typically filamentous fungal food compositions, i.e. edible filamentous fungal compositions that are adapted for consumption by humans or domesticated, farmed (e.g. agriculture or aquaculture), or livestock animals, that include filamentous fungal biomass. In some embodiments, the filamentous fungal food composition may be a food product that is analogous to a conventional or known food product comprising meat or another animal-derived ingredient, wherein the filamentous fungal biomass is provided in addition to or in lieu of the animal-derived ingredient. In embodiments, the filamentous fungal food composition of the present invention may be an analog of a meat product, such as, by way of non-limiting example, whole cuts of meat, ground meat (and products formed therefrom, e.g. meatballs), meatloaves, burger patties, shredded meat, jerky, and so on.

Embodiments of the present invention include food products prepared from a food composition comprising filamentous fungal biomass and a solution, commonly but not always an aqueous solution, comprising one or more food additives, such as, by way of non-limiting examples, salt, flavorings, vitamins, and nutritional components (e.g. carbohydrates, fats, proteins, etc.), in which the solution comprises about 5 wt%, about 10 wt%, about 15 wt%, about 20 wt%, about 25 wt%, about 30 wt%, about 35 wt%, about 40 wt%, about 45 wt%, or about 50 wt%, or alternatively in any range between 5 wt% and 50 wt%, or in any range from any whole number percentage by weight between 5 wt% and 50 wt% to any other whole number percentage by weight between 5 wt% and 50 wt% of the total food composition. One significant advantage and benefit of the present invention is

that the filamentous fungal biomass present in the food compositions of the invention may have significantly greater ability to absorb or otherwise take up a solution, e.g. a "marinade" or similar solution applied to the fungal biomass to achieve a seasoning, flavoring, and/or nutritional objective and/or to define a textural property (e.g. chewiness, elasticity, mechanical behavior characteristics such as tendency to rip or tear, etc.), than conventional meat ingredients; without wishing to be bound by any theory, the present inventors hypothesize that this effect is due to differences between the mycelial structure of a filamentous fungal biomat and the myofibrillar structure of meat, in that the mycelial structure is more amenable to changes in the ratio of bound water to unbound water (and thus to reabsorption of the marinade) than meat. Because the filamentous fungal biomass itself may have a moisture content of as much as 80 wt%, higher than most whole cuts of meat, even before a solution is applied thereto, the water content of food compositions, and particularly meat analog food products, of the invention may be advantageously high. Embodiments of the present invention further include methods of forming a food composition comprising filamentous fungal biomass and a solution as described above (e.g. by contacting filamentous fungal biomass with the solution and allowing the filamentous fungal biomass to absorb or otherwise take up the solution), and food compositions made by such methods. It is to be expressly understood that "food compositions," as that term is used herein unless otherwise specified, of the present invention may be "final" food compositions (i.e. compositions that are intended to be consumed by a human or a domesticated, farmed, or livestock animal without further processing) or "intermediate" food compositions (i.e. compositions that are intended to be further processed and consumed by a human or a domesticated, farmed, or livestock animal only after further processing). Processing steps by which "intermediate" food compositions may become "final" food compositions according to the present invention include, but are by no means limited to, dehydration.

In embodiments, the filamentous fungal biomass may have a moisture content of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. In some embodiments, very little or none of the moisture present in the filamentous fungal biomass may be free water, or, in other words, the filamentous fungal biomass may have a total content of physically bound water and tightly bound water of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. Without wishing to be bound by any particular theory, it is believed that the ability of the filamentous fungal

food compositions of the invention to absorb or otherwise take up a solution is related primarily to the content of physically bound and tightly bound water and not necessarily to the total moisture content.; particularly, free water may be more easily removed during dehydration and replaced by a marinade or other liquid solution than bound water Thus, even high-moisture filamentous fungal biomass may suitably be used in filamentous fungal food compositions of the invention and may absorb or take up a solution in significant quantities, so long as the proportion of moisture that is present as free water is relatively low. In some embodiments, therefore, methods of the present disclosure may include a step of treating a filamentous fungal biomass to remove at least a portion of the free water therefrom to increase the biomass' capacity for taking up a liquid solution in a subsequent treatment step; such a step may result in a longer shelf life for the resulting food product, as the present inventors hypothesize, without wishing to be bound by any particular theory, that shelf life correlates with the proportion of moisture initially present as bound water due to stabilization within the hyphal structure.

One particular advantage and benefit of the methods and compositions of the present invention is that food compositions according to the invention may have advantageously high shelf stability, or, in other words, an advantageously long shelf life, especially as compared to conventional food products to which the filamentous fungal food compositions may be analogous (e.g. meat products), while reducing, or in some embodiments even eliminating, the use of preservatives, stabilizers, and/or mold inhibitors (*e.g.*, potassium sorbate) that may adversely affect the aesthetic or nutritional properties of the food product; in some embodiments, the food product may be substantially free of preservatives, stabilizers, and/or mold inhibitors (i.e., a component added to a food product that, in the quantity added, can materially affect the shelf life of the product), and/or methods for making the food product may not include any step of adding a preservative, stabilizer, and/or mold inhibitor. Without wishing to be bound by any particular theory, this advantage and benefit may be, in at least some embodiments, a result of either or both of (1) control over the moisture content of the filamentous fungal biomass enabled by the methods of the invention, particularly, the ability to remove as much or as little of the free water within the filamentous fungal biomass (and optionally to replace the removed free water with other chemistries) as desired, and (2) inactivation of enzymes and secondary metabolites in the filamentous fungal biomass. By way of non-limiting example, conventional meat jerky products are extremely shelf-stable and may, under ambient conditions, have a shelf life of many months, but achieve this stability only by including significant quantities of salt and/or

sugar, which act as plasticizers and/or stabilizers for the jerky product. Additions of salt and sugar, however, have well-known nutritional drawbacks. The filamentous fungal food compositions of the present invention can overcome this drawback in any one of several ways, for example by substituting salt for sugar as a stabilizer (which may in embodiments result in a more acceptable nutritional profile), by using stabilizers in lesser amounts than analogous conventional food products, or by virtue of having a lower fat content (or other nutritional advantage) relative to true meat. In embodiments, food compositions of the present invention comprise filamentous fungal biomass and one or more food additives (e.g. salt, flavorings, vitamins, added carbohydrates, added fats, added proteins, etc.) and have a shelf life of at least about one week, at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months. In addition or alternatively, such embodiments can include food compositions including no more than 15 grams, no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food composition, and/or a sugar content of no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%. Particularly, food compositions of the present invention may have an “elastic” or “chewy” consistency and texture, and/or a “juiciness” or perceived amount or extent of moisture, analogous to conventional meat jerky products, while still possessing both an advantageously long shelf life and an advantageously low sugar content. These advantageously long shelf lives may, in embodiments, be a consequence of a low water activity, e.g. a water activity of less than about 0.95, less than about 0.90, less than about 0.85, less than about 0.80, less than about 0.75, less than about 0.70, less than about 0.65, less than about 0.60, less than about 0.55, less than about 0.50, less than about 0.45, less than about 0.40, less than about 0.35, less than about 0.30, less than about 0.25, less than about 0.20, less than about 0.15, less than about 0.10, or less than about 0.05.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavoring ingredients added to the filamentous fungal biomass may be enhanced relative to their perceptibility in both analogous conventional meat and dairy products and current vegan or vegetarian meat analog or dairy analog products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when salt is added to filamentous fungal biomass to form a food composition of the present invention, the resulting food composition is subjectively much "saltier" (i.e. has a greater gustatory perception of salt flavor) than a conventional meat product containing the same concentration of salt. Without wishing to be bound by any particular theory, it is believed that this result may be due to a lower fat content in filamentous fungal biomass than in meat (as fat may dull the perceptibility of salt in a food product) and/or due to the inherently "mild" or "neutral" flavor of filamentous fungal biomass compared to many types of meat. Regardless of the mechanism, however, this advantageous result allows flavoring additives to be used in lower quantities in the food compositions of the present invention than in conventional food products to which they may be analogous. In embodiments, filamentous fungal food compositions of the present invention may have a perceived saltiness comparable to a conventional meat product while including less than about 200 milligrams, less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per serving.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavors imparted to the food compositions due to a cooking or preparation process may be enhanced relative to their perceptibility in analogous conventional food products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when filamentous fungal biomass is smoked to form a smoked food composition of the present invention, the resulting food composition is subjectively much "smokier" (i.e. has a greater gustatory perception of smoke flavor) than a conventional meat product smoked in the same way, which may allow for a given perception of "smokiness" or smoky flavor to be achieved with lower quantities of smoke and/or shorter smoking times. Without wishing to be bound by any particular theory, it is believed that this result may be a result of any one or more of of (1) the use of porous filamentous fungal material, e.g. a filamentous fungal biomat, to allow molecules present in

smoke, marinades, etc. to travel through the fungal material and adhere to surfaces thereof, and/or (2) the filamentous fungal biomass absorbing or otherwise taking up smoke or components thereof (e.g. phenols, such as syringol, guaiacol, and pyrocatechol, and alkyl derivatives thereof) during the smoking process, which may in turn be due to a lower water content in the filamentous fungal biomass (whether inherently or as a result of a drying/dehydration process prior to smoking) making the filamentous fungal biomass more amenable to absorption of hydrophobic compounds in smoke than high-moisture cuts of meat, and/or (3) the strong umami or savory flavor response of the filamentous fungus itself. It may also be the case that, because filamentous fungal biomass has a lower fat content than meat, molecules present in smoke, marinades, etc. that impart flavor may adhere to, become entrenched in, or otherwise become present in the food composition in different locations or by different mechanisms. Regardless of the mechanism, however, this advantageous result allows filamentous fungal biomass in the food compositions of the present invention to be smoked or otherwise prepared for shorter times, at lesser intensity, with lesser environmental impact, etc. than in conventional food products to which they may be analogous, and/or for the food compositions of the present invention to have an enhanced, heightened, or intensified flavor relative to identically prepared conventional meat products. Further, filamentous fungal food compositions of the present invention may have a subjectively "smoky" flavor even when a fat content (which contributes to smoky flavor) of the food composition is much lower than that of an analogous meat product. In embodiments, filamentous fungal food compositions of the present invention may have a perceived smokiness comparable to a conventional smoked meat product while having a fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%. By comparison, smoked pork generally has a fat content of about 15 wt%, and beef brisket generally has a fat content of about 33 wt%.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the filamentous fungal biomass may be more readily processed into a desired physical form, and thus require a lower content, or may even allow the complete omission, of binders, fillers, or similar functional materials, compared to meat or other plant- or fungus-based meat analog materials. Particularly, the present inventors have

demonstrated that filamentous fungal biomass produced according to the present invention can be repeatedly frozen, thawed, dehydrated, rehydrated, etc. (as may be desirable for particular applications), and may in either fresh or frozen form (or both) be amenable to pressing, molding, or otherwise shaping into a desired physical configuration without the addition of any binder. In embodiments, filamentous fungal food compositions of the present invention, and in embodiments, meat analog filamentous fungal food compositions, may comprise at least about 50 wt%, at least about 60 wt%, at least about 70 wt%, at least about 80 wt%, at least about 90 wt%, at least about 91 wt%, at least about 92 wt%, at least about 93 wt%, at least about 94 wt%, or at least about 95 wt% fungal biomass, and/or may comprise no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, or no more than about 5 wt% of binders and fillers (which include similar functional materials). In some embodiments, the filamentous fungal food compositions of the present invention are substantially free of binders and fillers. This feature may be particularly advantageous where the filamentous fungal food composition is a meat analog food product, in which the total content of ingredients other than fungal biomass must be minimized.

Filamentous fungal food compositions according to the present invention may comprise any one or more forms or types of filamentous fungal biomass. By way of non-limiting example, forms or types of filamentous fungal biomass suitable for use in the food compositions of the present invention include, but are not limited to, processed biomats, fungal paste formed from biomats, unprocessed or “raw” biomats, and combinations and mixtures of these. By way of further non-limiting example, filamentous fungal biomass suitable for use in the food compositions of the present invention may be produced, instead of or in addition to surface fermentation processes that yield fungal biomats, any one or more other methods, e.g. a submerged fermentation process yielding a fungal paste, etc.; in some embodiments, it is also possible to combine forms or types of filamentous fungal biomass produced by two or more different processes, e.g. any two or more of a liquid surface fermentation process, a solid surface fermentation process, an air-medium colloid fermentation process, a submerged fermentation process, etc. The ability to incorporate any of several forms or types of filamentous fungal biomass is therefore another advantage and benefit of the compositions and methods of the present invention.

Filamentous fungal food compositions according to the present invention may, in embodiments, comprise a highly dense fungal biomass, and in some embodiments a highly dense fungal biomat or portion thereof. Depending on the fungus and growth conditions, the

filamentous fungal biomass may also exhibit a fibrous texture, which is an important consideration when producing food compositions that require texture to simulate meat (i.e. a meat analog food product); in some embodiments, the fibrous structure of the biomass may be engineered or oriented to provide a material (and thus, in some cases, a food composition or product) that is relatively difficult or relatively easy to tear, or has selected portions that are relatively difficult or relatively easy to tear. The dense nature of the biomass can also enable easy harvesting, without the need for a concentration step (e.g., centrifugation, filtration) between harvesting of the biomass and processing into a food composition. The density of the biomass can range from about 0.01 g dry weight/cm^3 to about 1 g/cm^3, and any subrange within this range. In some embodiments, the density can be greater than about 0.01, greater than about 0.02, greater than about 0.03, greater than about 0.04, greater than about 0.05, greater than about 0.06, greater than about 0.07, greater than about 0.08, greater than about 0.09, greater than about 0.1, greater than about 0.2, greater than about 0.3, greater than about 0.4, greater than about 0.5, greater than about 0.6, greater than about 0.7, greater than about 0.8, greater than about 0.9, or greater than about 1 g/cm^3. In some embodiments, relatively dry fungal biomass may be ground or otherwise size-reduced into relatively fine particles, e.g. a filamentous fungal "flour," before being incorporated into the food composition of the invention; in these embodiments, densities in the above-referenced ranges or even higher may be achieved due to the packing density of the dry fungal flour. In other embodiments, fungal biomass may be ground or otherwise size-reduced into somewhat coarser particles (*e.g.*, in which at least 90% of the particles have a length of between about 4 mm and about 10 mm, and/or a width of between about 1 mm and about 3 mm, and/or a height of up to about 0.75 mm), as is more typical of ground or processed meat.

Another advantage and benefit of the methods of manufacture of filamentous fungal food compositions according to the present invention is that material and/or mechanical properties of the filamentous fungal biomass as it is produced (e.g. in the form of a fungal biomat) may be preserved, or even enhanced, during processing into the filamentous fungal food composition. By way of first non-limiting example, the methods of manufacture disclosed herein may preserve or enhance a filamentous structure or network of a filamentous fungal biomat used to produce the food composition, which may be advantageous, for example, to maintain a high internal surface area suitable for absorption or other uptake of, e.g., flavoring or nutritional additives, smoke, food colorings, etc. By way of second non-limiting example, the methods of manufacture disclosed herein may

preserve or enhance the tensile strength of a filamentous fungal biomat used to produce the food composition. In embodiments, the filamentous fungal food composition, or a portion thereof comprising filamentous fungal biomass, may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, or at least about 600 g/cm^2, or at least about 650 g/cm^2, or at least about 700 g/cm^2, or at least about 750 g/cm^2, or at least about 800 g/cm^2, or at least about 850 g/cm^2, or at least about 900 g/cm^2, or at least about 950 g/cm^2, or at least about 1000 g/cm^2, or at least about 1500 g/cm^2, or at least about 2000 g/cm^2, or at least about 2500 g/cm^2, or at least about 3000 g/cm^2, or at least about 3500 g/cm^2, or at least about 4000 g/cm^2. In other embodiments, biomass of the invention (e.g. a fungal biomat) can have a tensile strength of greater than any whole number greater than 30 g/cm^2. Alternatively, the tensile strength of biomass of the invention (e.g. a fungal biomat) can be in a range of between about 30 g/cm^2 and about 4000 g/cm^2 or any whole number range between about 30 g/cm^2 and about 4000 g/cm^2. In embodiments in which the filamentous fungal biomass is produced as a biomat, the biomat may have sufficient tensile strength to be lifted essentially intact from the surface of a growth medium at the end of a growth period.

In many embodiments, the filamentous fungal biomass of the food composition will provide a substantial fraction of the protein in the food composition. Particularly, the filamentous fungal biomass may provide at least about 20 wt%, at least about 25 wt%, at least about 30 wt%, at least about 35 wt%, at least about 40 wt%, at least about 45 wt%, 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, at least about 75 wt%, at least about 80 wt%, at least about 85 wt%, at least about 90 wt%, at least about 95 wt%, at least about 96 wt%, at least about 97 wt%, at least about 98 wt%, at least about 99 wt%, or substantially all of the protein in the food composition. In some embodiments, the protein content of the filamentous fungal biomass may allow the filamentous fungal biomass to take the place of a protein-rich ingredient found in an analogous conventional food product, particularly an animal-derived ingredient (e.g. meat), whereas in other embodiments the filamentous fungal biomass may be provided in addition to or as a partial replacement for a protein-rich ingredient to augment the protein content of the food product. The filamentous fungal biomass may comprise at least about 20 wt%, at

least about 21 wt%, at least about 22 wt%, at least about 23 wt%, at least about 24 wt%, at least about 25 wt%, at least about 26 wt%, at least about 27 wt%, at least about 28 wt%, at least about 29 wt%, at least about 30 wt%, at least about 31 wt%, at least about 32 wt%, at least about 33 wt%, at least about 34 wt%, at least about 35 wt%, at least about 36 wt%, at least about 37 wt%, at least about 38 wt%, at least about 39 wt%, at least about 40 wt%, at least about 41 wt%, at least about 42 wt%, at least about 43 wt%, at least about 44 wt%, at least about 45 wt%, at least about 46 wt%, at least about 47 wt%, at least about 48 wt%, at least about 49 wt%, at least about 50 wt%, at least about 51 wt%, at least about 52 wt%, at least about 53 wt%, at least about 54 wt%, at least about 55 wt%, at least about 56 wt%, at least about 57 wt%, at least about 58 wt%, at least about 59 wt%, at least about 60 wt%, at least about 61 wt%, at least about 62 wt%, at least about 63 wt%, at least about 64 wt%, at least about 65 wt%, at least about 66 wt%, at least about 67 wt%, at least about 68 wt%, at least about 69 wt%, at least about 70 wt%, at least about 71 wt%, at least about 72 wt%, at least about 73 wt%, at least about 74 wt%, at least about 77 wt%, at least about 76 wt%, at least about 77 wt%, at least about 78 wt%, at least about 79 wt%, or at least about 80 wt% protein content. Alternatively, in embodiments of the invention, filamentous fungi can comprise protein in a range between 20 wt% and 80 wt% or in any whole number percentage range between 20 wt% and 80 wt%. As a result, the filamentous fungal food compositions of the present invention may thus have a notably high or enriched protein and/or fiber content. Thus, on a dry weight basis (or, in other words, at the same moisture content), the food compositions of the invention may be higher in protein than analogous conventional food products, and/or, by the same token, the food compositions of the invention may provide the same protein content as an analogous conventional food product in a smaller mass and/or serving size.

In some embodiments, food compositions and products according to the present disclosure may comprise at least about 10 wt%, at least about 11 wt%, at least about 12 wt%, at least about 13 wt%, at least about 14 wt%, at least about 15 wt%, at least about 16 wt%, at least about 17 wt%, at least about 18 wt%, at least about 19 wt%, at least about 20 wt%, at least about 21 wt%, at least about 22 wt%, at least about 23 wt%, at least about 24 wt%, or at least about 25 wt% protein content. Alternatively, in embodiments, food compositions and products according to the present disclosure can comprise protein in a range between 10 wt% and 25 wt% or in any whole number percentage range between 10 wt% and 25 wt%. As a result, the filamentous fungal food compositions of the present invention may thus have a notably high or enriched protein and/or fiber content. Thus, on a

dry weight basis (or, in other words, at the same moisture content), the food compositions of the present disclosure may be higher in protein than analogous conventional food products, and/or, by the same token, the food compositions of the present disclosure may provide the same protein content as an analogous conventional food product in a smaller mass and/or serving size.

In addition to having a high overall protein content, filamentous fungal biomass in food compositions of the present invention may provide advantageous protein compositions or chemistries. By way of first non-limiting example, the filamentous fungal biomass may represent a "complete" protein source by providing all nine essential amino acids. By way of second non-limiting example, the filamentous fungal biomass may comprise at least one branched-chain amino acid (e.g. leucine, isoleucine, valine), and may in some embodiments contain such amino acids in amounts of at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may be lower in fat than analogous conventional food products. Particularly, the filamentous fungal food compositions of the present invention may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the filamentous fungi may be produced by methods that enable the filamentous fungi to contain functional compounds that may not be present in, or cannot be delivered by, conventional food products. By way of first non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more beneficial nutrients or compounds (vitamins, lipids, glycolipids, polysaccharides, sugar alcohols, ω-3 fatty acids, etc.) that may be taken up by the fungus and thus passed on to the consumer of the food composition. By way of second non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more compounds (e.g. pigments, inks, dyes, fragrances, etc.) that may be taken up by the fungus and improve an aesthetic or sensory quality of the filamentous fungus.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the compositions may be free of allergens, antibiotics, and/or animal-derived products that may otherwise prevent persons with allergenic sensitivities or dietary restrictions (e.g. vegans or vegetarians) from consuming analogous conventional food products. By way of non-limiting example, analogs of a wide variety of conventional meat products (e.g. smoked meat products, meat jerky, etc.) that are meat-free, that are optionally also lactose-free, egg-free, soy-free, and/or dairy-free, and/or that are further optionally vegan, may be produced according to the present invention. Even more advantageously, these problematic ingredients can in some embodiments be replaced by components having nutritional benefits, e.g. red meat may be replaced by fungal filaments or mycelia (i.e. tissues not having the potential adverse effects on cardiovascular health presented by red meat).

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may have an advantageously high content of dietary fiber to allow for the creation of high-fiber food products (and in particular high-fiber alternatives to or analogs of conventional food products, particularly conventional meat products, that may have lower fiber contents). In some embodiments, the filamentous fungal particles may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber. Additionally or alternatively, the food composition may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition. A high fiber content may be advantageous for any one or more additional reasons not directly related to nutritional composition, e.g. improved hydration properties (such as decreased water activity to allow for easier preparation/storage and longer shelf life), increased satiation or "fullness" upon eating (which may encourage consumers to eat more moderate portions and thereby aid in preventing or mitigating adverse health effects such as high cholesterol), improved digestibility, improved digestion and/or prevention of constipation, etc. Particularly, increased satiation or "fullness" may allow consumers to consume fewer total calories and thereby aid, for example, a dieting consumer in losing weight. The filamentous fungal food compositions of the invention may therefore be particularly suitable or

advantageous for inclusion in known and/or commercially available weight loss diets or regimens.

In embodiments of the present invention, methods for preparing a filamentous fungal food composition comprise dehydrating a filamentous fungal biomass, in some embodiments a fungal biomat, at relatively low temperature, e.g. no more than about 185 °F and most typically no more than about 165 °F, over a period of, e.g., between about 20 minutes and about 12 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydration of the filamentous fungal biomass, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal biomass while otherwise retaining the fungal material's basic structure. A moisture content of the filamentous fungal biomass after the dehydration step may be no more than about 45 wt%, no more than about 44 wt%, no more than about 43 wt%, no more than about 42 wt%, no more than about 41 wt%, no more than about 40 wt%, no more than about 39 wt%, no more than about 38 wt%, no more than about 37 wt%, no more than about 36 wt%, no more than about 35 wt%, no more than about 34 wt%, no more than about 33 wt%, no more than about 32 wt%, no more than about 31 wt%, no more than about 30 wt%, no more than about 29 wt%, no more than about 28 wt%, no more than about 27 wt%, no more than about 26 wt%, no more than about 25 wt%, no more than about 24 wt%, no more than about 23 wt%, no more than about 22 wt%, no more than about 21 wt%, no more than about 20 wt%, no more than about 19 wt%, no more than about 18 wt%, no more than about 17 wt%, no more than about 16 wt%, no more than about 15 wt%, no more than about 14 wt%, no more than about 13 wt%, no more than about 12 wt%, no more than about 11 wt%, no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%. Alternatively, a moisture content of the filamentous fungal biomass after the dehydration step can be any whole number range between 1 wt% and 45 wt%.

The filamentous fungi suitable for use in the invention may be selected from the phyla or divisions zygomycota, glomermycota, chytridiomycota, basidiomycota or ascomycota. The phylum (or division) basidiomycota comprises, *inter alia*, the orders Agaricales, Russulales, Polyporales and Ustilaginales; the phylum ascomycota comprises, *inter alia*, the orders Pezizales and Hypocreales; and the phylum zygomycota comprises,

inter alia, the order Mucorales. The edible filamentous fungi of the present invention may belong to an order selected from Ustilaginales, Russulales, Polyporales, Agaricales, Pezizales, Hypocreales and Mucorales.

In some embodiments, the filamentous fungi of the order Ustilaginales are selected from the family Ustilaginaceae. In some embodiments, the filamentous fungi of the order Russulales are selected from the family Hericiaceae. In some embodiments, the filamentous fungi of the order Polyporales are selected from the families Polyporaceae or Grifolaceae. In some embodiments, the filamentous fungi of the order Agaricales are selected from the families Lyophyllaceae, Strophariaceae, Lycoperdaceae, Agaricaceae, Pleurotaceae, Physalacriaceae, or Omphalotaceae. In some embodiments, the filamentous fungi of the order Pezizales are selected from the families Tuberaceae or Morchellaceae. In some embodiments, the filamentous fungi of the order Mucorales are selected from the family Mucoraceae.

In some embodiments, the filamentous fungi may be selected from the genera Fusarium, Aspergillus, Trichoderma, Rhizopus, Ustilago, Hericululm, Polyporous, Grifola, Hypsizygus, Calocybe, Pholiota, Calvatia, Stropharia, Agaricus, Hypholoma, Pleurotus, Morchella, Sparassis, Disciotis, Cordyceps, Ganoderma, Flammulina, Lentinula, Ophiocordyceps, Trametes, Ceriporia, Leucoagaricus, Handkea, Monascus and Neurospora.

Examples of the species of filamentous fungi include, without limitation, Ustilago esculenta, Hericululm erinaceus, Polyporous squamosus, Grifola fondrosa, Hypsizygus marmoreus, Hypsizygus ulmariuos (elm oyster) Calocybe gambosa, Pholiota nameko, Calvatia gigantea, Agaricus bisporus, Stropharia rugosoannulata, Hypholoma lateritium, Pleurotus eryngii, Pleurotus ostreatus (pearl), Pleurotus ostreatus var. columbinus (Blue oyster),Tuber borchii, Morchella esculenta, Morchella conica, Morchella importuna, Sparassis crispa (cauliflower), Fusarium venenatum, Fusarium strain *flavolapis* (ATCC Accession Deposit No. PTA-10698), Disciotis venosa, Cordyceps militaris, Ganoderma lucidum (reishi), Flammulina velutipes, Lentinula edodes, Ophiocordyceps sinensis. Additional examples include, without limitation, Trametes versicolor, Ceriporia lacerate, Pholiota gigantea, Leucoagaricus holosericeus, Pleurotus djamor, Calvatia fragilis, Handkea utriformis, Rhizopus oligosporus, and Neurospora crassa.

In some embodiments, the filamentous fungus is a Fusarium species. In some embodiments, the filamentous fungus is the Fusarium strain *flavolapis* (ATCC PTA-10698 deposited with the American Type Culture Collection, 1081 University Boulevard, Manassas, Virginia, USA). This strain, which has been referred to in some previous work

as strain MK7, was previously reported to be a *Fusarium oxysporum* strain. However, it has subsequently been identified as not being an *oxysporum* strain and is considered a novel strain of *Fusarium* that has now been provisionally named *Fusarium* str. *flavolapis*. In some embodiments, the filamentous fungus is the Fusarium strain *Fusarium venenatum*.

Fungal biomass from which the filamentous fungal material in food compositions of the invention is derived may be produced by any known fermentation processes, such as, e.g., submerged, solid-state, membrane, or surface fermentation processes as described in PCT Application Publications WO 2017/151684, WO 2019/046480, or WO 2020/176758 or PCT Application PCT/US2020/064208 (the entireties of all of which are incorporated herein by reference), and/or a method as disclosed in PCT Application Publication WO2019/099474.

In some embodiments, the filamentous fungal biomass may be in the form of one or more filamentous fungal biomats produced by a surface fermentation process. In certain of these embodiments, parameters of the surface fermentation process may be selected or controlled to provide a desired morphology or structure to the filamentous fungal biomat and thus to the resulting food composition. By way of first non-limiting example, the surface fermentation process may be controlled such that fungal mycelia are oriented predominantly parallel to an interface between a liquid fermentation medium and the atmosphere or headspace above the fermentation medium, thereby ensuring that the mycelia grow primarily in a single plane (which may provide desired textural or mechanical characteristics to the resulting food composition or a portion thereof). By way of second non-limiting example, trays or vessels in which a filamentous fungus is grown in a surface fermentation process may be substantially longer than they are wide (or vice versa) to provide a similar "oriented" structure of the fungal mycelia. By these and other methods, which will be appreciate by those of ordinary skill in the art, multiple biomats and/or layers of filamentous fungal biomass, having similar or different geometric orientations of mycelia, may be "stacked" or "weaved" to obtain a layered food composition having preselected textural or mechanical characteristics.

Food compositions, including but not necessarily limited to meat analog food products, according to the present invention may further include proteins, such as a hydrophobin. These are low molecular weight proteins, ranging from about 100 to 150 amino acids in length, and are amphipathic molecules that are capable of self-assembly at a hydrophobic-hydrophilic interface into amphipathic films. Various uses for hydrophobins have been described in the art, including as emulsifiers, thickeners, or surfactants; for

hydrophilizing hydrophobic surfaces; for improving the water stability of hydrophilic substrates; and for preparing oil-in-water emulsions or water-in-oil emulsions, and they have applications in pharmaceutical and cosmetic as well as food compositions. In food products, hydrophobins have been shown to impact the formation and stability of air bubbles, thus assisting in foamability and foam stabilization (for instance, hydrophobins provide foam volume stability and inhibition of coarsening of foods), inhibiting growth of ice crystals in frozen food products, and affecting agglomeration of fats, thus improving the texture, stability, and storage time of aerated and/or frozen food compositions.

Accordingly, some embodiments of the present invention may include a hydrophobin. Hydrophobins are generally classified into class I and class II; while class I hydrophobins are relatively insoluble, class II hydrophobins readily dissolve in a variety of solvents and therefore are generally preferred. Hydrophobins and like proteins have been identified in filamentous fungi and bacteria, and their sequences are described in the art. All of these proteins, including class I and class II hydrophobins, are encompassed by the present invention. Hydrophobins suitable for use in the present invention may be isolated from natural sources, or by recombinant means. In some embodiments, the hydrophobins may be added to the food compositions as purified proteins. In some embodiments, the hydrophobins may be expressed by the filamentous fungal species used in the food composition and thus supplied as part of the fungal biomass. In embodiments, filamentous fungal biomass used in food compositions and food products according to the present disclosure may include at least about 500 reads per kilobase of transcript per million mapped reads (RPKM), at least about 1,000 RPKM, at least about 1,500 RPKM, at least about 2,000 RPKM, at least about 2,500 RPKM, or at least about 3,000 RPKM of class I hydrophobins, and/or at least about 1 RPKM, at least about 2 RPKM, at least about 3 RPKM, at least about 4 RPKM, at least about 5 RPKM, at least about 6 RPKM, or at least about 7 RPKM of class II hydrophobins.

Referring now to Figure 1A, a first embodiment of a method 100 for making a meat analog food product, such as, by way of non-limiting example, a shredded meat analog food product, according to an embodiment of the present invention, is illustrated. As shown in Figure 1A, this embodiment of the method 100 comprises a biomass production step 110, an inactivation step 120, a refrigeration step 130, a solution preparation step 135, a vacuum agitation step 140, a vacuum shaping step 150, a crust freezing step 160, an optional size reduction step 170, and an optional post-processing step 180.

In the biomass production step 110 of the embodiment of the method 100 illustrated in Figure 1A, a biomass of filamentous fungus is produced by any suitable method as known and described in the art, such as, by way of non-limiting example, a surface fermentation method as described in PCT Application Publication 2020/176758.

In the inactivation step 120 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass produced in step 110 is inactivated, *e.g.*, by steaming. In some embodiments, the filamentous fungal biomass may be a filamentous fungal biomat or relatively large (e.g. about 3 to about 5 inches wide) pieces thereof; it is to be expressly understood that size reduction of the biomass, if carried out at this stage of the method 100, may be undertaken before, simultaneous with, and/or after inactivation step 120.

In the refrigeration step 130 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass is cooled to a temperature of no more than about 34 °F. The refrigeration step 130 ensures complete inactivation of the filamentous fungus and hardens (and thereby improves the workability) of the filamentous fungal biomass for downstream processing steps.

In the solution preparation step 135 of the embodiment of the method 100 illustrated in Figure 1A, one or more food additives (e.g. salt, seasonings, nutritional additions, etc.) are dissolved and/or suspended in water. Preferably, the solution prepared in solution preparation step 135 is provided below room temperature (e.g. at a temperature of about 40 °F); the solution may be cooled before, simultaneous with, or after addition of the food additive solutes to water. Solution preparation step 135 may be carried out before, simultaneous with, or after refrigeration step 130. In some embodiments, the solution prepared in solution preparation step 135 may comprise one or more proteins to provide the food product with a desired functionality and/or augment the total protein content of the food product.

It is to be expressly understood that, although not illustrated in Figure 1A or provided for in the embodiment of the method 100 depicted therein, the solution prepared in solution preparation step 135 need not always be aqueous, and/or may include one or more solvents in addition to water. By way of non-limiting example, such solvents may include cooking oils, an oleovitamin solution, and the like. Embodiments in which the solution prepared in solution preparation step 135 is non-aqueous are therefore expressly contemplated as within the scope of the present invention.

Although not illustrated in Figure 1A, it is to be expressly understood that in some embodiments, the fungal biomass, at any time after inactivation step 120 but before the beginning of vacuum agitation step 140, may be subjected to any one or more mechanical or texturizing treatments to provide the finished food product with a desired structure, texture, mouthfeel, etc. By way of non-limiting example, where it is desired to provide the finished food product with a "softer" or more "tender" mouthfeel, the fungal biomass may be tenderized using a multi-blade (*e.g.*, Jaccard-style or similar) meat tenderizer to sever and/or disentangle long filaments in the fungal biomass.

In the vacuum agitation step 140 of the embodiment of the method 100 illustrated in Figure 1A, the refrigerated filamentous fungal biomass produced in step 130 and the cold aqueous solution prepared in step 135 are placed together in a vacuum tumbler; most typically, vacuum agitation step 140 is a cold vacuum agitation step carried out under refrigeration (i.e. at a temperature of no more than about 40 °F), but vacuum agitation step 140 may alternatively be carried out at room temperature or under heating to above reoom temperature. The atmosphere in the vacuum tumbler is then evacuated to leave a low vacuum (i.e. an absolute pressure of between about 3 kilopascals and about 100 kilopascals), a medium vacuum (i.e. an absolute pressure of between about 100 millipascals and about 3 kilopascals), a high vacuum (i.e. an absolute pressure of between about 100 nanopascals and about 100 millipascals), an ultra-high vacuum (i.e. an absolute pressure of between about 100 picopascals and about 100 nanopascals), or an extremely high vacuum (i.e. an absolute pressure of less than about 100 picopascals) in the tumbler. The filamentous fungal biomass and the aqueous solution are then agitated together to allow the aqueous solution to permeate the filamentous fungal biomass. Those skilled in the art will understand how to select appropriate agitation times, methods, and speeds; by way of non-limiting example, the vacuum tumbler may be a rotary tumbler, and the filamentous fungal biomass and aqueous solution may be rotated together at a speed of between about 7 RPM and about 10 RPM for a total time of about 40 minutes. It is to be expressly understood that the filamentous fungal biomass and aqueous solution may be agitated two or more times, with rest periods between periods of agitation (*e.g.*, two 20-minute agitation periods with a 10-minute rest period in between), as may be appreciated by those skilled in the art. As a result of vacuum agitation step 140, the filamentous fungal biomass will absorb or otherwise take up at least a portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass).

Where the filamentous fungal biomass is in the form of a biomat or relatively large pieces thereof, the sub-atmospheric pressure of vacuum agitation step 140 may affect any one or more of several physical properties of the biomat. By way of non-limiting example, exposure to this high-vacuum environment may enlarge spaces between fungal mycelia in the matrix of the biomat, increasing the available surface area of mycelia available for contact with the aqueous solution. This effect may, without wishing to be bound by any particular theory, explain the observation by the present inventors that filamentous fungal biomass agitated with an aqueous solution comprising salt in vacuum agitation step 140 tasted much saltier than expected; it is possible that increased mycelial surface area in contact with the salty aqueous solution allowed for a greater proportion of salt to be deposited on the surface of fungal mycelia, and/or increased the time required for the salt deposited on the surface of fungal mycelia to be transferred to the taste buds of the consumer upon consumption, and/or increases the surface area of the food product in contact with the taste-sensitive tissues in a consumer's mouth. In this way, it may be possible for filamentous fungal food compositions according to the present invention to have the further advantage and benefit of delivering a flavor to a consumer over a longer time.

In the vacuum shaping step 150 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass, having absorbed or otherwise taken up at least some portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass), is placed in a cavity or mold, and the atmosphere surrounding the cavity or mold is evacuated to leave a high vacuum (i.e. an absolute pressure of no more than about 0.1 pascals). This allows the filamentous fungal biomass to be placed in a desired shape or other physical configuration, and/or to undergo various physical deformations or operations, and/or for one portion of the filamentous fungal biomass to have a first density and another portion of the filamentous fungal biomass to have a second density; by way of non-limiting example, where it is desired to produce a sausage analog food product, the filamentous fungal biomass may be stuffed into a casing. In many embodiments, it may be desirable to form the filamentous fungal biomass into a "log" or "rod," *i.e.*, an approximately cylindrical mass. The vacuum shaping step 150 may also affect the density of the filamentous fungal biomass and/or properties of a mycelial network thereof, which may, by way of non-limiting example, further increase mycelial surface area and/or permeability of the fungal biomass for application of further functional or nutritional additives. It is therefore to be expressly understood that the filamentous fungal biomass may,

but need not, be contacted with one or more flavorings or other functional or nutritional additives, whether in a solid, liquid, or gas form, as part of vacuum shaping step 150.

It is to be expressly understood that, in the practice of the embodiment of the method 100 illustrated in Figure 1A, vacuum agitation step 140 and vacuum shaping step 150 may be repeated as many times as necessary. Particularly, where it is desirable to coat or impregnate a functional coating or additive onto or into any one or more of (1) spaces between fungal filaments, e.g. pores in a fungal biomat, (2) the surfaces of fungal filaments, and/or (3) the interiors of fungal filaments, repeated vacuum agitation steps 140 and/or vacuum shaping steps 150 may be necessary to ensure complete absorption by, or coating or coverage of, the fungal mycelia.

Without wishing to be bound by any particular theory, it is believed that one functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum agitation step 140 and vacuum shaping step 150 is that these pressures cause the fungal biomass to expand, thereby increasing the volume of interstitial spaces between hyphae and other fungal structures. As a result, additives applied during these steps may more readily infiltrate these spaces. Subsequently, when the mat is once again exposed to ambient or atmospheric pressures, the fungal biomass contracts, thus causing the additive(s) present in the interstitial spaces to be firmly entrapped within the fungal biomass.

In the crust freezing step 160 of the embodiment of the method 100 illustrated in Figure 1A, the shaped filamentous fungal biomass is placed in a blast freezer and rapidly cooled (in some embodiments, at a rate of at least about 0.35 °C per minute), for example, to an internal temperature of between about 25 °F and about 27 °F. This temperature range has been found by the present inventors to provide optimum conditions for the processing steps of the method 100 that follow.

In the optional size reduction step 170 of the embodiment of the method 100 illustrated in Figure 1A, the blast-frozen filamentous fungal biomass is cut, shredded, and/or shaved into smaller pieces, which may in some embodiments be suitable for use as a shredded meat analog. Most typically, the strips, shreds, or shavings of filamentous fungal biomass will preferably have a thickness of between about 0.1 millimeters and about 10 millimeters, as this range is most analogous to conventional shredded meat products. Any size-reducing means, including but not necessarily limited to a gravity slicer or conventional deli meat slicer, may be used to carry out size reduction step 170.

In the optional post-processing step 180 of the embodiment of the method 100 illustrated in Figure 1A, the size-reduced filamentous fungal biomass may be subjected to

any one or more forms of post-processing analogous to those used to prepare smoked or cured meat products or similar. By way of first non-limiting example, the size-reduced filamentous fungal biomass may be vacuum-steamed (e.g. to an internal temperature of about 85 °C for a period of about 12 minutes) to form a steamed meat analog food product. By way of second non-limiting example, the size-reduced filamentous fungal biomass may be cold-smoked (e.g. for a period of about four hours at a temperature of about 90 °F) to form a cold-smoked meat analog food product. By way of third non-limiting example, the size-reduced filamentous fungal biomass may be hot-smoked (e.g. for a period of about two hours at a temperature of about 230 °F) to form a hot-smoked meat analog food product. By way of fourth non-limiting example, the size-reduced filamentous fungal biomass may cooked by any other suitable cooking technique, such as, *e.g.*, roasting, baking, boiling, and/or frying. In general, any form(s) of post-processing to which a raw whole cut of meat or raw shredded meat may be subjected can be applied, *mutatis mutandis*, to the size-reduced filamentous fungal biomass to form an analogous filamentous fungal food product. Post-processing step 180 may be carried out when the size-reduced filamentous fungal biomass is frozen, refrigerated, or at room temperature.

In some embodiments, size reduction step 170 and/or post-processing step 180 may comprise extruding a fungal paste into long strips. This extrusion step may be carried out by any suitable device or method and may be particularly suitable or advantageous, by way of non-limiting example, to provide a food composition having a desired cross-sectional shape (especially if the desired cross-sectional shape is intricate or complex), to prevent (or deliberately impart) a selected type of physical stress (e.g. compressive stress, shear stress, etc.) to the food composition, to improve a finished appearance of the food composition, and/or to create a food composition that is analogous in appearance or structure to a conventional food product that is ordinarily provided in thin or narrow strips (e.g. jerky, bacon, etc.). Additional or alternative thermal or mechanical manipulations may be employed as part of size reduction step 170 and/or post-processing step 180, such as non-extrusive shearing, heating (with or without simultaneous shearing, *e.g.*, to coagulate proteins and/or carbohydrates), freezing, thawing, etc.

Referring now to Figure 1B, a second embodiment of a method 100 for making a meat analog food product, such as, by way of non-limiting example, a shredded meat analog food product, according to an embodiment of the present invention, is illustrated. As shown in Figure 1B, this embodiment of the method 100 comprises a biomass production step 110,

an inactivation step 120, a vacuum shaping step 150, a crust freezing step 160, an optional size reduction step 170, and an optional post-processing step 180.

In the biomass production step 110 of the embodiment of the method 100 illustrated in Figure 1B, a biomass of filamentous fungus is produced by any suitable method as known and described in the art, such as, by way of non-limiting example, a surface fermentation method as described in PCT Application Publication 2020/176758.

In the inactivation step 120 of the embodiment of the method 100 illustrated in Figure 1B, the filamentous fungal biomass produced in step 110 is inactivated, *e.g.*, by steaming. In some embodiments, the filamentous fungal biomass may be a filamentous fungal biomat or relatively large (e.g. about 1 inch wide) pieces thereof; it is to be expressly understood that size reduction of the biomass, if carried out at this stage of the method 100, may be undertaken before, simultaneous with, and/or after inactivation step 120.

In the vacuum shaping step 150 of the embodiment of the method 100 illustrated in Figure 1B, the filamentous fungal biomass, having absorbed or otherwise taken up at least some portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass), is placed in a cavity or mold, and the atmosphere surrounding the cavity or mold is evacuated to leave a high vacuum (i.e. an absolute pressure of no more than about 0.1 pascals). This allows the filamentous fungal biomass to be placed in a desired shape or other physical configuration and/or to undergo various physical deformations or operations; by way of non-limiting example, where it is desired to produce a sausage analog food product, the filamentous fungal biomass may be stuffed into a casing. In many embodiments, it may be desirable to form the filamentous fungal biomass into a "log," *i.e.*, an approximately cylindrical mass. The vacuum shaping step 150 may also affect the density of the filamentous fungal biomass and/or properties of a mycelial network thereof, which may, by way of non-limiting example, further increase mycelial surface area and/or permeability of the fungal biomass for application of further functional or nutritional additives. It is therefore to be expressly understood that the filamentous fungal biomass may, but need not, be contacted with one or more flavorings or other functional or nutritional additives, whether in a solid, liquid, or gas form, as part of vacuum shaping step 150.

Without wishing to be bound by any particular theory, it is believed that one functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum shaping step 150 is that these pressures cause the fungal biomass to expand, thereby increasing the volume of interstitial spaces between hyphae and other fungal structures. Subsequently, when the mat is once again exposed to ambient or atmospheric pressures, the

fungal biomass contracts. Again without wishing to be bound by any particular theory, it is believed that another functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum shaping step 150 is that this may beneficially alter surface behavior of the mycelia.

In the crust freezing step 160 of the embodiment of the method 100 illustrated in Figure 1B, the shaped filamentous fungal biomass is placed in a blast freezer and rapidly cooled, for example, to an internal temperature of between about 25 °F and about 27 °F. This temperature range has been found by the present inventors to provide optimum conditions for the processing steps of the method 100 that follow.

In the size reduction step 170 of the embodiment of the method 100 illustrated in Figure 1B, the blast-frozen filamentous fungal biomass is cut, shredded, and/or shaved into smaller pieces suitable for use as a meat analog. Most typically, the strips, shreds, or shavings of filamentous fungal biomass will preferably have a thickness of between about 0.1 millimeters and about 10 millimeters, as this range is most analogous to conventional meat products. to which the fungal products are analogous. Any size-reducing means, including but not necessarily limited to a gravity slicer or conventional deli meat slicer, may be used to carry out size reduction step 170.

In the optional post-processing step 180 of the embodiment of the method 100 illustrated in Figure 1B, the size-reduced filamentous fungal biomass may be subjected to any one or more forms of post-processing analogous to those used to prepare smoked or cured meat products or similar. By way of first non-limiting example, the size-reduced filamentous fungal biomass may be vacuum-steamed (e.g. to an internal temperature of about 85 °C for a period of about 12 minutes) to form a steamed meat analog food product. By way of second non-limiting example, the size-reduced filamentous fungal biomass may be cold-smoked (e.g. for a period of about four hours at a temperature of about 90 °F) to form a cold-smoked meat analog food product. By way of third non-limiting example, the size-reduced filamentous fungal biomass may be hot-smoked (e.g. for a period of about two hours at a temperature of about 230 °F) to form a hot-smoked meat analog food product. In general, any form(s) of post-processing to which a raw whole cut of meat or raw shredded meat may be subjected can be applied, *mutatis mutandis*, to the size-reduced filamentous fungal biomass to form an analogous filamentous fungal food product. Post-processing step 180 may be carried out when the size-reduced filamentous fungal biomass is frozen, refrigerated, or at room temperature.

In some embodiments, size reduction step 170 and/or post-processing step 180 may comprise extruding a fungal paste into long strips. This extrusion step may be carried out by any suitable device or method and may be particularly suitable or advantageous, by way of non-limiting example, to provide a food composition having a desired cross-sectional shape (especially if the desired cross-sectional shape is intricate or complex), to prevent (or deliberately impart) a selected type of physical stress (e.g. compressive stress, shear stress, etc.) to the food composition, to improve a finished appearance of the food composition, and/or to create a food composition that is analogous in appearance or structure to a conventional food product that is ordinarily provided in thin or narrow strips (e.g. jerky, bacon, etc.). Additional or alternative thermal or mechanical manipulations may be employed as part of size reduction step 170 and/or post-processing step 180, such as non-extrusive shearing, heating (with or without simultaneous shearing, *e.g.*, to coagulate proteins and/or carbohydrates), freezing, thawing, etc.

The difference between the two embodiments of the method 100 illustrated in Figures 1A and 1B is that refrigeration step 130, solution preparation step 135, and vacuum agitation step 140 are omitted in the embodiment illustrated in Figure 1B. Which embodiment of the method 100 is employed will depend on the desired flavor and intended use of the resulting meat analog food product; the method illustrated in Figure 1A will generally yield a pre-flavored product suitable for use in, *e.g.*, processed meat analog or smoked meat analog food products (*e.g.*, bacon analog food products, jerky analog food products, etc.), whereas the method illustrated in Figure 1B will generally yield a food product having a more neutral flavor profile suitable for use in raw or whole-cut meat analog food products. This flexibility of use is yet another benefit of the present invention, in that the method 100 can be used to produce any of a wide variety of meat analog food products.

Referring now to Figures 2A and 2B, a method 200 for making a meat jerky analog food product according to an embodiment of the present invention, is illustrated. As shown in Figures 2A and 2B, the method 200 comprises a marinade preparation step 210, a coating step 220, and a dehydrating step 230.

In the marinade preparation step 210 of the method 200, a marinade in which a filamentous fungal food material produced according to the method 100 illustrated in Figure 1A will be marinated, is prepared. Such a marinade can include any one or more ingredients commonly found in marinades for conventional meat products, including but not necessarily limited to meat jerky, but in some embodiments may include higher or lower amounts of these ingredients than in such conventional meat marinades. As in conventional meat

marination processes, marinades prepared according to marinade preparation step 210 will be liquids adapted to impart flavor to and/or tenderize or otherwise impart texture to the filamentous fungal biomass; as such, the marinades may (but need not) include one or more acidic ingredients (e.g. vinegar, lemon juice, wine) and/or one or more enzymatic ingredients (e.g. pineapple, papaya, yogurt, ginger), and may further include oils, herbs, and/or spices to further flavor the filamentous fungal biomass. Those skilled in the culinary arts will readily understand how to prepare an appropriate marinade according to marinade preparation step 210.

In the coating step 220 of the method 200, a filamentous fungal food material produced according to the method 100 illustrated in Figure 1A is marinated in, i.e. coated with, the marinade prepared in marinade preparation step 210, either at room temperature or under refrigeration. (Thus, any one or more steps 210, 220, 230 of method 200 can be considered a post-processing step 180 of method 100.) Most commonly, the coating step 220 may be carried out for a period of between about two seconds and about two days (i.e. as is typical of marination processes for conventional meat jerky products) at any temperature within a wide range (e.g. under refrigeration to at least as low as about 0 °C, at ambient temperatures, and/or under elevated temperatures of at least as high as about 40 °C), but in some embodiments, because filamentous fungal biomass does not spoil as readily as meat (whether at room temperature or under refrigeration), the coating step 220 may be carried out for a longer time to further impart flavor and/or tenderize the biomass. Without wishing to be bound by any particular theory, variations in coating step 220 temperatures and times may affect the internal structure of the filamentous fungal biomass and thus allow for different extents to which marinade is "entrapped" within the biomass. Coating step 220 may or may not include agitation or mixing of the filamentous fungal food material with the marinade, but it is generally desirable to ensure that substantially all sides and/or surfaces of the filamentous fungal food material are coated with the marinade, whether by agitation/mixing or by providing enough of the marinade in an appropriate vessel to completely soak or submerge the filamentous fungal food material for a desired residence or marination time. The coating step 220 may additionally or alternatively comprise any other means of coating the fungal biomass with the marinade, e.g. dipping the fungal biomass in the marinade, spraying the fungal biomass with the marinade (with or without subsequent drying), etc.

In some embodiments, coating step 220 optionally may, but need not, comprise application of a stabilizer or mold inhibitor, e.g. potassium sorbate, to further increase the

shelf life of the resulting food composition; in some embodiments, the stabilizer or mold inhibitor may also have an aesthetic or sensory benefit (e.g. potassium sorbate is a salty-tasting compound that stimulates salivation and contributes to a salty flavor). It is to be expressly understood, however, that application of a stabilizer and/or mold inhibitor may be omitted, and it may be preferable to omit this application in some embodiments.

In the dehydrating step 230 of the method 200, the filamentous fungal food material produced according to the method 100 illustrated in Figure 1A is dehydrated at relatively low temperature, e.g. no more than about 165 °F, over a period of between about 20 minutes and about 12 hours, and most commonly between about 2 hours and about 5 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydrating step 230, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal food material while otherwise retaining the fungal material's basic structure.

The difference between the two embodiments of the method 200 illustrated in Figures 2A and 2B is in the ordering of steps—coating step 220 may be carried out before dehydrating step 230, as in Figure 2A, or vice versa, as in Figure 2B. Which embodiment of the method 200 is employed will depend on the desired texture of the resulting meat jerky analog food product; the method illustrated in Figure 2A will generally yield a "chewy" texture akin to a true meat jerky, whereas the method illustrated in Figure 2B will generally yield a "crispy" texture like that of a potato or tortilla chip. This flexibility in the ordering of steps is yet another benefit of the present invention, in that the method 200 can be used to produce a true jerky analog food product, or alternatively a novel food product having a combination of meat jerky flavor with a "crispy," chip-like texture that may not be attainable using meat. In practice, the methods 200 of Figures 2A and 2B are, or may be, generally identical, with the exception that, because the marinade prepared in marinade preparation step 210 generally has a high moisture content, dehydrating step 230 may be carried out for a longer time (typically four to five hours) if preceded by the coating step 220 and for a shorter time (typically two to three hours) if preceding the coating step 220.

The invention is further described by the following illustrative, non-limiting Examples.

Example 1

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A. Subsequently, a marinade comprising 8.6 wt% nutritional

yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The pieces of marinated filamentous fungal food material were then placed on trays, with care taken to ensure that no two pieces touched each other, and dehydrated in a conventional dehydrator at 160 °F for between four and five hours. The resulting meat jerky analog food product had a taste like that of a conventional beef jerky and a similarly analogous chewy texture.

The meat jerky analog food product was found to have a water activity of 0.4894 and a moisture content of 14.09 wt%. These values are comparable to, or even better (i.e. drier) than, a conventional meat jerky food product.

Example 2

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A and placed on trays, with care taken to ensure that no two pieces touched each other. The pieces of filamentous fungal food material were then dehydrated in a conventional dehydrator at 160 °F for between two and four hours. Subsequently, a marinade comprising 8.6 wt% nutritional yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% tamari soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The dehydrated filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The resulting meat jerky analog food product had a taste like that of a conventional beef jerky, but, rather than exhibiting a typical “chewy” meat jerky texture, instead had a “crispy” texture like that of a potato or tortilla chip.

Example 3

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A and subsequently dehydrated in a conventional dehydrator at 160 °F for two hours, without prior marination. After dehydration, some pieces were marinated with the marinade of Examples 1 and 2 (“Jerky A”), while others were left unmarinated and instead placed in a bath of room-temperature water for two hours (“unmarinated Jerky A”). Separately, two other jerky analog products were produced: a

jerky analog product produced according to a second run of the method described in Example 1 ("Jerky C") and a jerky analog product produced according to the method described in Example 1, except that the filamentous fungal biomass was vacuum-tumbled with the marinade for 30 minutes rather than being surface-coated ("Jerky B"). In Jerkies B and C, the amount of marinade relative to the fungal biomass was also varied relative to the method described in Example 1; specifically, the fungal biomass was marinated in an equal (1:1) mass of marinade.

Samples of each of marinated Jerky A, Jerky B, and Jerky C were weighed before marination (i.e. fungal biomass only), with applied marinade before dehydration, and after dehydration. The water activity and moisture content of each jerky after dehydration was then assessed. All three jerkies were made using filamentous fungal biomass taken from a fungal biomat having a starting moisture content of 79.84%. The results of these tests are given in Table 1.

Table 1

	Jerky A	**Jerky B**	**Jerky C**
Pre-marination mass (fungus only)	95.4 g	95 g	91.5 g
Post-marination mass (before dehydration)	n/a	165.5 g	165.7 g
Post-dehydration mass	24.7 g	67.72 g	73.14 g
Post-dehydration water activity	0.64	0.371	0.459
Post-dehydration moisture content	28.89%	20.17%	23.58%

Images of samples of unmarinated Jerky A, Jerky B, and Jerky C are shown in Figures 3A, 3B, and 3C, respectively. The densities of Jerkies B and C were recorded as 0.74 and 0.73 g/cm^3, respectively.

The three jerkies differed greatly in their qualitative sensory impressions. Jerky A was observed to extremely crispy and brittle, with a tendency to undergo glass-like shattering, and had the least flavor even when marinade was applied. Jerky B was thin and crispy (though less so than Jerky A), with increased marinade flavor compared to Jerky A. Jerky C was by far the most similar in sensory evaluation to a conventional, shelf-stable, soft, chewy meat jerky; it was chewier and softer than Jerkies A and B and had a strong spicy and smoky flavor imparted by the marinade.

Example 4

Three unmarinated samples of Jerky A produced in Example 3 were placed into a room-temperature water bath for 30 minutes, 1 hour, and 2 hours, respectively, and weighed

both before and after rehydration to determine the water reuptake capabilities of Jerky A. The results are given in Table 2.

Table 2

Time in water	30 minutes	1 hour	2 hours
Pre-dehydration mass	NR	NR	5.04 g
Pre-rehydration mass	2.01 g	2.72 g	1.37 g
Post-rehydration mass	4.89 g	7.44 g	3.77 g
% mass increase	243%	274%	275%
% original water	NR	NR	74.8%

Air bubbles were observed when dry jerky products were immersed in water, showing very active rehydration of all samples tested.

Without wishing to be bound by any particular theory, the present inventors hypothesize that tightly bound water is, for the most part, not removed during dehydration in all samples. However, physically bound water and free water, held in, e.g., the capillaries and porous structure of the fungal biomass adds to the range of texture development in jerky products. While the moisture content of the dried jerky products is 24% ± 4%, their water activities (reported in Example 3) show that jerkies with a wide range of textures can be produced. The subsequent rehydration of the jerky products highlights the novel porous structure of the jerky products, where water droplets can be held and contribute to the plasticized properties of the jerky products. During this subsequent rehydration, liquid can enter the fungal structure where free water was previously present, but some physically bound water (~25 wt% of the total water) cannot be regained due to loss of fungal structures during dehydration. This mechanism would account for reuptake of less than all of the starting mass of moisture during rehydration. Thus, the present invention can be viewed as providing a method to maintain the porous structure of filamentous fungal biomass during dehydration, and particularly to leverage this porous structure to precisely control and/or select a desired extent of liquid removal from the fungal material. In this way, a desired water activity, e.g. of less than about 0.45, can be selected.

Example 5

Microscopic images of a whole piece of Jerky C were taken from a portion of the piece corresponding to a hydrophilic side of the filamentous fungal biomat. These images are shown as Figures 4A (light both above and below the sample) and 4B (light below the sample only). These images show small holes in the post-dehydration biomat. Without wishing to be bound by any particular theory, these images support the hypothesis that,

while some fungal mat structure may be destroyed during processing, most of the mat structure may remain intact.

The Jerky C piece was then laid flat, and two parallel lines, lying close to one another, were cut using a utility knife. The sample was then turned onto the side on which the knife passed. This procedure allowed the capture of two microscopic images: one of a hydrophobic side of the jerky piece (Figure 5A) and one from a hydrophilic side (Figure 5B).

In Figure 5A, the center or innermost part of the sample is on the left side of the image, while the edge of the sample is on the right side of the image. As Figures 5A and 5B illustrate, the smallest degree of structural deformation is observed near the center of the sample, with deformation increasing (e.g. larger pores) toward the edge of the sample.

In Figure 5B, the left side of the image represents the opposite edge of the sample relative to Figure 5A. The structure appears significantly denser. Without wishing to be bound by any particular theory, it is believed that the hydrophilic side of a filamentous fungal biomat, which grows submersed in or on the surface of a liquid (aqueous) growth medium, grows to have a denser structure because the hydrophobic (i.e. atmosphere-facing) side of the biomat is where aerial hyphae, having a filamentous structure, are formed.

Example 6

Pieces of unmarinated Jerky A, Jerky B, and Jerky C were prepared for tensile strength and strain-at-break testing. It was quickly discovered that pieces of unmarinated Jerky A could not be tested due to their brittleness; these samples were either impossible to cut for testing or would shatter when placed in the grips of the testing apparatus. Pieces of Jerky B were noticeably brittle, but flat sections of the pieces were malleable enough to allow for cutting of testing samples, and Jerky B was found to have a maximum tensile strength of 1.10 ± 0.51 MPa and a strain at break of $1.75\% \pm 0.71\%$. Pieces of Jerky C were much more malleable, making them much easier to cut samples from, and Jerky C was found to have a maximum tensile strength of 1.98 ± 0.66 MPa and a strain at break of $8.08\% \pm 0.81\%$.

The specimens tested for tensile strength and strain at break are shown in Figures 6A (Jerky B) and 6B (Jerky C). As Figures 6A and 6B clearly illustrate, Jerky B exhibited brittle fractures, while Jerky C exhibited more elastic fractures. The stress-strain curves for two tested samples of Jerky B and three tested samples of Jerky C, shown in Figure 7, confirm this observation; in Figure 7, the two samples of Jerky B are represented by the

square and triangle data points, while the three samples of Jerky C are represented by the dash, circle, and diamond data points.

The invention illustratively disclosed herein suitably may be practiced in the absence of any element which is not specifically disclosed herein. It is apparent to those skilled in the art, however, that many changes, variations, modifications, other uses, and applications of the invention are possible, and changes, variations, modifications, other uses, and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is limited only by the claims which follow.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description of the Invention, for example, various features of the invention are grouped together in one or more embodiments for the purpose of streamlining the disclosure. The features of the embodiments of the invention may be combined in alternate embodiments other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description of the Invention, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations, combinations, and modifications are within the scope of the invention, e.g. as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps to those claimed, regardless of whether such alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

CLAIMS

1. A method for preparing a food product, comprising:

(a) contacting a filamentous fungal biomass with a solution comprising a food additive;

(b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and

(c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive,

wherein steps (a) and (b) are carried out simultaneously or sequentially in any order.

2. The method of claim 1, wherein the food additive comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

3. The method of claim 1, wherein a mass of the solution is between about 1% and about 30% of a total mass of the filamentous fungal biomass prior to contacting the solution.

4. The method of claim 1, wherein step (a) is carried out under sub-atmospheric pressure.

5. The method of claim 4, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

6. The method of claim 1, wherein step (a) is carried out under super-atmospheric pressure.

7. The method of claim 1, wherein step (a) is carried out at a temperature below room temperature.

8. The method of claim 7, wherein the temperature below room temperature is no more than about 40 °F.

9. The method of claim 1, wherein, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass is no more than about 34 °F.

10. The method of claim 1, further comprising, prior to step (a), removing water from the filamentous fungal biomass.

11. The method of claim 1, wherein step (a) comprises agitating the filamentous fungal biomass together with the solution.

12. The method of claim 1, wherein the filamentous fungal biomass absorbs an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about

15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomass.

13. The method of claim 1, wherein step (a) comprises contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate, and wherein step (b) comprises size-reducing the filamentous fungal aggregate.

14. The method of claim 13, wherein the step of aggregating comprises encasing the at least two filamentous fungal biomasses in a casing.

15. The method of claim 13, wherein the aggregating step is carried out under sub-atmospheric pressure.

16. The method of claim 15, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

17. The method of claim 13, wherein the aggregating step comprises crust-freezing the at least two filamentous fungal biomasses.

18. The method of claim 1, further comprising, between steps (a) and (b), crust freezing the filamentous fungal biomass.

19. The method of claim 18, wherein an internal temperature of the filamentous fungal biomass after the crust freezing step is between about 25 °F and about 27 °F.

20. The method of claim 18, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

21. The method of claim 1, wherein step (b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomass.

22. The method of claim 21, wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass.

23. The method of claim 1, wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm.

24. The method of claim 1, wherein step (c) comprises at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

25. The method of claim 1, wherein the solution is an aqueous solution.

26. The method of claim 1, wherein the solution is a non-aqueous solution.

27. The method of claim 1, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in or on a fermentation medium or on a membrane associated with a fermentation medium; and

inactivating the filamentous fungal biomass.

28. The method of claim 27, wherein the fermentation method is selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid (AMC) fermentation method, and combinations thereof.

29. The method of claim 27, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

30. The method of claim 1, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

31. The method of claim 1, wherein the food product comprises all essential amino acids.

32. The method of claim 1, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

33. The method of claim 1, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

34. The method of claim 1, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than

about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

35. The method of claim 1, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

36. The method of claim 1, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

37. A meat analog food product made according to the method of claim 1.

38. A method for preparing a food product, comprising:

(a) contacting a filamentous fungal biomass with a solution comprising a food additive; and

(b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.

39. The method of claim 38, wherein the food product is a meat jerky analog food product.

40. The method of claim 38, wherein the solution comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

41. The method of claim 38, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

42. The method of claim 38, wherein step (a) is carried out under sub-atmospheric pressure.

43. The method of claim 42, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

44. The method of claim 38, wherein step (a) is carried out at a temperature below room temperature.

45. The method of claim 44, wherein the temperature below room temperature is no more than about 40 °F.

46. The method of claim 38, wherein step (a) is carried out at a temperature above room temperature.

47. The method of claim 38, wherein, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass is no more than about 34 °F.

48. The method of claim 38, further comprising, prior to step (a), removing water from the filamentous fungal biomass.

49. The method of claim 38, wherein step (a) is carried out by agitating the filamentous fungal biomass together with the solution.

50. The method of claim 38, wherein the filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

51. The method of claim 38, wherein the solution is an aqueous solution.

52. The method of claim 38, wherein the solution is a non-aqueous solution.

53. The method of claim 38, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the filamentous fungal biomass.

54. The method of claim 53, wherein the fermentation method is a surface fermentation method.

55. The method of claim 53, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

56. The method of claim 38, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

57. The method of claim 38, wherein the food product comprises all nine essential amino acids.

58. The method of claim 38, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

59. The method of claim 38, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

60. The method of claim 38, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

61. The method of claim 38, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

62. The method of claim 38, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

63. A meat jerky analog food product made according to the method of claim 39.

64. A meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true:

(i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product;

(ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food product; and

(iii) a sugar content of the meat analog food product is no more than about 10 wt%.

65. The meat analog food product of claim 64, having a shelf life of at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

66. The meat analog food product of claim 64, having a water activity of between about 0.35 and about 0.85.

67. The meat analog food product of claim 64, having a water activity of no more than about 0.45.

68. The meat analog food product of claim 64, comprising less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per 28 grams of food product.

69. The meat analog food product of claim 64, wherein at least one of the following is true:

(i) the meat analog food product comprises no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food product; and

(ii) a sugar content of the meat analog food product is no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%.

70. The meat analog food product of claim 64, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

71. The meat analog food product of claim 64, comprising all nine essential amino acids.

72. The meat analog food product of claim 64, comprising at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

73. The meat analog food product of claim 64, comprising at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

74. The meat analog food product of claim 64, having a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

75. The meat analog food product of claim 64, wherein the filamentous fungus comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

76. The meat analog food product of claim 64, wherein the filamentous fungus comprises a filamentous fungal biomat or a portion thereof.

77. A method for preparing a food product, comprising:

(a) contacting a first filamentous fungal biomass with a first solution;

(b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces;

(c) contacting a second filamentous fungal biomass with a second solution;

(d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass; and

(e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product.

78. The method of claim 77, wherein the food product is a meat jerky analog food product.

79. The method of claim 77, wherein at least one of the first and second solutions comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

80. The method of claim 77, wherein at least one of the following is true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass prior to step (c).

81. The method of claim 77, wherein at least one of step (a) and step (c) is carried out under sub-atmospheric pressure.

82. The method of claim 81, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

83. The method of claim 77, wherein at least one of step (a) and step (c) is carried out at a temperature below room temperature.

84. The method of claim 83, wherein the temperature below room temperature is no more than about 40 °F.

85. The method of claim 83, wherein, during at least part of a duration of step (a), a temperature of at least one of the first filamentous fungal biomass and the second filamentous fungal biomass is no more than about 34 °F.

86. The method of claim 77, wherein at least one of step (a) and step (c) is carried out at a temperature above room temperature.

87. The method of claim 77, further comprising at least one of: (i) prior to step (a), removing water from the first filamentous fungal biomass; and (ii) prior to step (c), removing water from the second filamentous fungal biomass.

88. The method of claim 77, wherein at least one of the following is true: (i) step (a) is carried out by agitating the first filamentous fungal biomass together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass together with the second solution.

89. The method of claim 77, wherein at least one of the following is true: (i) the first filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass absorbs least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

90. The method of claim 77, further comprising at least one of (i) between steps (a) and (b), crust freezing the first filamentous fungal biomass, and (ii) between steps (c) and (d), crust freezing the second filamentous fungal biomass.

91. The method of claim 90, wherein an internal temperature of the first filamentous fungal biomass when (i) is true, or an internal temperature of the second filamentous fungal biomass when (ii) is true, after the crust freezing step is between about 25 °F and about 27 °F.

92. The method of claim 90, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

93. The method of claim 77, wherein at least one of the first and second solutions is an aqueous solution.

94. The method of claim 77, wherein at least one of the first and second solutions is a non-aqueous solution.

95. The method of claim 77, further comprising, prior to at least one of steps (a) and (c):

forming at least one of the filamentous fungal biomass and the second filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the at least one of the first filamentous fungal biomass and the second filamentous fungal biomass.

96. The method of claim 95, wherein the fermentation method is a surface fermentation method.

97. The method of claim 95, wherein the inactivating step is carried out by at least one of dehydrating the filamentous fungal biomass, freezing the filamentous fungal biomass, pressure treating the filamentous fungal biomass, rinsing the filamentous fungal biomass, size reducing the filamentous fungal biomass, steaming the filamentous fungal biomass, and temperature cycling the filamentous fungal biomass.

98. The method of claim 77, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

99. The method of claim 77, wherein the food product comprises all nine essential amino acids.

100. The method of claim 77, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

101. The method of claim 77, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

102. The method of claim 77, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

103. The method of claim 77, wherein at least one of the filamentous fungal biomass and the second filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

104. The method of claim 77, wherein at least one of the first filamentous fungal biomass and the second filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

105. A meat jerky analog food product made according to the method of claim 78.

106. An intermediate food composition, comprising:

a filamentous fungal biomass; and

a solution comprising a food additive, absorbed by the filamentous fungal biomass.

107. The intermediate food composition of claim 106, wherein the solution comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

108. The intermediate food composition of claim 106, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomass.

109. The intermediate food composition of claim 106, wherein the solution is an aqueous solution.

110. The intermediate food composition of claim 106, wherein the solution is a non-aqueous solution.

111. The intermediate food composition of claim 106, wherein the filamentous fungal biomass is derived from a fermentation method selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, and an air-medium colloid (AMC) fermentation method, and combinations thereof.

112. The intermediate food composition of claim 106, wherein the filamentous fungal biomass is inactivated.

113. The intermediate food composition of claim 106, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

114. A method for preparing a food product, comprising:

(a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive;

(b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; and

(c)removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive.

115. The method of claim 114, wherein, in step (a), the filamentous fungal biomass is exposed to an absolute pressure of no more than about 0.1 pascals.

116. The method of claim 114, wherein, following step (a), the filamentous fungal biomass has an approximately cylindrical shape.

117. The method of claim 114, further comprising, between steps (a) and (b), crust freezing the filamentous fungal biomass.

118. The method of claim 117, wherein an internal temperature of the filamentous fungal biomass after the crust freezing step is between about 25 °F and about 27 °F.

119. The method of claim 117, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

120. The method of claim 114, wherein step (b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomass.

121. The method of claim 120, wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass.

122. The method of claim 114, wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm.

123. The method of claim 114, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the filamentous fungal biomass.

124. The method of claim 123, wherein the fermentation method is a surface fermentation method.

125. The method of claim 123, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

126. The method of claim 114, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

127. The method of claim 114, wherein the food product comprises all nine essential amino acids.

128. The method of claim 114, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

129. The method of claim 114, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

130. The method of claim 114, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less

than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

131. The method of claim 114, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

132. The method of claim 114, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

133. The method of claim 1, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

134. The method of claim 1, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

135. The method of claim 38, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

136. The method of claim 38, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

137. The meat analog food product of claim 64, having a total protein content from about 10 wt% to about 25 wt%.

138. The meat analog food product of claim 64, having a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

139. The method of claim 77, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

140. The method of claim 77, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

141. The method of claim 114, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

142. The method of claim 114, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

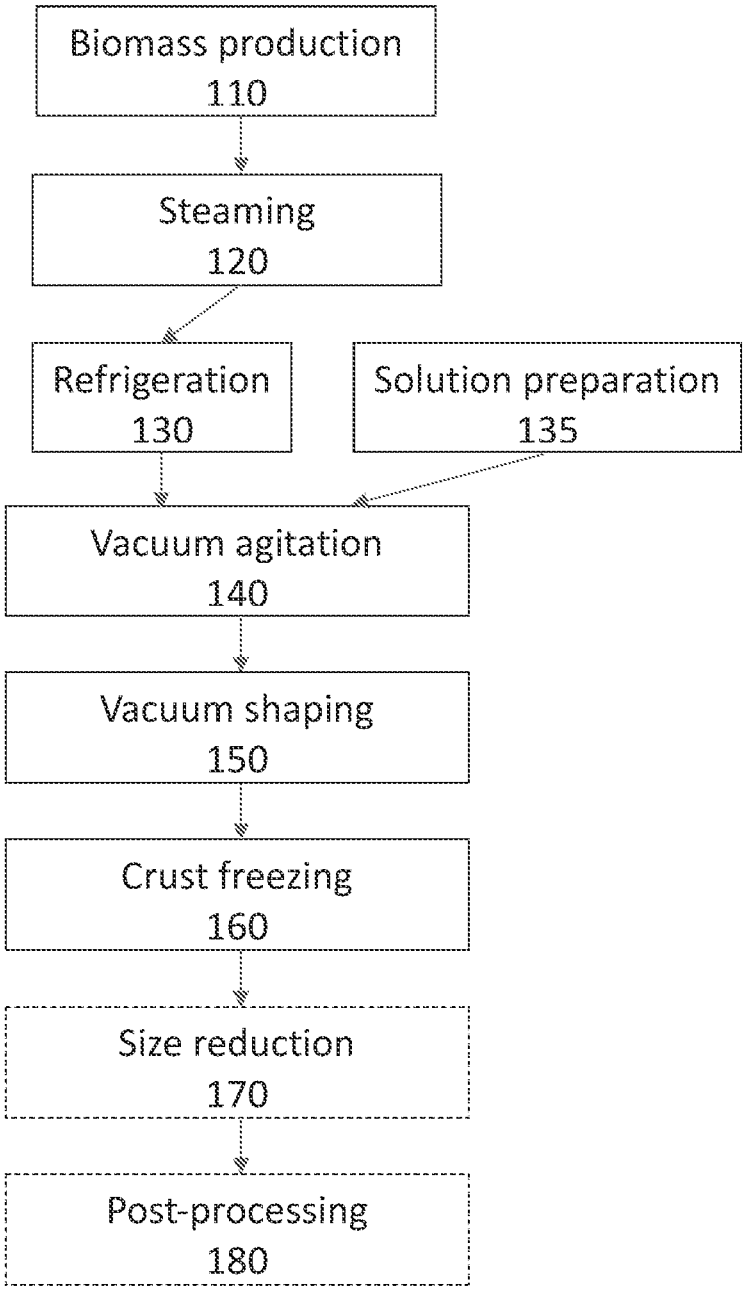

Biomass production
110
Steaming
120
Refrigeration
130
Solution preparation
135
Vacuum agitation
140
Vacuum shaping
150
Crust freezing
160
Size reduction
170
Post-processing
180

FIG. 1A

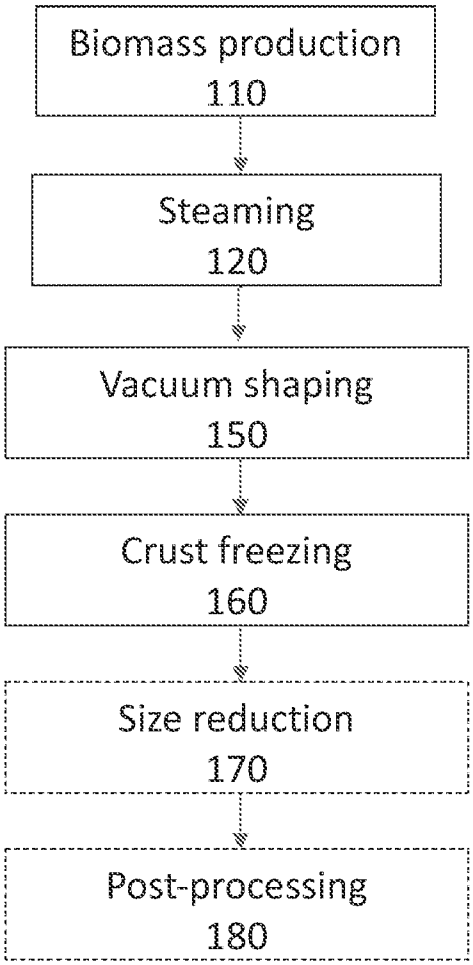

Biomass production
110
Steaming
120
Vacuum shaping
150
Crust freezing
160
Size reduction
170
Post-processing
180

FIG. 1B

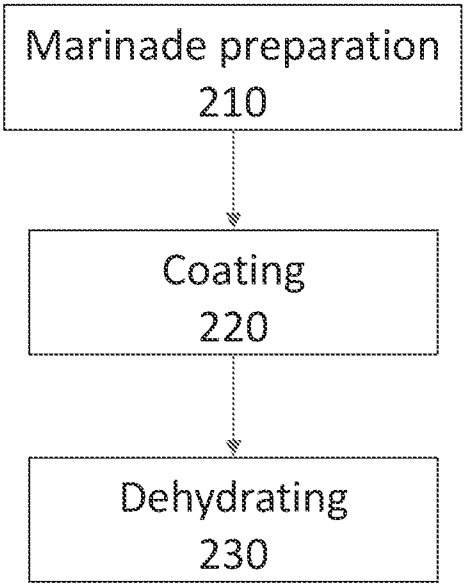


FIG. 2A

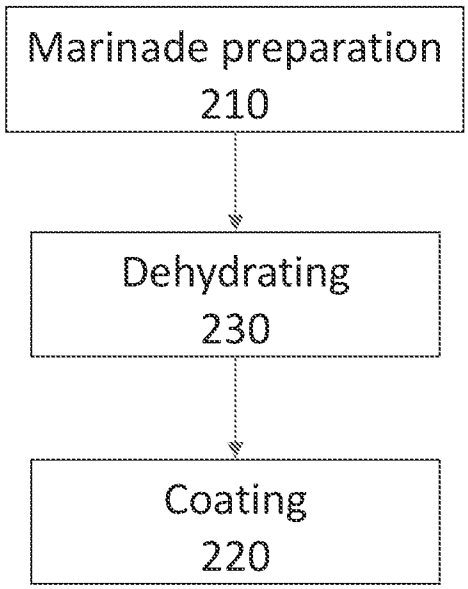


FIG. 2B



FIG. 3A



FIG. 3B



FIG. 3C

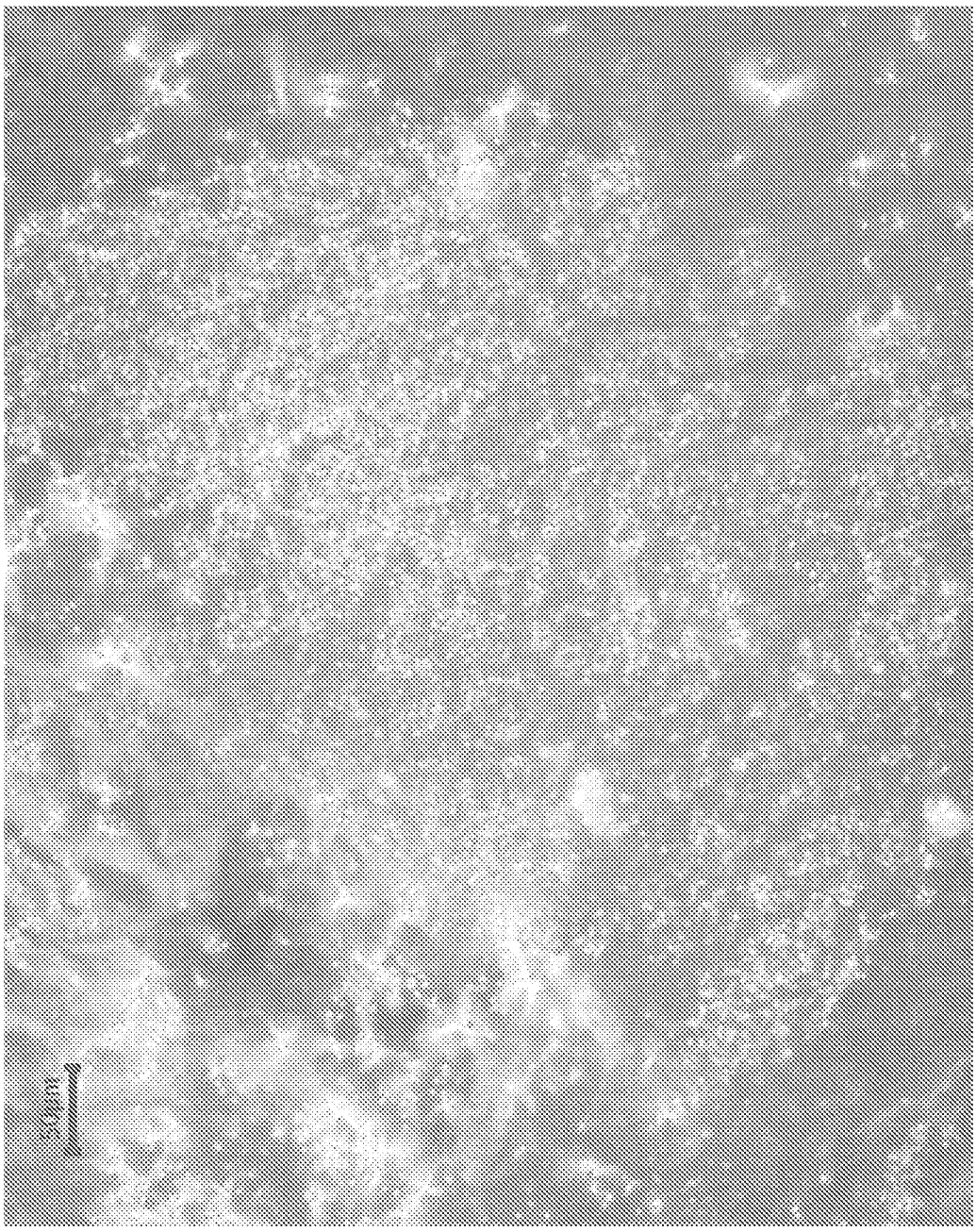


FIG. 4A



FIG. 4B

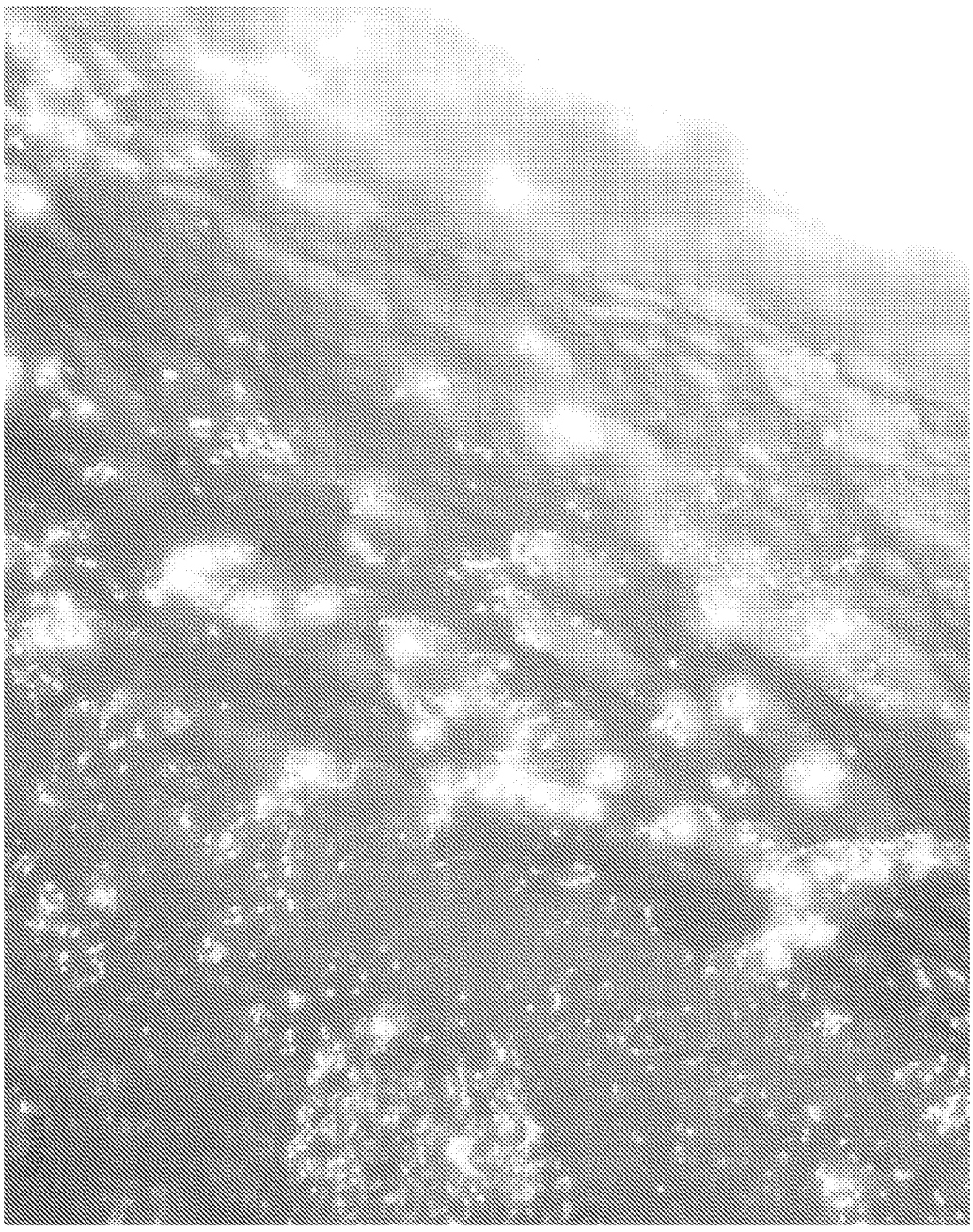


FIG. 5A

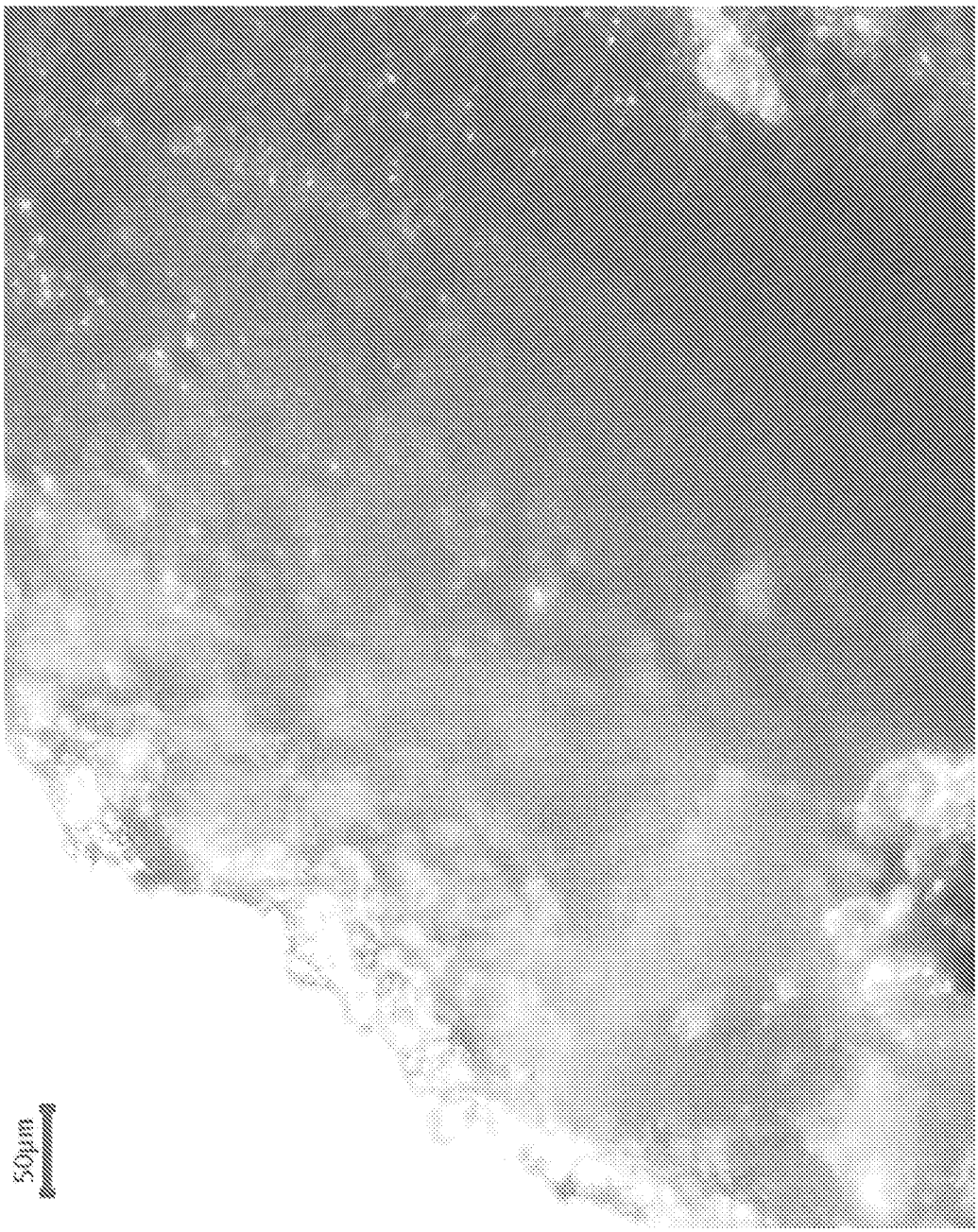


FIG. 5B



FIG. 6A

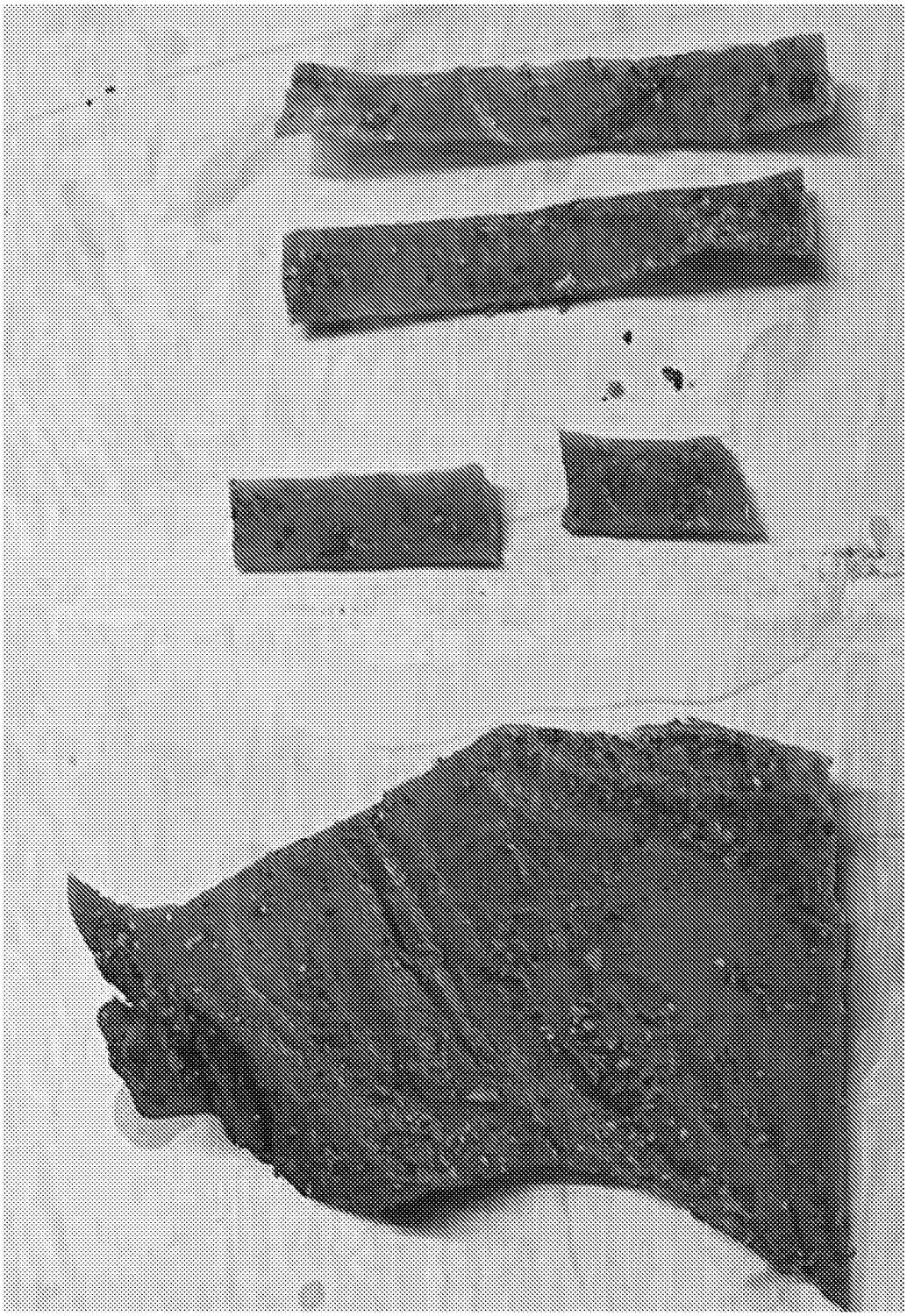


FIG. 6B

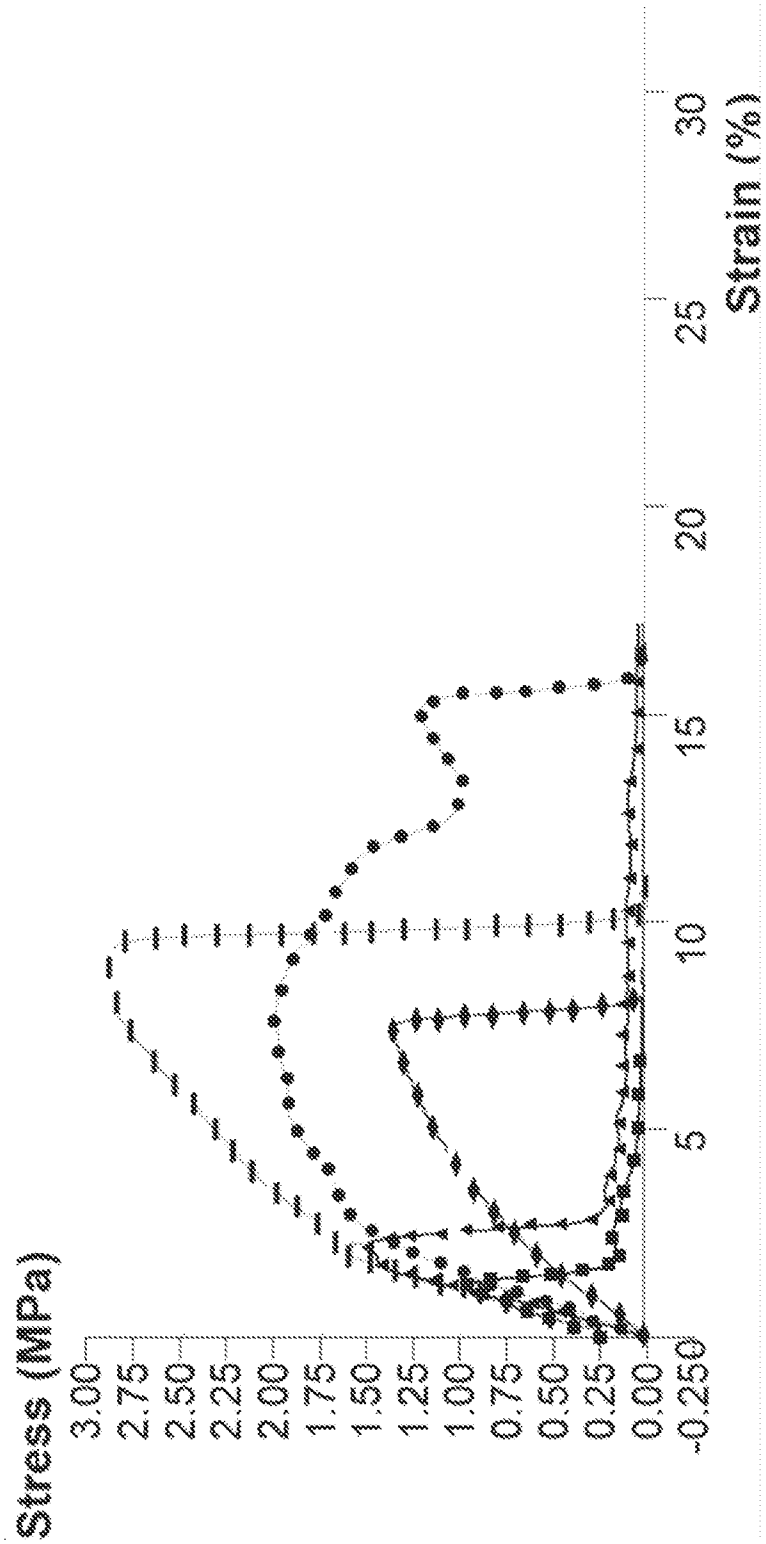

Stress (MPa)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.250
5
10
15
20
25
30
Strain (%)

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A23J 3/20; A23K 10/30; A23L 13/40; C12N 1/14; A23L 33/195 (2022.01)

CPC - A23J 3/20; A23K 10/30; A23L 31/00; A23L 13/40; A23J 3/227; A23L 33/195; A23L 29/065; C12M 21/00; C12N 1/14; A23V 2002/00; A23V 2250/208

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 4,800,093 A (HOGAN WILLIAM C) 24 January 1989; Column 2, 4, 5	1-3, 9, 11-12, 37 --- 4, 6, 10, 21-36, 133-134 --- 5, 7-8, 13-20, 114-134, 141-142
Y --- A	US 2020/0268031 A1 (SUSTAINABLE BIOPRODUCTS, INC.) 27 August 2020; Paragraph [0243], [0244], [0271], [0293]	4, 6, 25 --- 5, 13
Y --- A	WO 2020/061502 A1 (THE BETTER MEAT COMPANY) 26 March 2020; Paragraph [000110]-[000112], [000124], [000147], [000159], [000181-[000189]	10, 21-22, 31, 33-35, 133-134 --- 18-20, 114-132, 141-142
Y --- A	US 2021/0059287 A1 (THE FYNDER GROUP, INC.) 04 March 2021; Paragraph [0006], [0015], [0080]-[0089], [0097], [0102], [0105], [0149]-[0150], Table 1	23-24, 27-30, 32, 36 --- 7, 13
Y	KOTOGAN. "An Organic Solvent-Tolerant Lipase w. Both Hydrolytic & Synthetic Activities from the Oleaginous Fungus Mortierella echinosphaera" . Intl. J. of Molecular Sciences. . April 2018; Abstract; DOI: 10.3390/ijms19041129	26
A	US 2018/0080050 A1 (THE CHINESE UNIV. OF HONG KONG) 22 March 2018; Abstract	

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 July 2022 (22.07.2022)	AUG 10 2022
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,731,248 A (HOGAN WILLIAM C) 15 March 1988; Column 7	5
A	CN 101411343 B (ANGEL YEAST CO LTD) 27 June 2012; Paragraph [0005]	7-8
A	CN 107927741 A (CHANGSHU INST TECH) 20 April 2018; Paragraph [0006]	18-20
		114-132, 141-142

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
-***-Please See Supplemental Page-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-37, 114-134, and 141-142;

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-***-Continued From Box No. III: Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-37, 114-134, and 141-142 are directed toward a method for preparing a food product, comprising: c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order.
Group II: Claims 38-63 and 135-136 are directed toward a method for preparing a food product, comprising: b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.
Group III: Claims 64-76 and 137-138are directed toward a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks.
Group IV: Claims 77-105 and 139-140 are directed toward a method for preparing a food product, comprising: c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass.
Group V: Claims 106-113 are directed toward an intermediate food composition, comprising: a solution comprising a food additive, absorbed by the filamentous fungal biomass.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); and c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order (which are not present in Groups II-V).

Group II include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); and b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass (which are not present in Groups I and III-V).

Group III include a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true: i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product; ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food product; and iii) a sugar content of the meat analog food product is no more than about 10 wt% (which are not present in Groups I-II and IV-V).

Group IV include a method for preparing a food product, comprising: a) contacting a first filamentous fungal biomass with a first solution (which are not present in Group III); b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass; and e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product (which are not present in Groups I-III and V).

Group V include an intermediate food composition, comprising: a filamentous fungal biomass (which are not present in Group III); and a solution comprising a food additive, absorbed by the filamentous fungal biomass (which are not present in Groups I-IV).

The common technical feature of Groups I-II and IV-V a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive; forming the food product.

The common technical feature of Groups I and IV size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces.

The common technical feature of Groups I-II and IV-V are disclosed by US 2019/0059431 A1 (SUSTAINABLE). Sustainable discloses a method for preparing a food product (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]), comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]); forming the food product (to form food; paragraph [0095]).

The common technical feature of Groups I and IV are disclosed by Sustainable. Sustainable discloses size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (size reducing edible filamentous fungal biomats by cutting, chopping, etc.; paragraph [0087]).

Since the common technical feature is previously disclosed by the Sustainable reference, the common feature is not special and so Groups I-V lack unity.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
63/164,466	03/22/2021		150	10087-35-PROV		

CONFIRMATION NO. 3758
UPDATED FILING RECEIPT

158864
Sheridan Ross PC/Sustainable Bioproducts, Inc.
1560 Broadway
Suite 1200
Denver, CO 80202

OC000000130080910

Date Mailed: 11/30/2021

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt identifying the requested changes, preferably by including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Baljit Ghotra, Chicago, IL;
Yuval Avniel, Chicago, IL;
Brian Klopf, Chicago, IL;
Jessica Kawabata, Chicago, IL;
Eric Carre, Grayslake, IL;

Applicant(s)

Baljit Ghotra, Chicago, IL;
Yuval Avniel, Chicago, IL;
Brian Klopf, Chicago, IL;
Jessica Kawabata, Chicago, IL;
Eric Carre, Grayslake, IL;

Power of Attorney:
Tyler Boschert--70791

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 03/29/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 63/164,466**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No
** **SMALL ENTITY** **
Title

Food products comprising filamentous fungal material

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
63/164,466	03/22/2021		150	10087-35-PROV		

CONFIRMATION NO. 3758

158864
Sheridan Ross PC/Sustainable Bioproducts, Inc.
1560 Broadway
Suite 1200
Denver, CO 80202

FILING RECEIPT

OC000000124485895

Date Mailed: 03/30/2021

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt identifying the requested changes, preferably by including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Baljit Ghotra, Chicago, IL;
Yuval Avniel, Chicago, IL;
Brian Klopf, Chicago, IL;
Jessica Kawabata, Chicago, IL;
Eric Carre, Grayslake, IL;

Applicant(s)

Baljit Ghotra, Chicago, IL;
Yuval Avniel, Chicago, IL;
Brian Klopf, Chicago, IL;
Jessica Kawabata, Chicago, IL;
Eric Carre, Grayslake, IL;

Power of Attorney:
Tyler Boschert--70791

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 03/29/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 63/164,466**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No
** **SMALL ENTITY** **
Title

Food products comprising filamentous fungal material

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference		FOR FURTHER ACTION
10087-35-PCT		see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US22/21369	22 March 2022 (22.03.2022)	22 March 2021 (22.03.2021)
Applicant THE FYNDER GROUP, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☒ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 1A

☒ as suggested by the applicant.

☐ as selected by this Authority, because the applicant failed to suggest a figure.

☐ as selected by this Authority, because this figure better characterizes the invention.

b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
-***-Please See Supplemental Page-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-37, 114-134, and 141-142;

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A23J 3/20; A23K 10/30; A23L 13/40; C12N 1/14; A23L 33/195 (2022.01)

CPC - A23J 3/20; A23K 10/30; A23L 31/00; A23L 13/40; A23J 3/227; A23L 33/195; A23L 29/065; C12M 21/00; C12N 1/14; A23V 2002/00; A23V 2250/208

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 4,800,093 A (HOGAN WILLIAM C) 24 January 1989; Column 2, 4, 5	1-3, 9, 11-12, 37 --- 4, 6, 10, 21-36, 133-134 --- 5, 7-8, 13-20, 114-134, 141-142
Y --- A	US 2020/0268031 A1 (SUSTAINABLE BIOPRODUCTS, INC.) 27 August 2020; Paragraph [0243], [0244], [0271], [0293]	4, 6, 25 --- 5, 13
Y --- A	WO 2020/061502 A1 (THE BETTER MEAT COMPANY) 26 March 2020; Paragraph [000110]-[000112], [000124], [000147], [000159], [000181-[000189]	10, 21-22, 31, 33-35, 133-134 --- 18-20, 114-132, 141-142
Y --- A	US 2021/0059287 A1 (THE FYNDER GROUP, INC.) 04 March 2021; Paragraph [0006], [0015], [0080]-[0089], [0097], [0102], [0105], [0149]-[0150], Table 1	23-24, 27-30, 32, 36 --- 7, 13
Y	KOTOGAN. "An Organic Solvent-Tolerant Lipase w. Both Hydrolytic & Synthetic Activities from the Oleaginous Fungus Mortierella echinosphaera" . Intl. J. of Molecular Sciences. . April 2018; Abstract; DOI: 10.3390/ijms19041129	26
A	US 2018/0080050 A1 (THE CHINESE UNIV. OF HONG KONG) 22 March 2018; Abstract	

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 July 2022 (22.07.2022)	AUG 10 2022
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,731,248 A (HOGAN WILLIAM C) 15 March 1988; Column 7	5
A	CN 101411343 B (ANGEL YEAST CO LTD) 27 June 2012; Paragraph [0005]	7-8
A	CN 107927741 A (CHANGSHU INST TECH) 20 April 2018; Paragraph [0006]	18-20
		114-132, 141-142

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/21369

-***-Continued From Box No. III: Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-37, 114-134, and 141-142 are directed toward a method for preparing a food product, comprising: c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order.
Group II: Claims 38-63 and 135-136 are directed toward a method for preparing a food product, comprising: b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.
Group III: Claims 64-76 and 137-138are directed toward a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks.
Group IV: Claims 77-105 and 139-140 are directed toward a method for preparing a food product, comprising: c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass.
Group V: Claims 106-113 are directed toward an intermediate food composition, comprising: a solution comprising a food additive, absorbed by the filamentous fungal biomass.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); and c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order (which are not present in Groups II-V).

Group II include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); and b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass (which are not present in Groups I and III-V).

Group III include a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true: i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product; ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food product; and iii) a sugar content of the meat analog food product is no more than about 10 wt% (which are not present in Groups I-II and IV-V).

Group IV include a method for preparing a food product, comprising: a) contacting a first filamentous fungal biomass with a first solution (which are not present in Group III); b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass; and e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product (which are not present in Groups I-III and V).

Group V include an intermediate food composition, comprising: a filamentous fungal biomass (which are not present in Group III); and a solution comprising a food additive, absorbed by the filamentous fungal biomass (which are not present in Groups I-IV).

The common technical feature of Groups I-II and IV-V a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive; forming the food product.

The common technical feature of Groups I and IV size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces.

The common technical feature of Groups I-II and IV-V are disclosed by US 2019/0059431 A1 (SUSTAINABLE). Sustainable discloses a method for preparing a food product (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]), comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]); forming the food product (to form food; paragraph [0095]).

The common technical feature of Groups I and IV are disclosed by Sustainable. Sustainable discloses size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (size reducing edible filamentous fungal biomats by cutting, chopping, etc.; paragraph [0087]).

Since the common technical feature is previously disclosed by the Sustainable reference, the common feature is not special and so Groups I-V lack unity.

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: Tyler J. Boschert
Sheridan Ross P.C.
1560 Broadway
Suite 1200
Denver, CO 80202
United States Of America

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	AUG 10 2022
Applicant's or agent's file reference 10087-35-PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US22/21369	22 March 2022 (22.03.2022)	22 March 2021 (22.03.2021)

International Patent Classification (IPC) or both national classification and IPC

IPC - A23J 3/20; A23K 10/30; A23L 13/40; C12N 1/14; A23L 33/195 (2022.01)

CPC - A23J 3/20; A23K 10/30; A23L 31/00; A23L 13/40; A23J 3/227; A23L 33/195; A23L 29/065; C12M 21/00; C12N 1/14; A23V 2002/00; A23V 2250/208

Applicant THE FYNDER GROUP, INC.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [x] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	22 July 2022 (22.07.2022)	Shane Thomas PCT Help Desk Telephone No. 571-272-4300

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US22/21369

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(b)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US22/21369

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:

   ☐ paid additional fees.

   ☐ paid additional fees under protest and, where applicable, the protest fee.

   ☐ paid additional fees under protest but the applicable protest fee was not paid.

   ☒ not paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

-***-Please See Supplemental Page-***-

4. Consequently, this opinion has been established in respect of the following parts of the international application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. Group I: Claims 1-37, 114-134, and 141-142

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US22/21369

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	4-8, 10, 13-36, 114-134, 141-142	YES
	Claims	1-3, 9, 11-12, 37	NO
Inventive step (IS)	Claims	5, 7-8, 13-20, 114-132, 141-142	YES
	Claims	1-4, 6, 9, 10-12, 21-37, 133-134	NO
Industrial applicability (IA)	Claims	1-37, 114-134, 141-142	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 1-3, 9, 11-12, 37 lacks novelty under PCT Article 33(2) as being anticipated by US 4800093 A to Hogan W. et al. (hereinafter "Hogan").

As per claim 1, Hogan discloses a method for preparing a food product (food product prepared to be made more edible, column 2, line 14-16), comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (mixture of food and filamentous fungal biomass generated, column 2, line 18-20); b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (size of particles reduced into uniform pieces, column 2, line 20-22); and c) removing at least a portion of a solvent of the solution (biomass is removed from the medium via concentration methods, column 4, line 28-33) to treat the plurality of filamentous fungal pieces (filamentous fungal biomass treated, column 4, line 28-30) to form the food product (filtered biomass produced, column 4, line 33-35) comprising the filamentous fungal pieces and the food additive (food product results in uniform particle sizes of filamentous fungal biomass and fresh meat, column 5, line 37-39), wherein steps a) and b) are carried out simultaneously or sequentially in any order (food contacted with fungal biomass and reduced in size, column 2, line 18-22).

As per claim 2, Hogan discloses the method of claim 1, Hogan further discloses wherein the food additive comprises at least one of sodium chloride, a food seasoning, an edible protein (food additive was a fresh meat, column 5, line 37-38), and a fibrous base material.

As per claim 3, Hogan discloses the method of claim 1, Hogan further discloses wherein a mass of the solution is between about 1% and about 30% of a total mass of the filamentous fungal biomass prior to contacting the solution (1% to 18% fungal biomass solids by weight of the product solids, column 5, line 3-6).

As per claim 9, Hogan discloses the method of claim 1, Hogan further discloses wherein, during at least part of a duration of step a), a temperature of the filamentous fungal biomass is no more than about 34 °F (filamentous fungal mass is maintained between -20 F to +40 F, column 5, line 17-20).

As per claim 11, Hogan discloses the method of claim 1, Hogan further discloses wherein step a) comprises agitating the filamentous fungal biomass together with the solution (agitation important part of distributing biomass, column 4, line 3-10).

As per claim 12, Hogan discloses the method of claim 1, Hogan further discloses wherein the filamentous fungal biomass absorbs an amount of the solution equal to at least about 5 wt%, at least about 10 wt% (filamentous fungal biomass incorporated at a level of 1-18% of the solids, replacing the food product, column 5, line 1-8), at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomass.

As per claim 37, Hogan discloses a meat analog food product made according to the method of claim 1 (meat analog food product results in uniform particle sizes of filamentous fungal biomass and fresh meat, column 5, line 37-39).

Claims 10, 21-22, 31, 33-35, 133-134 lacks an inventive step under PCT Article 33(3) as being obvious over Hogan in view of WO 2020/061502 A1 to The Better Meat Company (Hereinafter "BMC").

As per claim 10, Hogan discloses the method of claim 1, Hogan does not disclose further comprising, prior to step a), removing water from the filamentous fungal biomass. BMC discloses prior to step a), removing water from the filamentous fungal biomass (biomass was de-watered, paragraph [000181]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the biomass of Hogan to include dewatering the biomass, as taught by BMC, because de-watering was used to refine the sample (BMC, paragraph [000181]).

As per claim 21, Hogan discloses the method of claim 1, Hogan does not disclose wherein step b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomass. BMC discloses wherein step b) comprises at least one of cutting, shredding (biomass shredded into particles, paragraph [000187]), and shaving the filamentous fungal biomass. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the size-reducing of Hogan to include shredding, as taught by BMC, because shredding was an efficient way to reduce the size of the particle and dehydrate the product (BMC, paragraph [000187]).

-***-Continued in Supplemental Box-***-

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US22/21369

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
-***-Continued From Box IV (ii): Lack of unity of invention-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-37, 114-134, and 141-142 are directed toward a method for preparing a food product, comprising: c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order.
Group II: Claims 38-63 and 135-136 are directed toward a method for preparing a food product, comprising: b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.
Group III: Claims 64-76 and 137-138are directed toward a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks.
Group IV: Claims 77-105 and 139-140 are directed toward a method for preparing a food product, comprising: c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass.
Group V: Claims 106-113 are directed toward an intermediate food composition, comprising: a solution comprising a food additive, absorbed by the filamentous fungal biomass.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); and c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps a) and b) are carried out simultaneously or sequentially in any order (which are not present in Groups II-V).

Group II include a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (which are not present in Group III); and b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass (which are not present in Groups I and III-V).

Group III include a meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true: i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product; ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food product; and iii) a sugar content of the meat analog food product is no more than about 10 wt% (which are not present in Groups I-II and IV-V).

Group IV include a method for preparing a food product, comprising: a) contacting a first filamentous fungal biomass with a first solution (which are not present in Group III); b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces (which are not present in Groups II-III and V); c) contacting a second filamentous fungal biomass with a second solution; d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass; and e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product (which are not present in Groups I-III and V).

Group V include an intermediate food composition, comprising: a filamentous fungal biomass (which are not present in Group III); and a solution comprising a food additive, absorbed by the filamentous fungal biomass (which are not present in Groups I-IV).

The common technical feature of Groups I-II and IV-V a method for preparing a food product, comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive; forming the food product.

The common technical feature of Groups I and IV size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces.

The common technical feature of Groups I-II and IV-V are disclosed by US 2019/0059431 A1 (SUSTAINABLE). Sustainable discloses a method for preparing a food product (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]), comprising: a) contacting a filamentous fungal biomass with a solution comprising a food additive (the reduced particle size of the filamentous fungal biomats is used to augment food by mixing with water and various binders such as color additives; paragraphs [0087], [0095], [0099]); forming the food product (to form food; paragraph [0095]).

The common technical feature of Groups I and IV are disclosed by Sustainable. Sustainable discloses size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (size reducing edible filamentous fungal biomats by cutting, chopping, etc.; paragraph [0087]).

Since the common technical feature is previously disclosed by the Sustainable reference, the common feature is not special and so Groups I-V lack unity.

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
-***-Continued From Box V. 2: Citations and Explanations-***-

As per claim 22, Hogan discloses the method of claim 21, Hogan does not disclose wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass. BMC discloses wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass (after particles were shaved, particles were separates with sieve, paragraph [000187]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the size-reducing of Hogan to include shredding, as taught by BMC, because shredding was an efficient way to reduce the size of the particle and dehydrate the product (BMC, paragraph [000187]).

As per claim 31, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product comprises all essential amino acids. BMC discloses wherein the food product comprises all essential amino acids (food ingredient contains all the essential amino acids, paragraph [000110]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include all the essential amino acids, as taught by BMC, because the essential amino acids would improve the protein quality (BMC, paragraph [000110]).

As per claim 33, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product comprises at least about 30 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids. BMC discloses wherein the food product comprises at least about 30 wt%, at least about 15 wt% (protein at least 5% protein, paragraph [000110]), at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include at least 5% protein, as taught by BMC, because this level of protein weight would improve the nutritional quality (BMC, paragraph [000110]).

As per claim 34, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%. BMC discloses wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt% (total fat content between 8% and 13%, paragraph [000111]), less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include less than 14% fat, as taught by BMC, because this level of fat content would improve the nutritional quality (BMC, paragraph [000111]).

As per claim 35, Hogan discloses the method of claim 1, Hogan does not disclose wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis. BMC discloses wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis (fiber of biomass was determined to be about 18.14%, paragraph [000189]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include at least 10 wt% dietary fiber, as taught by BMC, because this level of fiber content would improve the nutritional quality of the biomass (BMC, paragraph [000189]).

As per claim 133, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product has a total protein content from about 10 wt% to about 25 wt%. BMC discloses wherein the food product has a total protein content from about 10 wt% to about 25 wt% (protein concentration between 5-25%, paragraph [000110]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include at least 5% protein, as taught by BMC, because this level of protein weight would improve the nutritional quality (BMC, paragraph [000110]).

As per claim 134, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition. BMC discloses wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition (fiber composition was between 10% and about 50% or 3g and 14g, paragraph [000112]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food additive of Hogan to include at least 3g dietary fiber, as taught by BMC, because this level of fiber content would improve the nutritional quality of the biomass (BMC, paragraph [000112]).

Claims 23-24, 27-30, 32, 36 lacks an inventive step under PCT Article 33(3) as being obvious over Hogan in view of US 2021/0059287 A1 to The Fynder Group, Inc. (hereinafter "Fynder").

As per claim 23, Hogan discloses the method of claim 1, Hogan does not disclose wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm. Fynder discloses wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm (filaments average dimensions was between 1.0-1.2 mm, paragraph [0087], [0089], [0149]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the size of Hogan to include 1 mm in length,

-***-Continued Within the Next Supplemental Box-***-

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
-***-Continued from previous Supplemental Box-***-

width, and depth of the filaments, as taught by Fynder, because size reduced filaments can be used as protein sources (Fynder, paragraph [0086]).

As per claim 24, Hogan discloses the method of claim 1, Hogan does not disclose wherein step c) comprises at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces. Fynder discloses wherein step c) comprises at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces (filamentous pieces were steamed and then coated with egg whites, paragraph [0150]), cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify step c) of Hogan to include steaming filamentous pieces, as taught by Fynder, because this prepares the pieces to be combined with the food additive (Fynder, paragraph [0150]).

As per claim 27, Hogan discloses the method of claim 1, Hogan further discloses further comprising, prior to step a): forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in or on a fermentation medium (fermenting done in an inoculated medium, column 3, line 63-68) or on a membrane associated with a fermentation medium. Hogan does not disclose inactivating the filamentous fungal biomass. Fynder discloses inactivating the filamentous fungal biomass (biomass inactivated with steam, paragraph [0083]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the culturing of Hogan to include inactivation of biomass, as taught by Fynder, because inactivating the biomass would be needed to use the biomass as a protein in a food source (Fynder, paragraph [0080]).

As per claim 28, Hogan and Fynder disclose the method of claim 27, Hogan does not disclose wherein the fermentation method is selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid "AMC" fermentation method, and combinations thereof. Fynder discloses wherein the fermentation method is selected from the group consisting of a surface fermentation method, a submerged fermentation method (submerged fermentation method used, paragraph [0102]), a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid "AMC" fermentation method, and combinations thereof. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the culturing of Hogan to include the submerging method, as taught by Fynder, because submerged fermentation method would be useful to generate a biomass with tensile strength and easy harvesting (Fynder, paragraph [0105]).

As per claim 29, Hogan and Fynder disclose the method of claim 27, Hogan does not disclose wherein the inactivating step is carried out by steaming the filamentous fungal biomass. Fynder discloses wherein the inactivating step is carried out by steaming the filamentous fungal biomass (steaming is used to inactivate biomass, paragraph [0080]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the culturing of Hogan to include inactivation of biomass, as taught by Fynder, because inactivating the biomass would be needed to use the biomass as a protein in a food source (Fynder, paragraph [0080]).

As per claim 30, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product has a tensile strength of at least about 30 g/cm2 , at least about 40 g/cm2, at least about 50 g/cm2, at least about 60 g/cm2 , at least about 70 g/cm2, at least about 80 g/cm2 , at least about 90 g/cm2 , at least about 100 g/cm2, at least about 150 g/cm2, at least about 200 g/cm2, at least about 250 g/cm2 , at least about 300 g/cm2 , at least about 350 g/cm2 , at least about 400 g/cm2 , at least about 450 g/cm2 , at least about 500 g/cm2, at least about 550 g/cm2 , at least about 600 g/cm2 , at least about 650 g/cm2 , at least about 700 g/cm2 , at least about 750 g/cm2, at least about 800 g/cm2 , at least about 850 g/cm2 , at least about 900 g/cm2 , at least about 950 g/cm2, at least about 1000 g/cm2, at least about 1500 g/cm2, at least about 2000 g/cm2, at least about 2500 g/cm2, at least about 3000 g/cm2 , at least about 3500 g/cm2 , or at least about 4000 g/cm2. Fynder discloses wherein the food product has a tensile strength of at least about 30 g/cm2 , at least about 40 g/cm2, at least about 50 g/cm2, at least about 60 g/cm2 , at least about 70 g/cm2, at least about 80 g/cm2 , at least about 90 g/cm2 , at least about 100 g/cm2, at least about 150 g/cm2, at least about 200 g/cm2, at least about 250 g/cm2 , at least about 300 g/cm2 , at least about 350 g/cm2 , at least about 400 g/cm2 , at least about 450 g/cm2 , at least about 500 g/cm2 (tensile strength of biomass greater than 500 g/cm2, paragraph [0070]; [0097], Table 1), at least about 550 g/cm2 , at least about 600 g/cm2 , at least about 650 g/cm2 , at least about 700 g/cm2 , at least about 750 g/cm2, at least about 800 g/cm2 , at least about 850 g/cm2 , at least about 900 g/cm2 , at least about 950 g/cm2, at least about 1000 g/cm2, at least about 1500 g/cm2, at least about 2000 g/cm2, at least about 2500 g/cm2, at least about 3000 g/cm2 , at least about 3500 g/cm2 , or at least about 4000 g/cm2. It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food product of Hogan to include tensile strengthening of the biomass, as taught by Fynder, because improving the strength of the biomass would add to the tensile strength of the food and would therefore be lifted easily from surfaces (Fynder, paragraph [0080]).

As per claim 32, Hogan discloses the method of claim 1, Hogan does not disclose wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine. Fynder discloses wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine (alanine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, and tyrosine are amino acids which make up the profile of the protein, paragraph [000110]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the food product of Hogan to include anyone of the amino acids, as taught by Fynder, because these amino acids improve the nutrient quality of the protein (Fynder, paragraph [000110]).

As per claim 36, Hogan discloses the method of claim 1, Hogan does not disclose wherein the filamentous fungal biomass comprises a

-***-Continued Within the Next Supplemental Box-***-

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
-***-Continued from previous Supplemental Box-***-

filamentous fungal biomat or a portion thereof. Fynder discloses wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof (biomats formed from filamentous fungi via surface fermentation, paragraph [0058]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the fungus of Hogan to include formation into biomats, as taught by Fynder, because biomats are easier to harvest and dense (Fynder, paragraph [0006]).

Claims 4, 6, 25 lacks an inventive step under PCT Article 33(3) as being obvious over Hogan in view of US 2020/0268031 A1 to Sustainable Bioproducts Inc. (hereinafter "SB").

As per claim 4, Hogan discloses the method of claim 1, Hogan does not disclose wherein step a) is carried out under sub-atmospheric pressure. SB discloses wherein step a) is carried out under sub-atmospheric pressure (sub-atmospheric pressure applied, paragraph [0293]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the pressure of Hogan to include sub-atmospheric pressure, as taught by SB, because the growth of the biomass can be controlled in this manner (SB, paragraph [0293]).

As per claim 6, Hogan discloses the method of claim 1, Hogan does not disclose wherein step a) is carried out under super-atmospheric pressure. SB discloses wherein step a) is carried out under super-atmospheric pressure (super-atmospheric pressure applied, paragraph [0293]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the pressure of Hogan to include super-atmospheric pressure, as taught by SB, because the growth of the biomass can be controlled in this manner (SB, paragraph [0293]).

As per claim 25, Hogan discloses the method of claim 1, Hogan does not disclose wherein the solution is an aqueous solution. SB discloses wherein the solution is an aqueous solution (solution used at one point is dispersed in aqueous medium, paragraph [0243]). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the solution of Hogan to include an aqueous solution, as taught by SB, because this process results in a different consistency and can be adjusted to change the density of the solution (SB, paragraph [0243], [0244]).

Claim 26 lacks an inventive step under PCT Article 33(3) as being obvious over Hogan in view of publication entitled "An Organic Solvent-Tolerant Lipase with Both Hydrolytic and Synthetic Activities from the Oleaginous Fungus Mortierella echinosphaera" by Kotogan A. et al. (hereinafter "Kotogan").

As per claim 26, Hogan discloses the method of claim 1, Hogan does not disclose wherein the solution is a non-aqueous solution. Kotogan discloses wherein the solution is a non-aqueous solution (filamentous fungal displayed tolerance in non-aqueous environment, abstract). It would have been obvious to one of ordinary skill in the art, at the time the invention was made, to modify the solution of Hogan to include non-aqueous solution, as taught by Kotogan, because the filamentous fungal biomass displayed tolerance in this medium and did not show great loss (Kotogan, abstract).

Claims 5, 7-8, 13-20, 114-132, and 141-142 meet the criteria set out in PCT Article 33(2)-(3).

Claim 5 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest: wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

Hogan and SB, discloses the method of claim 4. However, the prior art fails to disclose the wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals as discussed above.

Hogan and SB, discloses the method of claim 4; SB further discloses wherein the sub-atmospheric pressure is a pressure (sub-atmospheric pressure applied, paragraph [0293]). However, the prior art fails to disclose the wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals as discussed above.

US 2018/0080050 A1 to The Chinese University of Hong Kong (hereinafter "CUHK") discloses pressure of about 0.1 pascals (pressure on nucleotide can be 0.1 Pa, abstract). However, the prior art fails to disclose the method of claim 4, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

Hogan, SB, and CUHK, either alone or in combination fail to disclose wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals. While CUHK discloses 0.1 Pa, it is being utilized for some different purpose and there is no motivation to combine the method of claim 4 and applying it to the surface of the filamentous fungal biomass, and as such a combination would not have been obvious without the benefit of impermissible hindsight.

Claim 7 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest: step a) is carried out at a temperature below room temperature.

Hogan, discloses the method of claim 1. However, the prior art fails to disclose step a) is carried out at a temperature below room temperature as discussed above.

BMC discloses temperature below room temperature (fermentation step performed around 20C, paragraph [000159]). BMC does not disclose the method of claim 1; wherein step a) is carried out at a temperature below room temperature.

-***-Continued Within the Next Supplemental Box-***-

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
-***-Continued from previous Supplemental Box-***-

US 4, 731, 248 A to Hogan W. et al. (hereinafter "Hogan'248") discloses temperature below room temperature (biomass was frozen and stored for future experiments, column 7, line 22-26). Hogan'248 discloses the method of claim 1, wherein step a) is carried out at a temperature below room temperature.

Hogan, BMC, and Hogan'248, either alone or in combination fail to disclose step a) is carried out at a temperature below room temperature. While Hogan'248 and BMC disclose biomass being frozen, it is being utilized for some different purpose and there is no motivation to combine the method of claim 1 and mixing the food additive with the biomass below room temperature, and as such a combination would not have been obvious without the benefit of impermissible hindsight.

Claim 8 meet the criteria set out in PCT Article 33(2)-(3), because they depend on positive claim 7.

Claim 13 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest: contacting at least two filamentous fungal biomasses with the solution.

Hogan, discloses the method of claim 1. However, the prior art fails to disclose the contacting at least two filamentous fungal biomasses with the solution as discussed above.

Fynder, discloses wherein step b) comprises size-reducing the filamentous fungal aggregate (size reducing the aggregates, paragraph [0015]). Fynder fails to disclose the method of claim 1, wherein step a) comprises contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps a) and b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate.

SB discloses aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate (aggregating biomass into a single coherent mat, paragraph [0271]). SB fails to disclose the method of claim 1, wherein step a) comprises contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps a) and b); and wherein step b) comprises size-reducing the filamentous fungal aggregate.

Hogan, Fynder, and SB, either alone or in combination fail to disclose the contacting at least two filamentous fungal biomasses with the solution of the claim. While Fynder & SB disclose something similar to aggregating of biomasses, they do not disclose the contacting at least two filamentous fungal biomasses. Thus, it would not have been obvious to a person of ordinary skill in the art, at the time of invention, to have implemented the apparatus or the method of claim 13 because the references of record fail to disclose all the elements.

Claims 14-17 meet the criteria set out in PCT Article 33(2)-(3), because they depend on positive claim 13.

Claim 18 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest: crust freezing the filamentous fungal biomass.

Hogan, discloses the method of claim 1. However, the prior art fails to disclose the between steps (a) and (b), crust freezing the filamentous fungal biomass, as discussed above.

BMC discloses freezing the filamentous fungal biomass, as discussed above (optionally freezing the biomass, paragraph [000147]). However, the prior art fails to disclose the method of claim 1, further comprising, between steps (a) and (b); crust freezing.

CN 101411343 B to Yu M. (hereinafter "YU") disclose crust freezing (surface of dumpling wrapper frozen, paragraph [0005]). YU does not disclose the method of claim 1, further comprising, between steps (a) and (b), crust freezing the filamentous fungal biomass.

Hogan, BMC, and YU, either alone or in combination fail to disclose crust freezing the filamentous fungal biomass. While YU discloses surface freezing, it is being utilized for some different purpose and there is no motivation to combine the method of claim 1 and applying it to the surface of the filamentous fungal biomass, and as such a combination would not have been obvious without the benefit of impermissible hindsight.

Claims 19-20 meet the criteria set out in PCT Article 33(2)-(3), because they depend on positive claim 18.

Claim 114 meets the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest: a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces.

Hogan, discloses a method for preparing a food product (food product prepared to be made more edible, column 2, line 14-16); c) removing at least a portion of a solvent of the solution (biomass is removed from the medium via concentration methods, column 4, line 28-33) to treat the plurality of filamentous fungal pieces (filamentous fungal biomass treated, column 4, line 28-30) to form the food product (filtered biomass produced, column 4, line 33-35) comprising the filamentous fungal pieces and the food additive (food product results in uniform particle sizes of filamentous fungal biomass and fresh meat, column 5, line 37-39). However, the prior art fails to disclose the a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; as discussed above.

BMC discloses a method for preparing a food product (fungal product formed into a food product, paragraph [00020]); b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces (size reduced further after dehydration, paragraph [00056]); c)

-***-Continued Within the Next Supplemental Box-***-

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
-***-Continued from previous Supplemental Box-***-

removing at least a portion of a solvent of the solution (removal of water done to slurry, paragraph [00057]) to treat the plurality of filamentous fungal pieces to form the food product (particle slurry was dehydrated and then packaged for final product, paragraph [000187]) comprising the filamentous fungal pieces and the food additive (solution mixed with additive, paragraph [000124]). BMC does not disclose a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces.

CN 107927741 A to Changshu Institute of Technology (hereinafter "CIT") discloses a) vacuum-shaping (vacuum shaping mushroom crisp chip, paragraph [0006]). CIT does not disclose a method for preparing a food product; a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; and c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive.

Hogan, BMC, and CIT, either alone or in combination fail to disclose a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces. While CIT disclose vacuum shaping, it is being utilized for some different purpose and there is no motivation to combine with the filamentous fungal biomass and mixing with the food additive, and as such a combination would not have been obvious without the benefit of impermissible hindsight.

Claims 115-132, 141-142 meet the criteria set out in PCT Article 33(2)-(3), because they depend on positive claim 114.

Claims 1-37, 114-134, 141-142 have industry applicability as defined by PCT article 33(4) because the subject matter can be made or used in industry.

FOOD PRODUCTS COMPRISING FILAMENTOUS FUNGAL MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority of U.S. Provisional Patent Application 63/164,466, filed 22 March 2021, the entirety of which is incorporated herein by reference.

FIELD OF THE INVENTION

This application relates generally to food products comprising filamentous fungal material and methods for the manufacture thereof, and particularly to food products that may serve as analogs or replicas of conventional food products but having improved properties relative thereto.

BACKGROUND OF THE INVENTION

Many conventional processed food products, such as smoked meats or dehydrated meats e.g. meat jerky, include an allergenic substance and/or a substance that is derived or obtained from animals, and may therefore be unsuitable for consumption by persons with dietary restrictions, e.g. persons wishing to reduce or eliminate animal meat intake or with allergic sensitivities. Existing hypoallergenic or vegan alternatives to conventional processed food products often suffer from poor stability and/or shelf life, unappealing taste or texture, and so on. Moreover, many of these conventional processed food products, as a result of processing conditions or requirements for attaining a particular taste, texture, or shelf life, have nutritional drawbacks; by way of non-limiting example, conventional meat jerky is often high in humectants, e.g. sugar, salt, etc. (which must be used in significant quantities during processing as a stabilizer and for its plasticizing effect to achieve jerky's characteristic tough texture), and smoked or otherwise processed conventional meat products are often high in fat (as a result of the fatty tissues from which they are obtained) and/or salt (for flavoring and extension of shelf life). Furthermore, because meat has a high moisture content and water activity, meat products either suffer from short shelf lives or must be dehydrated to a very substantial degree.

There is thus a need in the art for food products that are analogous in taste, texture, and other aesthetic and sensory characteristics to conventional processed food products, but that can be provided at lower cost and/or with an improved nutritional profile. It is further advantageous for such processed food products to be optionally free of allergenic or animal-derived products to allow these products to appeal to a wider range of potential consumers, and to remain stable over extended periods to provide for a longer usable shelf life, for example by having lower activity or moisture content and/or by including a coating or

sealing layer to retain internal moisture and provide a substantially hermetic barrier while avoiding colonization by microbes, while still retaining a desired texture.

SUMMARY OF THE INVENTION

In one aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution; (b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c) treating the plurality of filamentous fungal pieces to form the food product. Steps (a) and (b) may be performed simultaneously or sequentially in any order.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of between about zero and about 101.325 kilopascals, or no more than about 0.1 pascals.

In embodiments, step (a) may be carried out under a reduced-oxygen and/or nitrogen-enriched atmosphere.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb or otherwise take up an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the total (*i.e.*, "wet" or prior to dehydration/removal of water) weight of the filamentous fungal biomass.

In embodiments, step (a) may comprise contacting at least two filamentous fungal biomasses with the solution; the method may further comprise, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate; and step (b) may comprise size-reducing the filamentous fungal aggregate. The aggregate may, but need not, comprise a casing that encases the at least two filamentous fungal biomasses. The aggregating step may, but need not, be carried out under sub-atmospheric pressure, which may, but need not, be a pressure of no more than about 0.1

pascals. The aggregating step may, but need not, comprise crust-freezing the at least two filamentous fungal biomasses.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, step (c) may comprise at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution; and (b) dehydrating the filamentous fungal biomass.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb or otherwise take up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a first filamentous fungal biomass, or portion thereof, with a first solution; (b) size-reducing the first filamentous fungal biomass, or portion thereof, to form a plurality of filamentous fungal pieces; (c) contacting a second filamentous fungal biomass, or portion thereof, with a second solution; (d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass, or portion thereof; and (e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass, or portion thereof, to form the food product.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, at least one of the first and second solutions may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, at least one of the following may be true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass, or portion thereof, prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass, or portion thereof, prior to step (c).

In embodiments, at least one of step (a) and step (c) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, at least one of the following may be true: (i) step (a) comprises the sub-step of removing water from the first filamentous fungal biomass, or portion thereof; and (ii) step (c) comprises the sub-step of removing water from the second filamentous fungal biomass, or portion thereof.

In embodiments, at least one of the following may be true: (i) step (a) is carried out by agitating the first filamentous fungal biomass, or portion thereof, together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass, or portion thereof, together with the second solution.

In embodiments, at least one of the following may be true: (i) the first filamentous fungal biomass, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%,

at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

In embodiments, at least one of the first and second solutions may be an aqueous solution.

In embodiments, at least one of the first and second solutions may be a non-aqueous solution.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as described herein.

In embodiments, the meat jerky analog food product may have a water activity of between about 0.35 and about 0.85, or less than about 0.45.

In embodiments, the meat jerky analog food product may have a shelf life of at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

In another aspect of the present invention, an intermediate food composition comprises a filamentous fungal biomass or a portion thereof; and a solution, absorbed or otherwise taken up by the filamentous fungal biomass or portion thereof.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass or portion thereof.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution comprising a food additive; (b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive, wherein steps (a) and (b) are carried out simultaneously or sequentially in any order.

In embodiments, the food additive may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a total mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may be carried out under super-atmospheric pressure.

In embodiments, step (a) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F.

In embodiments, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass may be no more than about 34 °F.

In embodiments, the method may further comprise, prior to step (a), removing water from the filamentous fungal biomass.

In embodiments, step (a) may comprise agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomass.

In embodiments, step (a) may comprise contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate, and wherein step (b) comprises size-reducing the filamentous fungal aggregate. The step of aggregating may, but need not, comprise encasing the at least two filamentous fungal biomasses in a casing. The aggregating step may, but need not, be carried out under sub-atmospheric pressure, which may, but need not, be a pressure of no more than about 0.1 pascals. The aggregating step may, but need not, comprise crust-freezing the at least two filamentous fungal biomasses.

In embodiments, the method may further comprise, between steps (a) and (b), crust freezing the filamentous fungal biomass. An internal temperature of the filamentous fungal biomass after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, step (c) may comprise at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in or on a fermentation medium or on a membrane associated with a fermentation medium; and inactivating the filamentous fungal biomass. The fermentation method may, but need not, be selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, and an air-medium colloid (AMC) fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat analog food product is made according to a method as described herein.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomass with a solution comprising a food additive; and (b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F.

In embodiments, step (a) may be carried out at a temperature above room temperature.

In embodiments, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass may be no more than about 34 °F.

In embodiments, the method may further comprise, prior to step (a), removing water from the filamentous fungal biomass.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomass together with the solution.

In embodiments, the filamentous fungal biomass may absorb at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the filamentous fungal biomass. The fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least

about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as disclosed herein.

In another aspect of the present invention, a meat analog food product comprises filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true: (i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product; (ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food

product; and (iii) a sugar content of the meat analog food product is no more than about 10 wt%.

In embodiments, the meat analog food product may have a shelf life of at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

In embodiments, the meat analog food product may have a water activity of between about 0.35 and about 0.85.

In embodiments, the meat analog food product may have a water activity of no more than about 0.45.

In embodiments, the meat analog food product may comprise less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per 28 grams of food product.

In embodiments, at least one of the following may be true: (i) the meat analog food product comprises no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food product; and (ii) a sugar content of the meat analog food product is no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least

about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the meat analog food product may comprise all nine essential amino acids.

In embodiments, the meat analog food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the meat analog food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the meat analog food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the meat analog food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the meat analog food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a first filamentous fungal biomass with a first solution; (b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces; (c) contacting a second filamentous fungal biomass with a second solution; (d) combining the plurality of filamentous fungal pieces and the second filamentous fungal

biomass; and (e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, at least one of the first and second solutions may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, at least one of the following may be true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass prior to step (c).

In embodiments, at least one of step (a) and step (c) is carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, at least one of step (a) and step (c) may be carried out at a temperature below room temperature. The temperature below room temperature may, but need not, be no more than about 40 °F. During at least part of a duration of step (a), a temperature of at least one of the first filamentous fungal biomass and the second filamentous fungal biomass may, but need not, be no more than about 34 °F.

In embodiments, at least one of step (a) and step (c) may be carried out at a temperature above room temperature.

In embodiments, the method may further comprise at least one of: (i) prior to step (a), removing water from the first filamentous fungal biomass; and (ii) prior to step (c), removing water from the second filamentous fungal biomass.

In embodiments, at least one of the following may be true: (i) step (a) is carried out by agitating the first filamentous fungal biomass together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass together with the second solution.

In embodiments, at least one of the following may be true: (i) the first filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass absorbs least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

In embodiments, the method may further comprise at least one of (i) between steps (a) and (b), crust freezing the first filamentous fungal biomass, and (ii) between steps (c)

and (d), crust freezing the second filamentous fungal biomass. An internal temperature of the first filamentous fungal biomass when (i) is true, or an internal temperature of the second filamentous fungal biomass when (ii) is true, after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, at least one of the first and second solutions may be an aqueous solution.

In embodiments, at least one of the first and second solutions may be a non-aqueous solution.

In embodiments, the method may further comprise, prior to at least one of steps (a) and (c), forming at least one of the filamentous fungal biomass and the second filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the at least one of the first filamentous fungal biomass and the second filamentous fungal biomass. The fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by at least one of dehydrating the filamentous fungal biomass, freezing the filamentous fungal biomass, pressure treating the filamentous fungal biomass, rinsing the filamentous fungal biomass, size reducing the filamentous fungal biomass, steaming the filamentous fungal biomass, and temperature cycling the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, at least one of the filamentous fungal biomass and the second filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, at least one of the first filamentous fungal biomass and the second filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as disclosed herein.

In another aspect of the present invention, an intermediate food composition comprises a filamentous fungal biomass; and a solution comprising a food additive, absorbed by the filamentous fungal biomass.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomass.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In embodiments, the filamentous fungal biomass may be derived from a fermentation method selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid (AMC) fermentation method, and combinations thereof.

In embodiments, the filamentous fungal biomass is inactivated.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In another aspect of the present invention, a method for preparing a food product comprises (a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive; (b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; and (c)removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive.

In embodiments, in step (a), the filamentous fungal biomass may be exposed to an absolute pressure of no more than about 0.1 pascals.

In embodiments, following step (a), the filamentous fungal biomass may have an approximately cylindrical shape.

In embodiments, the method may further comprise, between steps (a) and (b), crust freezing the filamentous fungal biomass. An internal temperature of the filamentous fungal biomass after the crust freezing step may, but need not, be between about 25 °F and about 27 °F. The crust freezing step may, but need not, be carried out by placing the filamentous fungal biomass in a blast freezer.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomass. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomass.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, the method may further comprise, prior to step (a), forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and inactivating the filamentous fungal biomass. The

fermentation method may, but need not, be a surface fermentation method. The inactivating step may, but need not, be carried out by steaming the filamentous fungal biomass.

In embodiments, the food product may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

In embodiments, the food product may comprise all nine essential amino acids.

In embodiments, the food product may comprise at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

In embodiments, the food product may comprise at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

In embodiments, the food product may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

In embodiments, the filamentous fungal biomass may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

In embodiments, the food product may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

In embodiments, the filamentous fungal biomass may comprise a filamentous fungal biomat or a portion thereof.

In embodiments, the food product may have a total protein content from about 10 wt% to about 25 wt%.

The advantages of the present invention will be apparent from the disclosure contained herein.

As used herein, "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B, and C," "at least one of A, B, or C," one or more of A, B, and C," "one or more of A, B, or C," and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B, and C together.

It is to be noted that the term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more," and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising," "including," and "having" can be used interchangeably.

As used herein, unless otherwise specified, the terms "about," "approximately," etc., when used in relation to numerical limitations or ranges, mean that the recited limitation or range may vary by up to 10%. By way of non-limiting example, "about 750" can mean as little as 675 or as much as 825, or any value therebetween. When used in relation to ratios or relationships between two or more numerical limitations or ranges, the terms "about," "approximately," etc. mean that each of the limitations or ranges may vary by up to 10%; by way of non-limiting example, a statement that two quantities are "approximately equal" can mean that a ratio between the two quantities is as little as 0.9:1.1 or as much as 1.1:0.9 (or any value therebetween), and a statement that a four-way ratio is "about 5:3:1:1" can mean that the first number in the ratio can be any value of at least 4.5 and no more than 5.5, the second number in the ratio can be any value of at least 2.7 and no more than 3.3, and so on.

The embodiments and configurations described herein are neither complete nor exhaustive. As will be appreciated, other embodiments of the invention are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B are flowcharts depicting embodiments of a method for processing filamentous fungal material into a food product or material for use in a food product, according to embodiments of the present disclosure.

Figures 2A and 2B are flowcharts depicting embodiments of a method for processing a filamentous fungal food material, derived from a fungal biomat and processed according to the method depicted in Figure 1A, into a meat jerky analog food product, according to embodiments of the present disclosure.

Figures 3A, 3B, and 3C are images of pieces of three jerky analog food products, according to embodiments of the present invention.

Figures 4A and 4B are microscopic images of a hydrophilic side of a jerky analog food product, according to embodiments of the present invention.

Figure 5A and 5B are microscopic images of a hydrophobic side and a hydrophilic side, respectively, of a jerky analog food product, according to embodiments of the present invention.

Figures 6A and 6B are images of fractured tensile strength testing specimens of jerky analog food products, according to embodiments of the present invention.

Figure 7 is a graph of tensile strength testing results of the specimens illustrated in Figures 6A and 6B.

DETAILED DESCRIPTION OF THE INVENTION

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art. If there is a plurality of definitions for a term herein, the definition provided in the Summary of the Invention prevails unless otherwise stated.

As used herein, unless otherwise specified, the term “analog” or “analog food product” refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to an identified non-fungal food product. By way of non-limiting example, a “meat analog food product,” as that term is used herein, refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to animal meat, and a “jerky food analog product,” as that term is used herein, refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to conventional jerky made from animal meats.

As used herein, the term "biomass," unless otherwise specified, refers to a mass of a living or formerly living organism. By way of non-limiting example, the phrase "filamentous fungal biomass" as used herein refers to a mass of a living or formerly living filamentous fungus. Filamentous fungal biomasses may include biomats (as that term is used herein), as well as filamentous fungus produced by submerged fermentation, such as (but not limited to) a mycoprotein paste as described in U.S. Patent 7,635,492 to Finnigan *et al.*.

As used herein, the term "biomat," unless otherwise specified, refers to a cohesive mass of filamentous fungal tissue comprising a network of interwoven hyphae filaments. Biomats as that term is used herein may, but need not, be characterized by one or more of a density of between about 50 and about 200 grams per liter, a solids content of between about 5 wt% and about 20 wt%, and sufficient tensile strength to be lifted substantially intact from the surface of a growth substrate (*e.g.*, a liquid growth medium, a solid fungal composite, or a solid membrane or mesh). Biomats, as that term is used herein, may be produced by any one or more fungal fermentation methods known in the art, such as, by way of non-limiting example, methods described in PCT Application Publications 2020/176758, 2019/099474, and 2018/014004.

As used herein, unless otherwise specified, the term "free water" refers to water molecules within a mass of material that are not chemically or physically hindered from being removed from the mass of material.

As used herein, unless otherwise specified, the term "inactivated" refers to a filamentous fungal biomass in which the fungal cells have been rendered nonviable, or enzymes capable of degrading or causing biochemical transformations within the biomass have been deactivated, or both. By extension, the term "inactivation" refers to any method or process by which a filamentous fungal biomass may be inactivated, such as, by way of non-limiting example, dehydration, freezing, pressure treatment, rinsing, size reduction, steaming, and temperature cycling.

As used herein, unless otherwise specified, the term "physically bound water" refers to water molecules within a mass of material that are in physical contact with molecules of the material but are not chemically bound to the material.

As used herein, unless otherwise specified, the term "tightly bound water" refers to water molecules within a mass of material that are chemically bound by intermolecular forces, e.g. hydrogen bonding, ionic bonding, ion-dipole forces, van der Waals forces, etc., to molecules of the material.

As used herein, unless otherwise specified, the term "vegan" refers to a food product that is substantially free of food components or ingredients, such as protein, derived from animals. Specific examples of non-vegan food ingredients or products include blood, eggs, isinglass, meat (and components thereof, e.g. animal proteins or fats), milk, rennet, and foods made using any one or more of these ingredients (e.g. ice cream, mayonnaise, etc.). As disclosed herein, some vegan food products may be analogs of non-vegan food products.

As used herein, unless otherwise specified, the term "vegetarian" refers to a food product that is substantially free of meat and components thereof. "Vegetarian" food products, as that term is used herein, may (but need not) include food components or ingredients other than meat that are derived from animals (e.g. eggs, milk, etc.). Thus, as the terms are used herein, all "vegan" food products are "vegetarian," but not all "vegetarian" food products are necessarily "vegan."

Embodiments of the present invention include compositions comprising filamentous fungi, typically compositions comprising edible filamentous fungi, and most typically filamentous fungal food compositions, i.e. edible filamentous fungal compositions that are adapted for consumption by humans or domesticated, farmed (e.g. agriculture or aquaculture), or livestock animals, that include filamentous fungal biomass. In some embodiments, the filamentous fungal food composition may be a food product that is analogous to a conventional or known food product comprising meat or another animal-derived ingredient, wherein the filamentous fungal biomass is provided in addition to or in lieu of the animal-derived ingredient. In embodiments, the filamentous fungal food composition of the present invention may be an analog of a meat product, such as, by way of non-limiting example, whole cuts of meat, ground meat (and products formed therefrom, e.g. meatballs), meatloaves, burger patties, shredded meat, jerky, and so on.

Embodiments of the present invention include food products prepared from a food composition comprising filamentous fungal biomass and a solution, commonly but not always an aqueous solution, comprising one or more food additives, such as, by way of non-limiting examples, salt, flavorings, vitamins, and nutritional components (e.g. carbohydrates, fats, proteins, etc.), in which the solution comprises about 5 wt%, about 10 wt%, about 15 wt%, about 20 wt%, about 25 wt%, about 30 wt%, about 35 wt%, about 40 wt%, about 45 wt%, or about 50 wt%, or alternatively in any range between 5 wt% and 50 wt%, or in any range from any whole number percentage by weight between 5 wt% and 50 wt% to any other whole number percentage by weight between 5 wt% and 50 wt% of the total food composition. One significant advantage and benefit of the present invention is

that the filamentous fungal biomass present in the food compositions of the invention may have significantly greater ability to absorb or otherwise take up a solution, e.g. a "marinade" or similar solution applied to the fungal biomass to achieve a seasoning, flavoring, and/or nutritional objective and/or to define a textural property (e.g. chewiness, elasticity, mechanical behavior characteristics such as tendency to rip or tear, etc.), than conventional meat ingredients; without wishing to be bound by any theory, the present inventors hypothesize that this effect is due to differences between the mycelial structure of a filamentous fungal biomat and the myofibrillar structure of meat, in that the mycelial structure is more amenable to changes in the ratio of bound water to unbound water (and thus to reabsorption of the marinade) than meat. Because the filamentous fungal biomass itself may have a moisture content of as much as 80 wt%, higher than most whole cuts of meat, even before a solution is applied thereto, the water content of food compositions, and particularly meat analog food products, of the invention may be advantageously high. Embodiments of the present invention further include methods of forming a food composition comprising filamentous fungal biomass and a solution as described above (e.g. by contacting filamentous fungal biomass with the solution and allowing the filamentous fungal biomass to absorb or otherwise take up the solution), and food compositions made by such methods. It is to be expressly understood that "food compositions," as that term is used herein unless otherwise specified, of the present invention may be "final" food compositions (i.e. compositions that are intended to be consumed by a human or a domesticated, farmed, or livestock animal without further processing) or "intermediate" food compositions (i.e. compositions that are intended to be further processed and consumed by a human or a domesticated, farmed, or livestock animal only after further processing). Processing steps by which "intermediate" food compositions may become "final" food compositions according to the present invention include, but are by no means limited to, dehydration.

In embodiments, the filamentous fungal biomass may have a moisture content of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. In some embodiments, very little or none of the moisture present in the filamentous fungal biomass may be free water, or, in other words, the filamentous fungal biomass may have a total content of physically bound water and tightly bound water of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. Without wishing to be bound by any particular theory, it is believed that the ability of the filamentous fungal

food compositions of the invention to absorb or otherwise take up a solution is related primarily to the content of physically bound and tightly bound water and not necessarily to the total moisture content.; particularly, free water may be more easily removed during dehydration and replaced by a marinade or other liquid solution than bound water Thus, even high-moisture filamentous fungal biomass may suitably be used in filamentous fungal food compositions of the invention and may absorb or take up a solution in significant quantities, so long as the proportion of moisture that is present as free water is relatively low. In some embodiments, therefore, methods of the present disclosure may include a step of treating a filamentous fungal biomass to remove at least a portion of the free water therefrom to increase the biomass' capacity for taking up a liquid solution in a subsequent treatment step; such a step may result in a longer shelf life for the resulting food product, as the present inventors hypothesize, without wishing to be bound by any particular theory, that shelf life correlates with the proportion of moisture initially present as bound water due to stabilization within the hyphal structure.

One particular advantage and benefit of the methods and compositions of the present invention is that food compositions according to the invention may have advantageously high shelf stability, or, in other words, an advantageously long shelf life, especially as compared to conventional food products to which the filamentous fungal food compositions may be analogous (e.g. meat products), while reducing, or in some embodiments even eliminating, the use of preservatives, stabilizers, and/or mold inhibitors (*e.g.*, potassium sorbate) that may adversely affect the aesthetic or nutritional properties of the food product; in some embodiments, the food product may be substantially free of preservatives, stabilizers, and/or mold inhibitors (i.e., a component added to a food product that, in the quantity added, can materially affect the shelf life of the product), and/or methods for making the food product may not include any step of adding a preservative, stabilizer, and/or mold inhibitor. Without wishing to be bound by any particular theory, this advantage and benefit may be, in at least some embodiments, a result of either or both of (1) control over the moisture content of the filamentous fungal biomass enabled by the methods of the invention, particularly, the ability to remove as much or as little of the free water within the filamentous fungal biomass (and optionally to replace the removed free water with other chemistries) as desired, and (2) inactivation of enzymes and secondary metabolites in the filamentous fungal biomass. By way of non-limiting example, conventional meat jerky products are extremely shelf-stable and may, under ambient conditions, have a shelf life of many months, but achieve this stability only by including significant quantities of salt and/or

sugar, which act as plasticizers and/or stabilizers for the jerky product. Additions of salt and sugar, however, have well-known nutritional drawbacks. The filamentous fungal food compositions of the present invention can overcome this drawback in any one of several ways, for example by substituting salt for sugar as a stabilizer (which may in embodiments result in a more acceptable nutritional profile), by using stabilizers in lesser amounts than analogous conventional food products, or by virtue of having a lower fat content (or other nutritional advantage) relative to true meat. In embodiments, food compositions of the present invention comprise filamentous fungal biomass and one or more food additives (e.g. salt, flavorings, vitamins, added carbohydrates, added fats, added proteins, etc.) and have a shelf life of at least about one week, at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months. In addition or alternatively, such embodiments can include food compositions including no more than 15 grams, no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food composition, and/or a sugar content of no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%. Particularly, food compositions of the present invention may have an “elastic” or “chewy” consistency and texture, and/or a “juiciness” or perceived amount or extent of moisture, analogous to conventional meat jerky products, while still possessing both an advantageously long shelf life and an advantageously low sugar content. These advantageously long shelf lives may, in embodiments, be a consequence of a low water activity, e.g. a water activity of less than about 0.95, less than about 0.90, less than about 0.85, less than about 0.80, less than about 0.75, less than about 0.70, less than about 0.65, less than about 0.60, less than about 0.55, less than about 0.50, less than about 0.45, less than about 0.40, less than about 0.35, less than about 0.30, less than about 0.25, less than about 0.20, less than about 0.15, less than about 0.10, or less than about 0.05.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavoring ingredients added to the filamentous fungal biomass may be enhanced relative to their perceptibility in both analogous conventional meat and dairy products and current vegan or vegetarian meat analog or dairy analog products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when salt is added to filamentous fungal biomass to form a food composition of the present invention, the resulting food composition is subjectively much "saltier" (i.e. has a greater gustatory perception of salt flavor) than a conventional meat product containing the same concentration of salt. Without wishing to be bound by any particular theory, it is believed that this result may be due to a lower fat content in filamentous fungal biomass than in meat (as fat may dull the perceptibility of salt in a food product) and/or due to the inherently "mild" or "neutral" flavor of filamentous fungal biomass compared to many types of meat. Regardless of the mechanism, however, this advantageous result allows flavoring additives to be used in lower quantities in the food compositions of the present invention than in conventional food products to which they may be analogous. In embodiments, filamentous fungal food compositions of the present invention may have a perceived saltiness comparable to a conventional meat product while including less than about 200 milligrams, less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per serving.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavors imparted to the food compositions due to a cooking or preparation process may be enhanced relative to their perceptibility in analogous conventional food products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when filamentous fungal biomass is smoked to form a smoked food composition of the present invention, the resulting food composition is subjectively much "smokier" (i.e. has a greater gustatory perception of smoke flavor) than a conventional meat product smoked in the same way, which may allow for a given perception of "smokiness" or smoky flavor to be achieved with lower quantities of smoke and/or shorter smoking times. Without wishing to be bound by any particular theory, it is believed that this result may be a result of any one or more of of (1) the use of porous filamentous fungal material, e.g. a filamentous fungal biomat, to allow molecules present in

smoke, marinades, etc. to travel through the fungal material and adhere to surfaces thereof, and/or (2) the filamentous fungal biomass absorbing or otherwise taking up smoke or components thereof (e.g. phenols, such as syringol, guaiacol, and pyrocatechol, and alkyl derivatives thereof) during the smoking process, which may in turn be due to a lower water content in the filamentous fungal biomass (whether inherently or as a result of a drying/dehydration process prior to smoking) making the filamentous fungal biomass more amenable to absorption of hydrophobic compounds in smoke than high-moisture cuts of meat, and/or (3) the strong umami or savory flavor response of the filamentous fungus itself. It may also be the case that, because filamentous fungal biomass has a lower fat content than meat, molecules present in smoke, marinades, etc. that impart flavor may adhere to, become entrenched in, or otherwise become present in the food composition in different locations or by different mechanisms. Regardless of the mechanism, however, this advantageous result allows filamentous fungal biomass in the food compositions of the present invention to be smoked or otherwise prepared for shorter times, at lesser intensity, with lesser environmental impact, etc. than in conventional food products to which they may be analogous, and/or for the food compositions of the present invention to have an enhanced, heightened, or intensified flavor relative to identically prepared conventional meat products. Further, filamentous fungal food compositions of the present invention may have a subjectively "smoky" flavor even when a fat content (which contributes to smoky flavor) of the food composition is much lower than that of an analogous meat product. In embodiments, filamentous fungal food compositions of the present invention may have a perceived smokiness comparable to a conventional smoked meat product while having a fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%. By comparison, smoked pork generally has a fat content of about 15 wt%, and beef brisket generally has a fat content of about 33 wt%.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the filamentous fungal biomass may be more readily processed into a desired physical form, and thus require a lower content, or may even allow the complete omission, of binders, fillers, or similar functional materials, compared to meat or other plant- or fungus-based meat analog materials. Particularly, the present inventors have

demonstrated that filamentous fungal biomass produced according to the present invention can be repeatedly frozen, thawed, dehydrated, rehydrated, etc. (as may be desirable for particular applications), and may in either fresh or frozen form (or both) be amenable to pressing, molding, or otherwise shaping into a desired physical configuration without the addition of any binder. In embodiments, filamentous fungal food compositions of the present invention, and in embodiments, meat analog filamentous fungal food compositions, may comprise at least about 50 wt%, at least about 60 wt%, at least about 70 wt%, at least about 80 wt%, at least about 90 wt%, at least about 91 wt%, at least about 92 wt%, at least about 93 wt%, at least about 94 wt%, or at least about 95 wt% fungal biomass, and/or may comprise no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, or no more than about 5 wt% of binders and fillers (which include similar functional materials). In some embodiments, the filamentous fungal food compositions of the present invention are substantially free of binders and fillers. This feature may be particularly advantageous where the filamentous fungal food composition is a meat analog food product, in which the total content of ingredients other than fungal biomass must be minimized.

Filamentous fungal food compositions according to the present invention may comprise any one or more forms or types of filamentous fungal biomass. By way of non-limiting example, forms or types of filamentous fungal biomass suitable for use in the food compositions of the present invention include, but are not limited to, processed biomats, fungal paste formed from biomats, unprocessed or "raw" biomats, and combinations and mixtures of these. By way of further non-limiting example, filamentous fungal biomass suitable for use in the food compositions of the present invention may be produced, instead of or in addition to surface fermentation processes that yield fungal biomats, any one or more other methods, e.g. a submerged fermentation process yielding a fungal paste, etc.; in some embodiments, it is also possible to combine forms or types of filamentous fungal biomass produced by two or more different processes, e.g. any two or more of a liquid surface fermentation process, a solid surface fermentation process, an air-medium colloid fermentation process, a submerged fermentation process, etc. The ability to incorporate any of several forms or types of filamentous fungal biomass is therefore another advantage and benefit of the compositions and methods of the present invention.

Filamentous fungal food compositions according to the present invention may, in embodiments, comprise a highly dense fungal biomass, and in some embodiments a highly dense fungal biomat or portion thereof. Depending on the fungus and growth conditions, the

filamentous fungal biomass may also exhibit a fibrous texture, which is an important consideration when producing food compositions that require texture to simulate meat (i.e. a meat analog food product); in some embodiments, the fibrous structure of the biomass may be engineered or oriented to provide a material (and thus, in some cases, a food composition or product) that is relatively difficult or relatively easy to tear, or has selected portions that are relatively difficult or relatively easy to tear. The dense nature of the biomass can also enable easy harvesting, without the need for a concentration step (e.g., centrifugation, filtration) between harvesting of the biomass and processing into a food composition. The density of the biomass can range from about 0.01 g dry weight/cm^3 to about 1 g/cm^3, and any subrange within this range. In some embodiments, the density can be greater than about 0.01, greater than about 0.02, greater than about 0.03, greater than about 0.04, greater than about 0.05, greater than about 0.06, greater than about 0.07, greater than about 0.08, greater than about 0.09, greater than about 0.1, greater than about 0.2, greater than about 0.3, greater than about 0.4, greater than about 0.5, greater than about 0.6, greater than about 0.7, greater than about 0.8, greater than about 0.9, or greater than about 1 g/cm^3. In some embodiments, relatively dry fungal biomass may be ground or otherwise size-reduced into relatively fine particles, e.g. a filamentous fungal "flour," before being incorporated into the food composition of the invention; in these embodiments, densities in the above-referenced ranges or even higher may be achieved due to the packing density of the dry fungal flour. In other embodiments, fungal biomass may be ground or otherwise size-reduced into somewhat coarser particles (*e.g.*, in which at least 90% of the particles have a length of between about 4 mm and about 10 mm, and/or a width of between about 1 mm and about 3 mm, and/or a height of up to about 0.75 mm), as is more typical of ground or processed meat.

Another advantage and benefit of the methods of manufacture of filamentous fungal food compositions according to the present invention is that material and/or mechanical properties of the filamentous fungal biomass as it is produced (e.g. in the form of a fungal biomat) may be preserved, or even enhanced, during processing into the filamentous fungal food composition. By way of first non-limiting example, the methods of manufacture disclosed herein may preserve or enhance a filamentous structure or network of a filamentous fungal biomat used to produce the food composition, which may be advantageous, for example, to maintain a high internal surface area suitable for absorption or other uptake of, e.g., flavoring or nutritional additives, smoke, food colorings, etc. By way of second non-limiting example, the methods of manufacture disclosed herein may

preserve or enhance the tensile strength of a filamentous fungal biomat used to produce the food composition. In embodiments, the filamentous fungal food composition, or a portion thereof comprising filamentous fungal biomass, may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, or at least about 600 g/cm^2, or at least about 650 g/cm^2, or at least about 700 g/cm^2, or at least about 750 g/cm^2, or at least about 800 g/cm^2, or at least about 850 g/cm^2, or at least about 900 g/cm^2, or at least about 950 g/cm^2, or at least about 1000 g/cm^2, or at least about 1500 g/cm^2, or at least about 2000 g/cm^2, or at least about 2500 g/cm^2, or at least about 3000 g/cm^2, or at least about 3500 g/cm^2, or at least about 4000 g/cm^2. In other embodiments, biomass of the invention (e.g. a fungal biomat) can have a tensile strength of greater than any whole number greater than 30 g/cm^2. Alternatively, the tensile strength of biomass of the invention (e.g. a fungal biomat) can be in a range of between about 30 g/cm^2 and about 4000 g/cm^2 or any whole number range between about 30 g/cm^2 and about 4000 g/cm^2. In embodiments in which the filamentous fungal biomass is produced as a biomat, the biomat may have sufficient tensile strength to be lifted essentially intact from the surface of a growth medium at the end of a growth period.

In many embodiments, the filamentous fungal biomass of the food composition will provide a substantial fraction of the protein in the food composition. Particularly, the filamentous fungal biomass may provide at least about 20 wt%, at least about 25 wt%, at least about 30 wt%, at least about 35 wt%, at least about 40 wt%, at least about 45 wt%, 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, at least about 75 wt%, at least about 80 wt%, at least about 85 wt%, at least about 90 wt%, at least about 95 wt%, at least about 96 wt%, at least about 97 wt%, at least about 98 wt%, at least about 99 wt%, or substantially all of the protein in the food composition. In some embodiments, the protein content of the filamentous fungal biomass may allow the filamentous fungal biomass to take the place of a protein-rich ingredient found in an analogous conventional food product, particularly an animal-derived ingredient (e.g. meat), whereas in other embodiments the filamentous fungal biomass may be provided in addition to or as a partial replacement for a protein-rich ingredient to augment the protein content of the food product. The filamentous fungal biomass may comprise at least about 20 wt%, at

least about 21 wt%, at least about 22 wt%, at least about 23 wt%, at least about 24 wt%, at least about 25 wt%, at least about 26 wt%, at least about 27 wt%, at least about 28 wt%, at least about 29 wt%, at least about 30 wt%, at least about 31 wt%, at least about 32 wt%, at least about 33 wt%, at least about 34 wt%, at least about 35 wt%, at least about 36 wt%, at least about 37 wt%, at least about 38 wt%, at least about 39 wt%, at least about 40 wt%, at least about 41 wt%, at least about 42 wt%, at least about 43 wt%, at least about 44 wt%, at least about 45 wt%, at least about 46 wt%, at least about 47 wt%, at least about 48 wt%, at least about 49 wt%, at least about 50 wt%, at least about 51 wt%, at least about 52 wt%, at least about 53 wt%, at least about 54 wt%, at least about 55 wt%, at least about 56 wt%, at least about 57 wt%, at least about 58 wt%, at least about 59 wt%, at least about 60 wt%, at least about 61 wt%, at least about 62 wt%, at least about 63 wt%, at least about 64 wt%, at least about 65 wt%, at least about 66 wt%, at least about 67 wt%, at least about 68 wt%, at least about 69 wt%, at least about 70 wt%, at least about 71 wt%, at least about 72 wt%, at least about 73 wt%, at least about 74 wt%, at least about 77 wt%, at least about 76 wt%, at least about 77 wt%, at least about 78 wt%, at least about 79 wt%, or at least about 80 wt% protein content. Alternatively, in embodiments of the invention, filamentous fungi can comprise protein in a range between 20 wt% and 80 wt% or in any whole number percentage range between 20 wt% and 80 wt%. As a result, the filamentous fungal food compositions of the present invention may thus have a notably high or enriched protein and/or fiber content. Thus, on a dry weight basis (or, in other words, at the same moisture content), the food compositions of the invention may be higher in protein than analogous conventional food products, and/or, by the same token, the food compositions of the invention may provide the same protein content as an analogous conventional food product in a smaller mass and/or serving size.

In some embodiments, food compositions and products according to the present disclosure may comprise at least about 10 wt%, at least about 11 wt%, at least about 12 wt%, at least about 13 wt%, at least about 14 wt%, at least about 15 wt%, at least about 16 wt%, at least about 17 wt%, at least about 18 wt%, at least about 19 wt%, at least about 20 wt%, at least about 21 wt%, at least about 22 wt%, at least about 23 wt%, at least about 24 wt%, or at least about 25 wt% protein content. Alternatively, in embodiments, food compositions and products according to the present disclosure can comprise protein in a range between 10 wt% and 25 wt% or in any whole number percentage range between 10 wt% and 25 wt%. As a result, the filamentous fungal food compositions of the present invention may thus have a notably high or enriched protein and/or fiber content. Thus, on a

dry weight basis (or, in other words, at the same moisture content), the food compositions of the present disclosure may be higher in protein than analogous conventional food products, and/or, by the same token, the food compositions of the present disclosure may provide the same protein content as an analogous conventional food product in a smaller mass and/or serving size.

In addition to having a high overall protein content, filamentous fungal biomass in food compositions of the present invention may provide advantageous protein compositions or chemistries. By way of first non-limiting example, the filamentous fungal biomass may represent a "complete" protein source by providing all nine essential amino acids. By way of second non-limiting example, the filamentous fungal biomass may comprise at least one branched-chain amino acid (e.g. leucine, isoleucine, valine), and may in some embodiments contain such amino acids in amounts of at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may be lower in fat than analogous conventional food products. Particularly, the filamentous fungal food compositions of the present invention may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the filamentous fungi may be produced by methods that enable the filamentous fungi to contain functional compounds that may not be present in, or cannot be delivered by, conventional food products. By way of first non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more beneficial nutrients or compounds (vitamins, lipids, glycolipids, polysaccharides, sugar alcohols, ω-3 fatty acids, etc.) that may be taken up by the fungus and thus passed on to the consumer of the food composition. By way of second non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more compounds (e.g. pigments, inks, dyes, fragrances, etc.) that may be taken up by the fungus and improve an aesthetic or sensory quality of the filamentous fungus.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the compositions may be free of allergens, antibiotics, and/or animal-derived products that may otherwise prevent persons with allergenic sensitivities or dietary restrictions (e.g. vegans or vegetarians) from consuming analogous conventional food products. By way of non-limiting example, analogs of a wide variety of conventional meat products (e.g. smoked meat products, meat jerky, etc.) that are meat-free, that are optionally also lactose-free, egg-free, soy-free, and/or dairy-free, and/or that are further optionally vegan, may be produced according to the present invention. Even more advantageously, these problematic ingredients can in some embodiments be replaced by components having nutritional benefits, e.g. red meat may be replaced by fungal filaments or mycelia (i.e. tissues not having the potential adverse effects on cardiovascular health presented by red meat).

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may have an advantageously high content of dietary fiber to allow for the creation of high-fiber food products (and in particular high-fiber alternatives to or analogs of conventional food products, particularly conventional meat products, that may have lower fiber contents). In some embodiments, the filamentous fungal particles may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber. Additionally or alternatively, the food composition may have a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition. A high fiber content may be advantageous for any one or more additional reasons not directly related to nutritional composition, e.g. improved hydration properties (such as decreased water activity to allow for easier preparation/storage and longer shelf life), increased satiation or "fullness" upon eating (which may encourage consumers to eat more moderate portions and thereby aid in preventing or mitigating adverse health effects such as high cholesterol), improved digestibility, improved digestion and/or prevention of constipation, etc. Particularly, increased satiation or "fullness" may allow consumers to consume fewer total calories and thereby aid, for example, a dieting consumer in losing weight. The filamentous fungal food compositions of the invention may therefore be particularly suitable or

advantageous for inclusion in known and/or commercially available weight loss diets or regimens.

In embodiments of the present invention, methods for preparing a filamentous fungal food composition comprise dehydrating a filamentous fungal biomass, in some embodiments a fungal biomat, at relatively low temperature, e.g. no more than about 185 °F and most typically no more than about 165 °F, over a period of, e.g., between about 20 minutes and about 12 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydration of the filamentous fungal biomass, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal biomass while otherwise retaining the fungal material's basic structure. A moisture content of the filamentous fungal biomass after the dehydration step may be no more than about 45 wt%, no more than about 44 wt%, no more than about 43 wt%, no more than about 42 wt%, no more than about 41 wt%, no more than about 40 wt%, no more than about 39 wt%, no more than about 38 wt%, no more than about 37 wt%, no more than about 36 wt%, no more than about 35 wt%, no more than about 34 wt%, no more than about 33 wt%, no more than about 32 wt%, no more than about 31 wt%, no more than about 30 wt%, no more than about 29 wt%, no more than about 28 wt%, no more than about 27 wt%, no more than about 26 wt%, no more than about 25 wt%, no more than about 24 wt%, no more than about 23 wt%, no more than about 22 wt%, no more than about 21 wt%, no more than about 20 wt%, no more than about 19 wt%, no more than about 18 wt%, no more than about 17 wt%, no more than about 16 wt%, no more than about 15 wt%, no more than about 14 wt%, no more than about 13 wt%, no more than about 12 wt%, no more than about 11 wt%, no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%. Alternatively, a moisture content of the filamentous fungal biomass after the dehydration step can be any whole number range between 1 wt% and 45 wt%.

The filamentous fungi suitable for use in the invention may be selected from the phyla or divisions zygomycota, glomermycota, chytridiomycota, basidiomycota or ascomycota. The phylum (or division) basidiomycota comprises, *inter alia*, the orders Agaricales, Russulales, Polyporales and Ustilaginales; the phylum ascomycota comprises, *inter alia*, the orders Pezizales and Hypocreales; and the phylum zygomycota comprises,

inter alia, the order Mucorales. The edible filamentous fungi of the present invention may belong to an order selected from Ustilaginales, Russulales, Polyporales, Agaricales, Pezizales, Hypocreales and Mucorales.

In some embodiments, the filamentous fungi of the order Ustilaginales are selected from the family Ustilaginaceae. In some embodiments, the filamentous fungi of the order Russulales are selected from the family Hericiaceae. In some embodiments, the filamentous fungi of the order Polyporales are selected from the families Polyporaceae or Grifolaceae. In some embodiments, the filamentous fungi of the order Agaricales are selected from the families Lyophyllaceae, Strophariaceae, Lycoperdaceae, Agaricaceae, Pleurotaceae, Physalacriaceae, or Omphalotaceae. In some embodiments, the filamentous fungi of the order Pezizales are selected from the families Tuberaceae or Morchellaceae. In some embodiments, the filamentous fungi of the order Mucorales are selected from the family Mucoraceae.

In some embodiments, the filamentous fungi may be selected from the genera Fusarium, Aspergillus, Trichoderma, Rhizopus, Ustilago, Hericululm, Polyporous, Grifola, Hypsizygus, Calocybe, Pholiota, Calvatia, Stropharia, Agaricus, Hypholoma, Pleurotus, Morchella, Sparassis, Disciotis, Cordyceps, Ganoderma, Flammulina, Lentinula, Ophiocordyceps, Trametes, Ceriporia, Leucoagaricus, Handkea, Monascus and Neurospora.

Examples of the species of filamentous fungi include, without limitation, Ustilago esculenta, Hericululm erinaceus, Polyporous squamosus, Grifola fondrosa, Hypsizygus marmoreus, Hypsizygus ulmariuos (elm oyster) Calocybe gambosa, Pholiota nameko, Calvatia gigantea, Agaricus bisporus, Stropharia rugosoannulata, Hypholoma lateritium, Pleurotus eryngii, Pleurotus ostreatus (pearl), Pleurotus ostreatus var. columbinus (Blue oyster),Tuber borchii, Morchella esculenta, Morchella conica, Morchella importuna, Sparassis crispa (cauliflower), Fusarium venenatum, Fusarium strain *flavolapis* (ATCC Accession Deposit No. PTA-10698), Disciotis venosa, Cordyceps militaris, Ganoderma lucidum (reishi), Flammulina velutipes, Lentinula edodes, Ophiocordyceps sinensis. Additional examples include, without limitation, Trametes versicolor, Ceriporia lacerate, Pholiota gigantea, Leucoagaricus holosericeus, Pleurotus djamor, Calvatia fragilis, Handkea utriformis, Rhizopus oligosporus, and Neurospora crassa.

In some embodiments, the filamentous fungus is a Fusarium species. In some embodiments, the filamentous fungus is the Fusarium strain *flavolapis* (ATCC PTA-10698 deposited with the American Type Culture Collection, 1081 University Boulevard, Manassas, Virginia, USA). This strain, which has been referred to in some previous work

as strain MK7, was previously reported to be a *Fusarium oxysporum* strain. However, it has subsequently been identified as not being an *oxysporum* strain and is considered a novel strain of *Fusarium* that has now been provisionally named *Fusarium* str. *flavolapis*. In some embodiments, the filamentous fungus is the Fusarium strain *Fusarium venenatum*.

Fungal biomass from which the filamentous fungal material in food compositions of the invention is derived may be produced by any known fermentation processes, such as, e.g., submerged, solid-state, membrane, or surface fermentation processes as described in PCT Application Publications WO 2017/151684, WO 2019/046480, or WO 2020/176758 or PCT Application PCT/US2020/064208 (the entireties of all of which are incorporated herein by reference), and/or a method as disclosed in PCT Application Publication WO2019/099474.

In some embodiments, the filamentous fungal biomass may be in the form of one or more filamentous fungal biomats produced by a surface fermentation process. In certain of these embodiments, parameters of the surface fermentation process may be selected or controlled to provide a desired morphology or structure to the filamentous fungal biomat and thus to the resulting food composition. By way of first non-limiting example, the surface fermentation process may be controlled such that fungal mycelia are oriented predominantly parallel to an interface between a liquid fermentation medium and the atmosphere or headspace above the fermentation medium, thereby ensuring that the mycelia grow primarily in a single plane (which may provide desired textural or mechanical characteristics to the resulting food composition or a portion thereof). By way of second non-limiting example, trays or vessels in which a filamentous fungus is grown in a surface fermentation process may be substantially longer than they are wide (or vice versa) to provide a similar "oriented" structure of the fungal mycelia. By these and other methods, which will be appreciate by those of ordinary skill in the art, multiple biomats and/or layers of filamentous fungal biomass, having similar or different geometric orientations of mycelia, may be "stacked" or "weaved" to obtain a layered food composition having preselected textural or mechanical characteristics.

Food compositions, including but not necessarily limited to meat analog food products, according to the present invention may further include proteins, such as a hydrophobin. These are low molecular weight proteins, ranging from about 100 to 150 amino acids in length, and are amphipathic molecules that are capable of self-assembly at a hydrophobic-hydrophilic interface into amphipathic films. Various uses for hydrophobins have been described in the art, including as emulsifiers, thickeners, or surfactants; for

hydrophilizing hydrophobic surfaces; for improving the water stability of hydrophilic substrates; and for preparing oil-in-water emulsions or water-in-oil emulsions, and they have applications in pharmaceutical and cosmetic as well as food compositions. In food products, hydrophobins have been shown to impact the formation and stability of air bubbles, thus assisting in foamability and foam stabilization (for instance, hydrophobins provide foam volume stability and inhibition of coarsening of foods), inhibiting growth of ice crystals in frozen food products, and affecting agglomeration of fats, thus improving the texture, stability, and storage time of aerated and/or frozen food compositions.

Accordingly, some embodiments of the present invention may include a hydrophobin. Hydrophobins are generally classified into class I and class II; while class I hydrophobins are relatively insoluble, class II hydrophobins readily dissolve in a variety of solvents and therefore are generally preferred. Hydrophobins and like proteins have been identified in filamentous fungi and bacteria, and their sequences are described in the art. All of these proteins, including class I and class II hydrophobins, are encompassed by the present invention. Hydrophobins suitable for use in the present invention may be isolated from natural sources, or by recombinant means. In some embodiments, the hydrophobins may be added to the food compositions as purified proteins. In some embodiments, the hydrophobins may be expressed by the filamentous fungal species used in the food composition and thus supplied as part of the fungal biomass. In embodiments, filamentous fungal biomass used in food compositions and food products according to the present disclosure may include at least about 500 reads per kilobase of transcript per million mapped reads (RPKM), at least about 1,000 RPKM, at least about 1,500 RPKM, at least about 2,000 RPKM, at least about 2,500 RPKM, or at least about 3,000 RPKM of class I hydrophobins, and/or at least about 1 RPKM, at least about 2 RPKM, at least about 3 RPKM, at least about 4 RPKM, at least about 5 RPKM, at least about 6 RPKM, or at least about 7 RPKM of class II hydrophobins.

Referring now to Figure 1A, a first embodiment of a method 100 for making a meat analog food product, such as, by way of non-limiting example, a shredded meat analog food product, according to an embodiment of the present invention, is illustrated. As shown in Figure 1A, this embodiment of the method 100 comprises a biomass production step 110, an inactivation step 120, a refrigeration step 130, a solution preparation step 135, a vacuum agitation step 140, a vacuum shaping step 150, a crust freezing step 160, an optional size reduction step 170, and an optional post-processing step 180.

In the biomass production step 110 of the embodiment of the method 100 illustrated in Figure 1A, a biomass of filamentous fungus is produced by any suitable method as known and described in the art, such as, by way of non-limiting example, a surface fermentation method as described in PCT Application Publication 2020/176758.

In the inactivation step 120 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass produced in step 110 is inactivated, *e.g.*, by steaming. In some embodiments, the filamentous fungal biomass may be a filamentous fungal biomat or relatively large (e.g. about 3 to about 5 inches wide) pieces thereof; it is to be expressly understood that size reduction of the biomass, if carried out at this stage of the method 100, may be undertaken before, simultaneous with, and/or after inactivation step 120.

In the refrigeration step 130 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass is cooled to a temperature of no more than about 34 °F. The refrigeration step 130 ensures complete inactivation of the filamentous fungus and hardens (and thereby improves the workability) of the filamentous fungal biomass for downstream processing steps.

In the solution preparation step 135 of the embodiment of the method 100 illustrated in Figure 1A, one or more food additives (e.g. salt, seasonings, nutritional additions, etc.) are dissolved and/or suspended in water. Preferably, the solution prepared in solution preparation step 135 is provided below room temperature (e.g. at a temperature of about 40 °F); the solution may be cooled before, simultaneous with, or after addition of the food additive solutes to water. Solution preparation step 135 may be carried out before, simultaneous with, or after refrigeration step 130. In some embodiments, the solution prepared in solution preparation step 135 may comprise one or more proteins to provide the food product with a desired functionality and/or augment the total protein content of the food product.

It is to be expressly understood that, although not illustrated in Figure 1A or provided for in the embodiment of the method 100 depicted therein, the solution prepared in solution preparation step 135 need not always be aqueous, and/or may include one or more solvents in addition to water. By way of non-limiting example, such solvents may include cooking oils, an oleovitamin solution, and the like. Embodiments in which the solution prepared in solution preparation step 135 is non-aqueous are therefore expressly contemplated as within the scope of the present invention.

Although not illustrated in Figure 1A, it is to be expressly understood that in some embodiments, the fungal biomass, at any time after inactivation step 120 but before the beginning of vacuum agitation step 140, may be subjected to any one or more mechanical or texturizing treatments to provide the finished food product with a desired structure, texture, mouthfeel, etc. By way of non-limiting example, where it is desired to provide the finished food product with a "softer" or more "tender" mouthfeel, the fungal biomass may be tenderized using a multi-blade (*e.g.*, Jaccard-style or similar) meat tenderizer to sever and/or disentangle long filaments in the fungal biomass.

In the vacuum agitation step 140 of the embodiment of the method 100 illustrated in Figure 1A, the refrigerated filamentous fungal biomass produced in step 130 and the cold aqueous solution prepared in step 135 are placed together in a vacuum tumbler; most typically, vacuum agitation step 140 is a cold vacuum agitation step carried out under refrigeration (i.e. at a temperature of no more than about 40 °F), but vacuum agitation step 140 may alternatively be carried out at room temperature or under heating to above reoom temperature. The atmosphere in the vacuum tumbler is then evacuated to leave a low vacuum (i.e. an absolute pressure of between about 3 kilopascals and about 100 kilopascals), a medium vacuum (i.e. an absolute pressure of between about 100 millipascals and about 3 kilopascals), a high vacuum (i.e. an absolute pressure of between about 100 nanopascals and about 100 millipascals), an ultra-high vacuum (i.e. an absolute pressure of between about 100 picopascals and about 100 nanopascals), or an extremely high vacuum (i.e. an absolute pressure of less than about 100 picopascals) in the tumbler. The filamentous fungal biomass and the aqueous solution are then agitated together to allow the aqueous solution to permeate the filamentous fungal biomass. Those skilled in the art will understand how to select appropriate agitation times, methods, and speeds; by way of non-limiting example, the vacuum tumbler may be a rotary tumbler, and the filamentous fungal biomass and aqueous solution may be rotated together at a speed of between about 7 RPM and about 10 RPM for a total time of about 40 minutes. It is to be expressly understood that the filamentous fungal biomass and aqueous solution may be agitated two or more times, with rest periods between periods of agitation (*e.g.*, two 20-minute agitation periods with a 10-minute rest period in between), as may be appreciated by those skilled in the art. As a result of vacuum agitation step 140, the filamentous fungal biomass will absorb or otherwise take up at least a portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass).

Where the filamentous fungal biomass is in the form of a biomat or relatively large pieces thereof, the sub-atmospheric pressure of vacuum agitation step 140 may affect any one or more of several physical properties of the biomat. By way of non-limiting example, exposure to this high-vacuum environment may enlarge spaces between fungal mycelia in the matrix of the biomat, increasing the available surface area of mycelia available for contact with the aqueous solution. This effect may, without wishing to be bound by any particular theory, explain the observation by the present inventors that filamentous fungal biomass agitated with an aqueous solution comprising salt in vacuum agitation step 140 tasted much saltier than expected; it is possible that increased mycelial surface area in contact with the salty aqueous solution allowed for a greater proportion of salt to be deposited on the surface of fungal mycelia, and/or increased the time required for the salt deposited on the surface of fungal mycelia to be transferred to the taste buds of the consumer upon consumption, and/or increases the surface area of the food product in contact with the taste-sensitive tissues in a consumer's mouth. In this way, it may be possible for filamentous fungal food compositions according to the present invention to have the further advantage and benefit of delivering a flavor to a consumer over a longer time.

In the vacuum shaping step 150 of the embodiment of the method 100 illustrated in Figure 1A, the filamentous fungal biomass, having absorbed or otherwise taken up at least some portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass), is placed in a cavity or mold, and the atmosphere surrounding the cavity or mold is evacuated to leave a high vacuum (i.e. an absolute pressure of no more than about 0.1 pascals). This allows the filamentous fungal biomass to be placed in a desired shape or other physical configuration, and/or to undergo various physical deformations or operations, and/or for one portion of the filamentous fungal biomass to have a first density and another portion of the filamentous fungal biomass to have a second density; by way of non-limiting example, where it is desired to produce a sausage analog food product, the filamentous fungal biomass may be stuffed into a casing. In many embodiments, it may be desirable to form the filamentous fungal biomass into a "log" or "rod," *i.e.*, an approximately cylindrical mass. The vacuum shaping step 150 may also affect the density of the filamentous fungal biomass and/or properties of a mycelial network thereof, which may, by way of non-limiting example, further increase mycelial surface area and/or permeability of the fungal biomass for application of further functional or nutritional additives. It is therefore to be expressly understood that the filamentous fungal biomass may,

but need not, be contacted with one or more flavorings or other functional or nutritional additives, whether in a solid, liquid, or gas form, as part of vacuum shaping step 150.

It is to be expressly understood that, in the practice of the embodiment of the method 100 illustrated in Figure 1A, vacuum agitation step 140 and vacuum shaping step 150 may be repeated as many times as necessary. Particularly, where it is desirable to coat or impregnate a functional coating or additive onto or into any one or more of (1) spaces between fungal filaments, e.g. pores in a fungal biomat, (2) the surfaces of fungal filaments, and/or (3) the interiors of fungal filaments, repeated vacuum agitation steps 140 and/or vacuum shaping steps 150 may be necessary to ensure complete absorption by, or coating or coverage of, the fungal mycelia.

Without wishing to be bound by any particular theory, it is believed that one functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum agitation step 140 and vacuum shaping step 150 is that these pressures cause the fungal biomass to expand, thereby increasing the volume of interstitial spaces between hyphae and other fungal structures. As a result, additives applied during these steps may more readily infiltrate these spaces. Subsequently, when the mat is once again exposed to ambient or atmospheric pressures, the fungal biomass contracts, thus causing the additive(s) present in the interstitial spaces to be firmly entrapped within the fungal biomass.

In the crust freezing step 160 of the embodiment of the method 100 illustrated in Figure 1A, the shaped filamentous fungal biomass is placed in a blast freezer and rapidly cooled (in some embodiments, at a rate of at least about 0.35 °C per minute), for example, to an internal temperature of between about 25 °F and about 27 °F. This temperature range has been found by the present inventors to provide optimum conditions for the processing steps of the method 100 that follow.

In the optional size reduction step 170 of the embodiment of the method 100 illustrated in Figure 1A, the blast-frozen filamentous fungal biomass is cut, shredded, and/or shaved into smaller pieces, which may in some embodiments be suitable for use as a shredded meat analog. Most typically, the strips, shreds, or shavings of filamentous fungal biomass will preferably have a thickness of between about 0.1 millimeters and about 10 millimeters, as this range is most analogous to conventional shredded meat products. Any size-reducing means, including but not necessarily limited to a gravity slicer or conventional deli meat slicer, may be used to carry out size reduction step 170.

In the optional post-processing step 180 of the embodiment of the method 100 illustrated in Figure 1A, the size-reduced filamentous fungal biomass may be subjected to

any one or more forms of post-processing analogous to those used to prepare smoked or cured meat products or similar. By way of first non-limiting example, the size-reduced filamentous fungal biomass may be vacuum-steamed (e.g. to an internal temperature of about 85 °C for a period of about 12 minutes) to form a steamed meat analog food product. By way of second non-limiting example, the size-reduced filamentous fungal biomass may be cold-smoked (e.g. for a period of about four hours at a temperature of about 90 °F) to form a cold-smoked meat analog food product. By way of third non-limiting example, the size-reduced filamentous fungal biomass may be hot-smoked (e.g. for a period of about two hours at a temperature of about 230 °F) to form a hot-smoked meat analog food product. By way of fourth non-limiting example, the size-reduced filamentous fungal biomass may cooked by any other suitable cooking technique, such as, *e.g.*, roasting, baking, boiling, and/or frying. In general, any form(s) of post-processing to which a raw whole cut of meat or raw shredded meat may be subjected can be applied, *mutatis mutandis*, to the size-reduced filamentous fungal biomass to form an analogous filamentous fungal food product. Post-processing step 180 may be carried out when the size-reduced filamentous fungal biomass is frozen, refrigerated, or at room temperature.

In some embodiments, size reduction step 170 and/or post-processing step 180 may comprise extruding a fungal paste into long strips. This extrusion step may be carried out by any suitable device or method and may be particularly suitable or advantageous, by way of non-limiting example, to provide a food composition having a desired cross-sectional shape (especially if the desired cross-sectional shape is intricate or complex), to prevent (or deliberately impart) a selected type of physical stress (e.g. compressive stress, shear stress, etc.) to the food composition, to improve a finished appearance of the food composition, and/or to create a food composition that is analogous in appearance or structure to a conventional food product that is ordinarily provided in thin or narrow strips (e.g. jerky, bacon, etc.). Additional or alternative thermal or mechanical manipulations may be employed as part of size reduction step 170 and/or post-processing step 180, such as non-extrusive shearing, heating (with or without simultaneous shearing, *e.g.*, to coagulate proteins and/or carbohydrates), freezing, thawing, etc.

Referring now to Figure 1B, a second embodiment of a method 100 for making a meat analog food product, such as, by way of non-limiting example, a shredded meat analog food product, according to an embodiment of the present invention, is illustrated. As shown in Figure 1B, this embodiment of the method 100 comprises a biomass production step 110,

an inactivation step 120, a vacuum shaping step 150, a crust freezing step 160, an optional size reduction step 170, and an optional post-processing step 180.

In the biomass production step 110 of the embodiment of the method 100 illustrated in Figure 1B, a biomass of filamentous fungus is produced by any suitable method as known and described in the art, such as, by way of non-limiting example, a surface fermentation method as described in PCT Application Publication 2020/176758.

In the inactivation step 120 of the embodiment of the method 100 illustrated in Figure 1B, the filamentous fungal biomass produced in step 110 is inactivated, *e.g.*, by steaming. In some embodiments, the filamentous fungal biomass may be a filamentous fungal biomat or relatively large (e.g. about 1 inch wide) pieces thereof; it is to be expressly understood that size reduction of the biomass, if carried out at this stage of the method 100, may be undertaken before, simultaneous with, and/or after inactivation step 120.

In the vacuum shaping step 150 of the embodiment of the method 100 illustrated in Figure 1B, the filamentous fungal biomass, having absorbed or otherwise taken up at least some portion of the aqueous solution (in some embodiments, up to about 30% of the initial weight of the filamentous fungal biomass), is placed in a cavity or mold, and the atmosphere surrounding the cavity or mold is evacuated to leave a high vacuum (i.e. an absolute pressure of no more than about 0.1 pascals). This allows the filamentous fungal biomass to be placed in a desired shape or other physical configuration and/or to undergo various physical deformations or operations; by way of non-limiting example, where it is desired to produce a sausage analog food product, the filamentous fungal biomass may be stuffed into a casing. In many embodiments, it may be desirable to form the filamentous fungal biomass into a "log," *i.e.*, an approximately cylindrical mass. The vacuum shaping step 150 may also affect the density of the filamentous fungal biomass and/or properties of a mycelial network thereof, which may, by way of non-limiting example, further increase mycelial surface area and/or permeability of the fungal biomass for application of further functional or nutritional additives. It is therefore to be expressly understood that the filamentous fungal biomass may, but need not, be contacted with one or more flavorings or other functional or nutritional additives, whether in a solid, liquid, or gas form, as part of vacuum shaping step 150.

Without wishing to be bound by any particular theory, it is believed that one functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum shaping step 150 is that these pressures cause the fungal biomass to expand, thereby increasing the volume of interstitial spaces between hyphae and other fungal structures. Subsequently, when the mat is once again exposed to ambient or atmospheric pressures, the

fungal biomass contracts. Again without wishing to be bound by any particular theory, it is believed that another functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in vacuum shaping step 150 is that this may beneficially alter surface behavior of the mycelia.

In the crust freezing step 160 of the embodiment of the method 100 illustrated in Figure 1B, the shaped filamentous fungal biomass is placed in a blast freezer and rapidly cooled, for example, to an internal temperature of between about 25 °F and about 27 °F. This temperature range has been found by the present inventors to provide optimum conditions for the processing steps of the method 100 that follow.

In the size reduction step 170 of the embodiment of the method 100 illustrated in Figure 1B, the blast-frozen filamentous fungal biomass is cut, shredded, and/or shaved into smaller pieces suitable for use as a meat analog. Most typically, the strips, shreds, or shavings of filamentous fungal biomass will preferably have a thickness of between about 0.1 millimeters and about 10 millimeters, as this range is most analogous to conventional meat products. to which the fungal products are analogous. Any size-reducing means, including but not necessarily limited to a gravity slicer or conventional deli meat slicer, may be used to carry out size reduction step 170.

In the optional post-processing step 180 of the embodiment of the method 100 illustrated in Figure 1B, the size-reduced filamentous fungal biomass may be subjected to any one or more forms of post-processing analogous to those used to prepare smoked or cured meat products or similar. By way of first non-limiting example, the size-reduced filamentous fungal biomass may be vacuum-steamed (e.g. to an internal temperature of about 85 °C for a period of about 12 minutes) to form a steamed meat analog food product. By way of second non-limiting example, the size-reduced filamentous fungal biomass may be cold-smoked (e.g. for a period of about four hours at a temperature of about 90 °F) to form a cold-smoked meat analog food product. By way of third non-limiting example, the size-reduced filamentous fungal biomass may be hot-smoked (e.g. for a period of about two hours at a temperature of about 230 °F) to form a hot-smoked meat analog food product. In general, any form(s) of post-processing to which a raw whole cut of meat or raw shredded meat may be subjected can be applied, *mutatis mutandis*, to the size-reduced filamentous fungal biomass to form an analogous filamentous fungal food product. Post-processing step 180 may be carried out when the size-reduced filamentous fungal biomass is frozen, refrigerated, or at room temperature.

In some embodiments, size reduction step 170 and/or post-processing step 180 may comprise extruding a fungal paste into long strips. This extrusion step may be carried out by any suitable device or method and may be particularly suitable or advantageous, by way of non-limiting example, to provide a food composition having a desired cross-sectional shape (especially if the desired cross-sectional shape is intricate or complex), to prevent (or deliberately impart) a selected type of physical stress (e.g. compressive stress, shear stress, etc.) to the food composition, to improve a finished appearance of the food composition, and/or to create a food composition that is analogous in appearance or structure to a conventional food product that is ordinarily provided in thin or narrow strips (e.g. jerky, bacon, etc.). Additional or alternative thermal or mechanical manipulations may be employed as part of size reduction step 170 and/or post-processing step 180, such as non-extrusive shearing, heating (with or without simultaneous shearing, *e.g.*, to coagulate proteins and/or carbohydrates), freezing, thawing, etc.

The difference between the two embodiments of the method 100 illustrated in Figures 1A and 1B is that refrigeration step 130, solution preparation step 135, and vacuum agitation step 140 are omitted in the embodiment illustrated in Figure 1B. Which embodiment of the method 100 is employed will depend on the desired flavor and intended use of the resulting meat analog food product; the method illustrated in Figure 1A will generally yield a pre-flavored product suitable for use in, *e.g.*, processed meat analog or smoked meat analog food products (*e.g.*, bacon analog food products, jerky analog food products, etc.), whereas the method illustrated in Figure 1B will generally yield a food product having a more neutral flavor profile suitable for use in raw or whole-cut meat analog food products. This flexibility of use is yet another benefit of the present invention, in that the method 100 can be used to produce any of a wide variety of meat analog food products.

Referring now to Figures 2A and 2B, a method 200 for making a meat jerky analog food product according to an embodiment of the present invention, is illustrated. As shown in Figures 2A and 2B, the method 200 comprises a marinade preparation step 210, a coating step 220, and a dehydrating step 230.

In the marinade preparation step 210 of the method 200, a marinade in which a filamentous fungal food material produced according to the method 100 illustrated in Figure 1A will be marinated, is prepared. Such a marinade can include any one or more ingredients commonly found in marinades for conventional meat products, including but not necessarily limited to meat jerky, but in some embodiments may include higher or lower amounts of these ingredients than in such conventional meat marinades. As in conventional meat

marination processes, marinades prepared according to marinade preparation step 210 will be liquids adapted to impart flavor to and/or tenderize or otherwise impart texture to the filamentous fungal biomass; as such, the marinades may (but need not) include one or more acidic ingredients (e.g. vinegar, lemon juice, wine) and/or one or more enzymatic ingredients (e.g. pineapple, papaya, yogurt, ginger), and may further include oils, herbs, and/or spices to further flavor the filamentous fungal biomass. Those skilled in the culinary arts will readily understand how to prepare an appropriate marinade according to marinade preparation step 210.

In the coating step 220 of the method 200, a filamentous fungal food material produced according to the method 100 illustrated in Figure 1A is marinated in, i.e. coated with, the marinade prepared in marinade preparation step 210, either at room temperature or under refrigeration. (Thus, any one or more steps 210, 220, 230 of method 200 can be considered a post-processing step 180 of method 100.) Most commonly, the coating step 220 may be carried out for a period of between about two seconds and about two days (i.e. as is typical of marination processes for conventional meat jerky products) at any temperature within a wide range (e.g. under refrigeration to at least as low as about 0 °C, at ambient temperatures, and/or under elevated temperatures of at least as high as about 40 °C), but in some embodiments, because filamentous fungal biomass does not spoil as readily as meat (whether at room temperature or under refrigeration), the coating step 220 may be carried out for a longer time to further impart flavor and/or tenderize the biomass. Without wishing to be bound by any particular theory, variations in coating step 220 temperatures and times may affect the internal structure of the filamentous fungal biomass and thus allow for different extents to which marinade is "entrapped" within the biomass. Coating step 220 may or may not include agitation or mixing of the filamentous fungal food material with the marinade, but it is generally desirable to ensure that substantially all sides and/or surfaces of the filamentous fungal food material are coated with the marinade, whether by agitation/mixing or by providing enough of the marinade in an appropriate vessel to completely soak or submerge the filamentous fungal food material for a desired residence or marination time. The coating step 220 may additionally or alternatively comprise any other means of coating the fungal biomass with the marinade, e.g. dipping the fungal biomass in the marinade, spraying the fungal biomass with the marinade (with or without subsequent drying), etc.

In some embodiments, coating step 220 optionally may, but need not, comprise application of a stabilizer or mold inhibitor, e.g. potassium sorbate, to further increase the

shelf life of the resulting food composition; in some embodiments, the stabilizer or mold inhibitor may also have an aesthetic or sensory benefit (e.g. potassium sorbate is a salty-tasting compound that stimulates salivation and contributes to a salty flavor). It is to be expressly understood, however, that application of a stabilizer and/or mold inhibitor may be omitted, and it may be preferable to omit this application in some embodiments.

In the dehydrating step 230 of the method 200, the filamentous fungal food material produced according to the method 100 illustrated in Figure 1A is dehydrated at relatively low temperature, e.g. no more than about 165 °F, over a period of between about 20 minutes and about 12 hours, and most commonly between about 2 hours and about 5 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydrating step 230, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal food material while otherwise retaining the fungal material's basic structure.

The difference between the two embodiments of the method 200 illustrated in Figures 2A and 2B is in the ordering of steps—coating step 220 may be carried out before dehydrating step 230, as in Figure 2A, or vice versa, as in Figure 2B. Which embodiment of the method 200 is employed will depend on the desired texture of the resulting meat jerky analog food product; the method illustrated in Figure 2A will generally yield a "chewy" texture akin to a true meat jerky, whereas the method illustrated in Figure 2B will generally yield a "crispy" texture like that of a potato or tortilla chip. This flexibility in the ordering of steps is yet another benefit of the present invention, in that the method 200 can be used to produce a true jerky analog food product, or alternatively a novel food product having a combination of meat jerky flavor with a "crispy," chip-like texture that may not be attainable using meat. In practice, the methods 200 of Figures 2A and 2B are, or may be, generally identical, with the exception that, because the marinade prepared in marinade preparation step 210 generally has a high moisture content, dehydrating step 230 may be carried out for a longer time (typically four to five hours) if preceded by the coating step 220 and for a shorter time (typically two to three hours) if preceding the coating step 220.

The invention is further described by the following illustrative, non-limiting Examples.

Example 1

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A. Subsequently, a marinade comprising 8.6 wt% nutritional

yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The pieces of marinated filamentous fungal food material were then placed on trays, with care taken to ensure that no two pieces touched each other, and dehydrated in a conventional dehydrator at 160 °F for between four and five hours. The resulting meat jerky analog food product had a taste like that of a conventional beef jerky and a similarly analogous chewy texture.

The meat jerky analog food product was found to have a water activity of 0.4894 and a moisture content of 14.09 wt%. These values are comparable to, or even better (i.e. drier) than, a conventional meat jerky food product.

Example 2

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A and placed on trays, with care taken to ensure that no two pieces touched each other. The pieces of filamentous fungal food material were then dehydrated in a conventional dehydrator at 160 °F for between two and four hours. Subsequently, a marinade comprising 8.6 wt% nutritional yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% tamari soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The dehydrated filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The resulting meat jerky analog food product had a taste like that of a conventional beef jerky, but, rather than exhibiting a typical “chewy” meat jerky texture, instead had a “crispy” texture like that of a potato or tortilla chip.

Example 3

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1A and subsequently dehydrated in a conventional dehydrator at 160 °F for two hours, without prior marination. After dehydration, some pieces were marinated with the marinade of Examples 1 and 2 (“Jerky A”), while others were left unmarinated and instead placed in a bath of room-temperature water for two hours (“unmarinated Jerky A”). Separately, two other jerky analog products were produced: a

jerky analog product produced according to a second run of the method described in Example 1 ("Jerky C") and a jerky analog product produced according to the method described in Example 1, except that the filamentous fungal biomass was vacuum-tumbled with the marinade for 30 minutes rather than being surface-coated ("Jerky B"). In Jerkies B and C, the amount of marinade relative to the fungal biomass was also varied relative to the method described in Example 1; specifically, the fungal biomass was marinated in an equal (1:1) mass of marinade.

Samples of each of marinated Jerky A, Jerky B, and Jerky C were weighed before marination (i.e. fungal biomass only), with applied marinade before dehydration, and after dehydration. The water activity and moisture content of each jerky after dehydration was then assessed. All three jerkies were made using filamentous fungal biomass taken from a fungal biomat having a starting moisture content of 79.84%. The results of these tests are given in Table 1.

Table 1

	Jerky A	**Jerky B**	**Jerky C**
Pre-marination mass (fungus only)	95.4 g	95 g	91.5 g
Post-marination mass (before dehydration)	n/a	165.5 g	165.7 g
Post-dehydration mass	24.7 g	67.72 g	73.14 g
Post-dehydration water activity	0.64	0.371	0.459
Post-dehydration moisture content	28.89%	20.17%	23.58%

Images of samples of unmarinated Jerky A, Jerky B, and Jerky C are shown in Figures 3A, 3B, and 3C, respectively. The densities of Jerkies B and C were recorded as 0.74 and 0.73 g/cm^3, respectively.

The three jerkies differed greatly in their qualitative sensory impressions. Jerky A was observed to extremely crispy and brittle, with a tendency to undergo glass-like shattering, and had the least flavor even when marinade was applied. Jerky B was thin and crispy (though less so than Jerky A), with increased marinade flavor compared to Jerky A. Jerky C was by far the most similar in sensory evaluation to a conventional, shelf-stable, soft, chewy meat jerky; it was chewier and softer than Jerkies A and B and had a strong spicy and smoky flavor imparted by the marinade.

Example 4

Three unmarinated samples of Jerky A produced in Example 3 were placed into a room-temperature water bath for 30 minutes, 1 hour, and 2 hours, respectively, and weighed

both before and after rehydration to determine the water reuptake capabilities of Jerky A. The results are given in Table 2.

Table 2

Time in water	30 minutes	1 hour	2 hours
Pre-dehydration mass	NR	NR	5.04 g
Pre-rehydration mass	2.01 g	2.72 g	1.37 g
Post-rehydration mass	4.89 g	7.44 g	3.77 g
% mass increase	243%	274%	275%
% original water	NR	NR	74.8%

Air bubbles were observed when dry jerky products were immersed in water, showing very active rehydration of all samples tested.

Without wishing to be bound by any particular theory, the present inventors hypothesize that tightly bound water is, for the most part, not removed during dehydration in all samples. However, physically bound water and free water, held in, e.g., the capillaries and porous structure of the fungal biomass adds to the range of texture development in jerky products. While the moisture content of the dried jerky products is 24% ± 4%, their water activities (reported in Example 3) show that jerkies with a wide range of textures can be produced. The subsequent rehydration of the jerky products highlights the novel porous structure of the jerky products, where water droplets can be held and contribute to the plasticized properties of the jerky products. During this subsequent rehydration, liquid can enter the fungal structure where free water was previously present, but some physically bound water (~25 wt% of the total water) cannot be regained due to loss of fungal structures during dehydration. This mechanism would account for reuptake of less than all of the starting mass of moisture during rehydration. Thus, the present invention can be viewed as providing a method to maintain the porous structure of filamentous fungal biomass during dehydration, and particularly to leverage this porous structure to precisely control and/or select a desired extent of liquid removal from the fungal material. In this way, a desired water activity, e.g. of less than about 0.45, can be selected.

Example 5

Microscopic images of a whole piece of Jerky C were taken from a portion of the piece corresponding to a hydrophilic side of the filamentous fungal biomat. These images are shown as Figures 4A (light both above and below the sample) and 4B (light below the sample only). These images show small holes in the post-dehydration biomat. Without wishing to be bound by any particular theory, these images support the hypothesis that,

while some fungal mat structure may be destroyed during processing, most of the mat structure may remain intact.

The Jerky C piece was then laid flat, and two parallel lines, lying close to one another, were cut using a utility knife. The sample was then turned onto the side on which the knife passed. This procedure allowed the capture of two microscopic images: one of a hydrophobic side of the jerky piece (Figure 5A) and one from a hydrophilic side (Figure 5B).

In Figure 5A, the center or innermost part of the sample is on the left side of the image, while the edge of the sample is on the right side of the image. As Figures 5A and 5B illustrate, the smallest degree of structural deformation is observed near the center of the sample, with deformation increasing (e.g. larger pores) toward the edge of the sample.

In Figure 5B, the left side of the image represents the opposite edge of the sample relative to Figure 5A. The structure appears significantly denser. Without wishing to be bound by any particular theory, it is believed that the hydrophilic side of a filamentous fungal biomat, which grows submersed in or on the surface of a liquid (aqueous) growth medium, grows to have a denser structure because the hydrophobic (i.e. atmosphere-facing) side of the biomat is where aerial hyphae, having a filamentous structure, are formed.

Example 6

Pieces of unmarinated Jerky A, Jerky B, and Jerky C were prepared for tensile strength and strain-at-break testing. It was quickly discovered that pieces of unmarinated Jerky A could not be tested due to their brittleness; these samples were either impossible to cut for testing or would shatter when placed in the grips of the testing apparatus. Pieces of Jerky B were noticeably brittle, but flat sections of the pieces were malleable enough to allow for cutting of testing samples, and Jerky B was found to have a maximum tensile strength of 1.10 ± 0.51 MPa and a strain at break of 1.75% ± 0.71%. Pieces of Jerky C were much more malleable, making them much easier to cut samples from, and Jerky C was found to have a maximum tensile strength of 1.98 ± 0.66 MPa and a strain at break of 8.08% ± 0.81%.

The specimens tested for tensile strength and strain at break are shown in Figures 6A (Jerky B) and 6B (Jerky C). As Figures 6A and 6B clearly illustrate, Jerky B exhibited brittle fractures, while Jerky C exhibited more elastic fractures. The stress-strain curves for two tested samples of Jerky B and three tested samples of Jerky C, shown in Figure 7, confirm this observation; in Figure 7, the two samples of Jerky B are represented by the

square and triangle data points, while the three samples of Jerky C are represented by the dash, circle, and diamond data points.

The invention illustratively disclosed herein suitably may be practiced in the absence of any element which is not specifically disclosed herein. It is apparent to those skilled in the art, however, that many changes, variations, modifications, other uses, and applications of the invention are possible, and changes, variations, modifications, other uses, and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is limited only by the claims which follow.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description of the Invention, for example, various features of the invention are grouped together in one or more embodiments for the purpose of streamlining the disclosure. The features of the embodiments of the invention may be combined in alternate embodiments other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description of the Invention, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations, combinations, and modifications are within the scope of the invention, e.g. as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps to those claimed, regardless of whether such alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

CLAIMS

1. A method for preparing a food product, comprising:

(a) contacting a filamentous fungal biomass with a solution comprising a food additive;

(b) size-reducing the filamentous fungal biomass to form a plurality of filamentous fungal pieces; and

(c) removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive,

wherein steps (a) and (b) are carried out simultaneously or sequentially in any order.

2. The method of claim 1, wherein the food additive comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

3. The method of claim 1, wherein a mass of the solution is between about 1% and about 30% of a total mass of the filamentous fungal biomass prior to contacting the solution.

4. The method of claim 1, wherein step (a) is carried out under sub-atmospheric pressure.

5. The method of claim 4, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

6. The method of claim 1, wherein step (a) is carried out under super-atmospheric pressure.

7. The method of claim 1, wherein step (a) is carried out at a temperature below room temperature.

8. The method of claim 7, wherein the temperature below room temperature is no more than about 40 °F.

9. The method of claim 1, wherein, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass is no more than about 34 °F.

10. The method of claim 1, further comprising, prior to step (a), removing water from the filamentous fungal biomass.

11. The method of claim 1, wherein step (a) comprises agitating the filamentous fungal biomass together with the solution.

12. The method of claim 1, wherein the filamentous fungal biomass absorbs an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about

15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomass.

13. The method of claim 1, wherein step (a) comprises contacting at least two filamentous fungal biomasses with the solution, wherein the method further comprises, between steps (a) and (b), aggregating the at least two filamentous fungal biomasses to form a filamentous fungal aggregate, and wherein step (b) comprises size-reducing the filamentous fungal aggregate.

14. The method of claim 13, wherein the step of aggregating comprises encasing the at least two filamentous fungal biomasses in a casing.

15. The method of claim 13, wherein the aggregating step is carried out under sub-atmospheric pressure.

16. The method of claim 15, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

17. The method of claim 13, wherein the aggregating step comprises crust-freezing the at least two filamentous fungal biomasses.

18. The method of claim 1, further comprising, between steps (a) and (b), crust freezing the filamentous fungal biomass.

19. The method of claim 18, wherein an internal temperature of the filamentous fungal biomass after the crust freezing step is between about 25 °F and about 27 °F.

20. The method of claim 18, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

21. The method of claim 1, wherein step (b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomass.

22. The method of claim 21, wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass.

23. The method of claim 1, wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm.

24. The method of claim 1, wherein step (c) comprises at least one of roasting the plurality of filamentous fungal pieces, baking the plurality of filamentous fungal pieces, boiling the plurality of filamentous fungal pieces, frying the plurality of filamentous fungal pieces, steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

25. The method of claim 1, wherein the solution is an aqueous solution.

26. The method of claim 1, wherein the solution is a non-aqueous solution.

27. The method of claim 1, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in or on a fermentation medium or on a membrane associated with a fermentation medium; and

inactivating the filamentous fungal biomass.

28. The method of claim 27, wherein the fermentation method is selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, an air-medium colloid (AMC) fermentation method, and combinations thereof.

29. The method of claim 27, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

30. The method of claim 1, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

31. The method of claim 1, wherein the food product comprises all essential amino acids.

32. The method of claim 1, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

33. The method of claim 1, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

34. The method of claim 1, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than

about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

35. The method of claim 1, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

36. The method of claim 1, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

37. A meat analog food product made according to the method of claim 1.

38. A method for preparing a food product, comprising:

(a) contacting a filamentous fungal biomass with a solution comprising a food additive; and

(b) dehydrating the filamentous fungal biomass to form the food product comprising the filamentous fungal biomass and the food additive dispersed within the filamentous fungal biomass.

39. The method of claim 38, wherein the food product is a meat jerky analog food product.

40. The method of claim 38, wherein the solution comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

41. The method of claim 38, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomass prior to contacting the solution.

42. The method of claim 38, wherein step (a) is carried out under sub-atmospheric pressure.

43. The method of claim 42, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

44. The method of claim 38, wherein step (a) is carried out at a temperature below room temperature.

45. The method of claim 44, wherein the temperature below room temperature is no more than about 40 °F.

46. The method of claim 38, wherein step (a) is carried out at a temperature above room temperature.

47. The method of claim 38, wherein, during at least part of a duration of step (a), a temperature of the filamentous fungal biomass is no more than about 34 °F.

48. The method of claim 38, further comprising, prior to step (a), removing water from the filamentous fungal biomass.

49. The method of claim 38, wherein step (a) is carried out by agitating the filamentous fungal biomass together with the solution.

50. The method of claim 38, wherein the filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

51. The method of claim 38, wherein the solution is an aqueous solution.

52. The method of claim 38, wherein the solution is a non-aqueous solution.

53. The method of claim 38, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the filamentous fungal biomass.

54. The method of claim 53, wherein the fermentation method is a surface fermentation method.

55. The method of claim 53, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

56. The method of claim 38, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

57. The method of claim 38, wherein the food product comprises all nine essential amino acids.

58. The method of claim 38, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

59. The method of claim 38, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

60. The method of claim 38, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

61. The method of claim 38, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

62. The method of claim 38, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

63. A meat jerky analog food product made according to the method of claim 39.

64. A meat analog food product comprising filamentous fungus, wherein the meat analog food product has a shelf life of at least about two weeks and wherein at least one of the following is true:

(i) the meat analog food product comprises less than about 200 milligrams of sodium per 28 grams of food product;

(ii) the meat analog food product comprises no more than 15 grams of sugar per 28 grams of food product; and

(iii) a sugar content of the meat analog food product is no more than about 10 wt%.

65. The meat analog food product of claim 64, having a shelf life of at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

66. The meat analog food product of claim 64, having a water activity of between about 0.35 and about 0.85.

67. The meat analog food product of claim 64, having a water activity of no more than about 0.45.

68. The meat analog food product of claim 64, comprising less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per 28 grams of food product.

69. The meat analog food product of claim 64, wherein at least one of the following is true:

(i) the meat analog food product comprises no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per 28 grams of food product; and

(ii) a sugar content of the meat analog food product is no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%.

70. The meat analog food product of claim 64, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

71. The meat analog food product of claim 64, comprising all nine essential amino acids.

72. The meat analog food product of claim 64, comprising at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

73. The meat analog food product of claim 64, comprising at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

74. The meat analog food product of claim 64, having a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

75. The meat analog food product of claim 64, wherein the filamentous fungus comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

76. The meat analog food product of claim 64, wherein the filamentous fungus comprises a filamentous fungal biomat or a portion thereof.

77. A method for preparing a food product, comprising:

(a) contacting a first filamentous fungal biomass with a first solution;

(b) size-reducing the first filamentous fungal biomass to form a plurality of filamentous fungal pieces;

(c) contacting a second filamentous fungal biomass with a second solution;

(d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomass; and

(e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomass to form the food product.

78. The method of claim 77, wherein the food product is a meat jerky analog food product.

79. The method of claim 77, wherein at least one of the first and second solutions comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

80. The method of claim 77, wherein at least one of the following is true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomass prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomass prior to step (c).

81. The method of claim 77, wherein at least one of step (a) and step (c) is carried out under sub-atmospheric pressure.

82. The method of claim 81, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

83. The method of claim 77, wherein at least one of step (a) and step (c) is carried out at a temperature below room temperature.

84. The method of claim 83, wherein the temperature below room temperature is no more than about 40 °F.

85. The method of claim 83, wherein, during at least part of a duration of step (a), a temperature of at least one of the first filamentous fungal biomass and the second filamentous fungal biomass is no more than about 34 °F.

86. The method of claim 77, wherein at least one of step (a) and step (c) is carried out at a temperature above room temperature.

87. The method of claim 77, further comprising at least one of: (i) prior to step (a), removing water from the first filamentous fungal biomass; and (ii) prior to step (c), removing water from the second filamentous fungal biomass.

88. The method of claim 77, wherein at least one of the following is true: (i) step (a) is carried out by agitating the first filamentous fungal biomass together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomass together with the second solution.

89. The method of claim 77, wherein at least one of the following is true: (i) the first filamentous fungal biomass absorbs at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomass absorbs least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

90. The method of claim 77, further comprising at least one of (i) between steps (a) and (b), crust freezing the first filamentous fungal biomass, and (ii) between steps (c) and (d), crust freezing the second filamentous fungal biomass.

91. The method of claim 90, wherein an internal temperature of the first filamentous fungal biomass when (i) is true, or an internal temperature of the second filamentous fungal biomass when (ii) is true, after the crust freezing step is between about 25 °F and about 27 °F.

92. The method of claim 90, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

93. The method of claim 77, wherein at least one of the first and second solutions is an aqueous solution.

94. The method of claim 77, wherein at least one of the first and second solutions is a non-aqueous solution.

95. The method of claim 77, further comprising, prior to at least one of steps (a) and (c):

forming at least one of the filamentous fungal biomass and the second filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the at least one of the first filamentous fungal biomass and the second filamentous fungal biomass.

96. The method of claim 95, wherein the fermentation method is a surface fermentation method.

97. The method of claim 95, wherein the inactivating step is carried out by at least one of dehydrating the filamentous fungal biomass, freezing the filamentous fungal biomass, pressure treating the filamentous fungal biomass, rinsing the filamentous fungal biomass, size reducing the filamentous fungal biomass, steaming the filamentous fungal biomass, and temperature cycling the filamentous fungal biomass.

98. The method of claim 77, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

99. The method of claim 77, wherein the food product comprises all nine essential amino acids.

100. The method of claim 77, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

101. The method of claim 77, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

102. The method of claim 77, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

103. The method of claim 77, wherein at least one of the filamentous fungal biomass and the second filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

104. The method of claim 77, wherein at least one of the first filamentous fungal biomass and the second filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

105. A meat jerky analog food product made according to the method of claim 78.

106. An intermediate food composition, comprising:

a filamentous fungal biomass; and

a solution comprising a food additive, absorbed by the filamentous fungal biomass.

107. The intermediate food composition of claim 106, wherein the solution comprises at least one of sodium chloride, a food seasoning, an edible protein, and a fibrous base material.

108. The intermediate food composition of claim 106, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomass.

109. The intermediate food composition of claim 106, wherein the solution is an aqueous solution.

110. The intermediate food composition of claim 106, wherein the solution is a non-aqueous solution.

111. The intermediate food composition of claim 106, wherein the filamentous fungal biomass is derived from a fermentation method selected from the group consisting of a surface fermentation method, a submerged fermentation method, a membrane fermentation method, a solid-substrate fermentation method, and an air-medium colloid (AMC) fermentation method, and combinations thereof.

112. The intermediate food composition of claim 106, wherein the filamentous fungal biomass is inactivated.

113. The intermediate food composition of claim 106, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

114. A method for preparing a food product, comprising:

(a) vacuum-shaping a filamentous fungal biomass, wherein the filamentous fungal biomass comprises a solution comprising a food additive;

(b) size-reducing the vacuum-shaped filamentous fungal biomass to form a plurality of filamentous fungal pieces; and

(c)removing at least a portion of a solvent of the solution to treat the plurality of filamentous fungal pieces to form the food product comprising the filamentous fungal pieces and the food additive.

115. The method of claim 114, wherein, in step (a), the filamentous fungal biomass is exposed to an absolute pressure of no more than about 0.1 pascals.

116. The method of claim 114, wherein, following step (a), the filamentous fungal biomass has an approximately cylindrical shape.

117. The method of claim 114, further comprising, between steps (a) and (b), crust freezing the filamentous fungal biomass.

118. The method of claim 117, wherein an internal temperature of the filamentous fungal biomass after the crust freezing step is between about 25 °F and about 27 °F.

119. The method of claim 117, wherein the crust freezing step is carried out by placing the filamentous fungal biomass in a blast freezer.

120. The method of claim 114, wherein step (b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomass.

121. The method of claim 120, wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomass.

122. The method of claim 114, wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm.

123. The method of claim 114, further comprising, prior to step (a):

forming the filamentous fungal biomass by a fermentation method comprising culturing a filamentous fungus in a fermentation medium; and

inactivating the filamentous fungal biomass.

124. The method of claim 123, wherein the fermentation method is a surface fermentation method.

125. The method of claim 123, wherein the inactivating step is carried out by steaming the filamentous fungal biomass.

126. The method of claim 114, wherein the food product has a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, at least about 600 g/cm^2, at least about 650 g/cm^2, at least about 700 g/cm^2, at least about 750 g/cm^2, at least about 800 g/cm^2, at least about 850 g/cm^2, at least about 900 g/cm^2, at least about 950 g/cm^2, at least about 1000 g/cm^2, at least about 1500 g/cm^2, at least about 2000 g/cm^2, at least about 2500 g/cm^2, at least about 3000 g/cm^2, at least about 3500 g/cm^2, or at least about 4000 g/cm^2.

127. The method of claim 114, wherein the food product comprises all nine essential amino acids.

128. The method of claim 114, wherein the food product comprises at least one amino acid selected from the group consisting of alanine, cysteine, aspartic acid, glutamic acid, glycine, asparagine, proline, glutamine, arginine, serine, selenocysteine, and tyrosine.

129. The method of claim 114, wherein the food product comprises at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% branched-chain amino acids.

130. The method of claim 114, wherein the food product has a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less

than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

131. The method of claim 114, wherein the filamentous fungal biomass comprises at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber on a dry weight basis.

132. The method of claim 114, wherein the filamentous fungal biomass comprises a filamentous fungal biomat or a portion thereof.

133. The method of claim 1, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

134. The method of claim 1, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition.

135. The method of claim 38, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

136. The method of claim 38, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

137. The meat analog food product of claim 64, having a total protein content from about 10 wt% to about 25 wt%.

138. The meat analog food product of claim 64, having a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

139. The method of claim 77, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

140. The method of claim 77, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

141. The method of claim 114, wherein the food product has a total protein content from about 10 wt% to about 25 wt%.

142. The method of claim 114, wherein the food product has a dietary fiber content of at least about 1 gram, at least about 2 grams, at least about 3 grams, at least about 4 grams, at least about 5 grams, at least about 6 grams, at least about 7 grams, at least about 8 grams, at least about 9 grams, at least about 10 grams, at least about 11 grams, at least about 12 grams, at least about 13 grams, or at least about 14 grams of dietary fiber per 28 grams of food composition

ABSTRACT

Filamentous fungal food compositions are disclosed, as are methods of making such filamentous fungal food compositions. The filamentous fungal food compositions may serve as analogs of conventional non-fungal food products, particularly meat products such as meat jerky. The methods of manufacture of the filamentous fungal food compositions may include processing of filamentous fungal biomass under sub-atmospheric pressure.

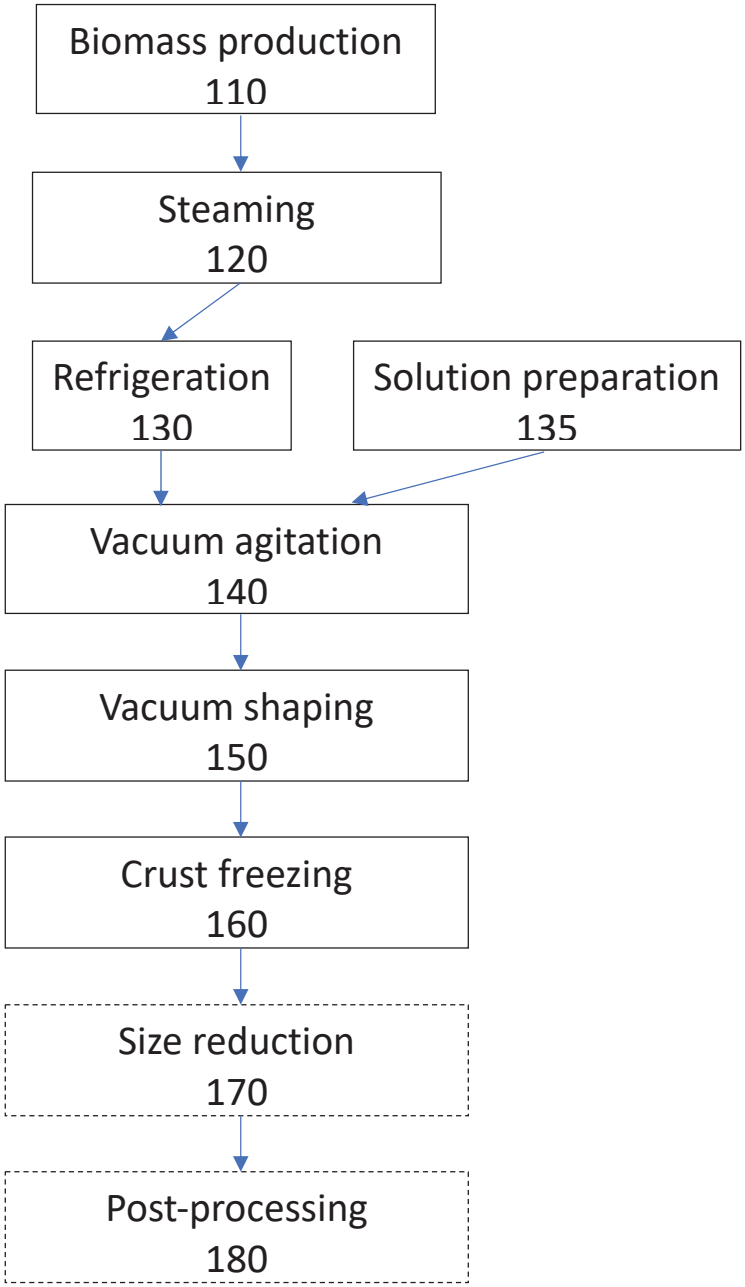

Biomass production
110
Steaming
120
Refrigeration
130
Solution preparation
135
Vacuum agitation
140
Vacuum shaping
150
Crust freezing
160
Size reduction
170
Post-processing
180

FIG. 1A

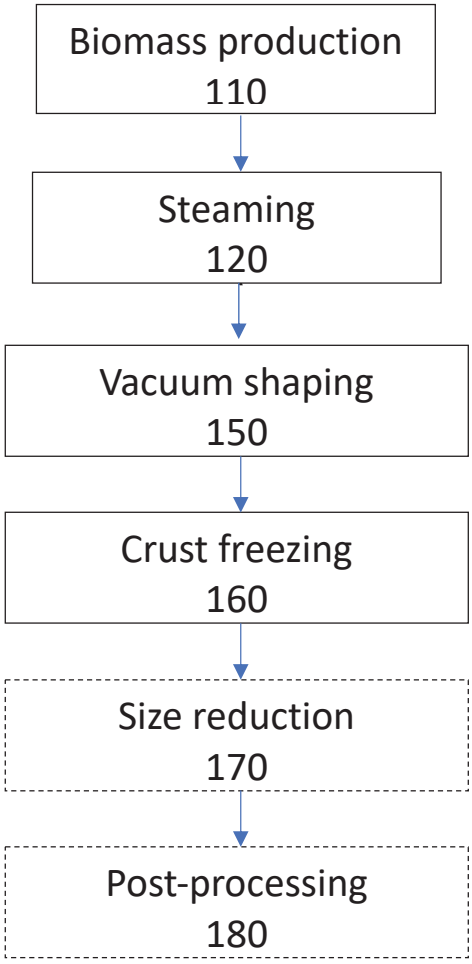

Biomass production
110
Steaming
120
Vacuum shaping
150
Crust freezing
160
Size reduction
170
Post-processing
180

FIG. 1B

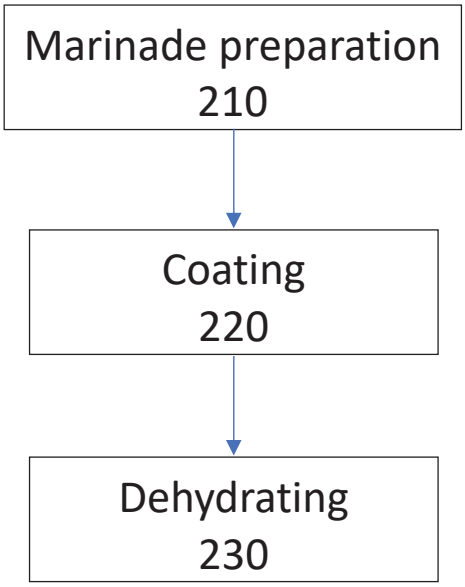


FIG. 2A

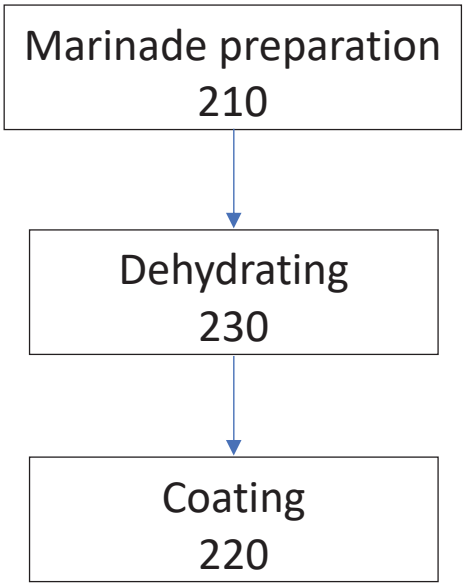


FIG. 2B

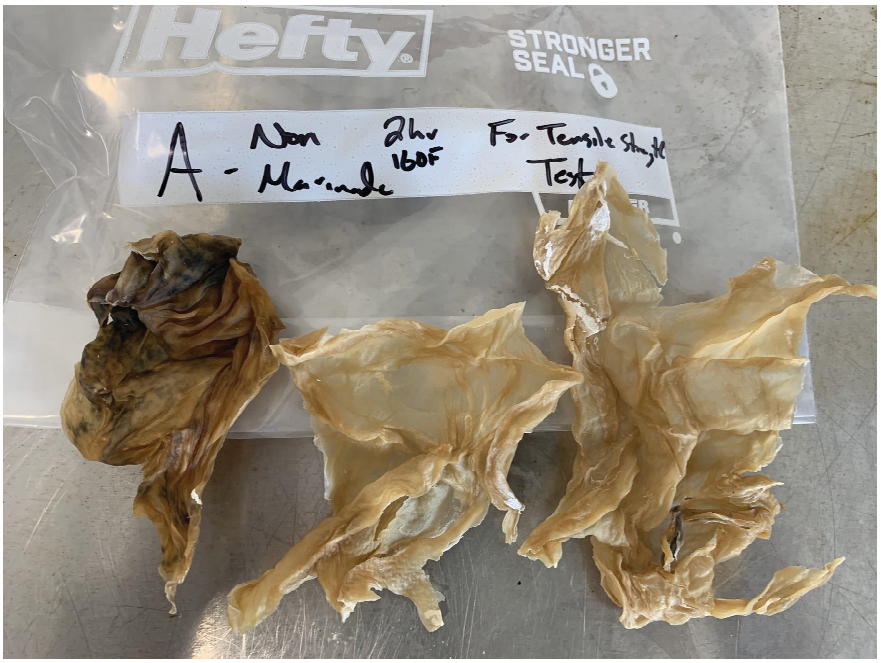

Hefty
STRONGER SEAL
A - Non Marinade 2hr 160F For Tensile Strength Test

FIG. 3A


Hefty
STRONGER SEAL
B - Vacuum Marinade 4hr 160F For Tensile Strength Test
FREEZER

FIG. 3B


Hefty
STRONG SEAL
C - Topical Aloe Marmalade For Tensile Strength Test
FREEZER

FIG. 3C

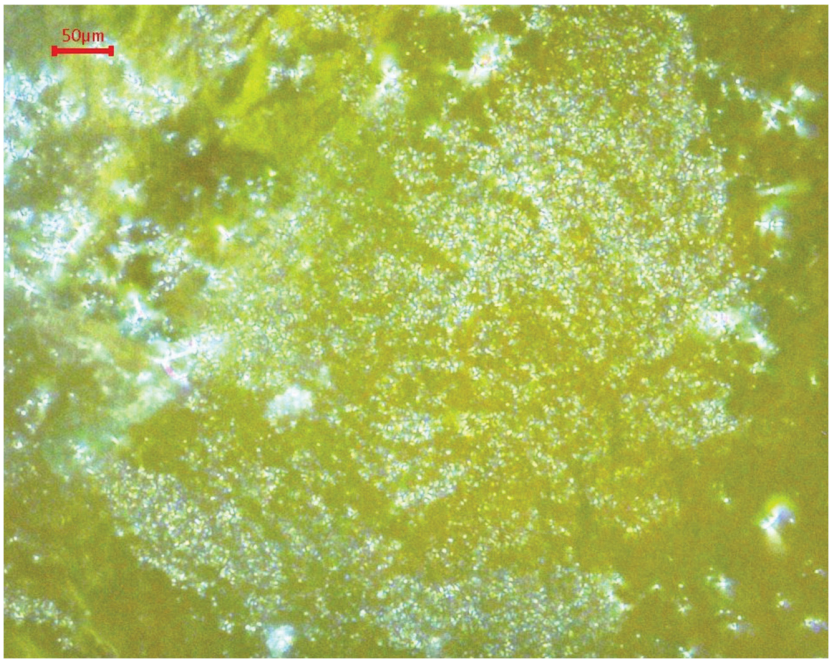

50µm

FIG. 4A

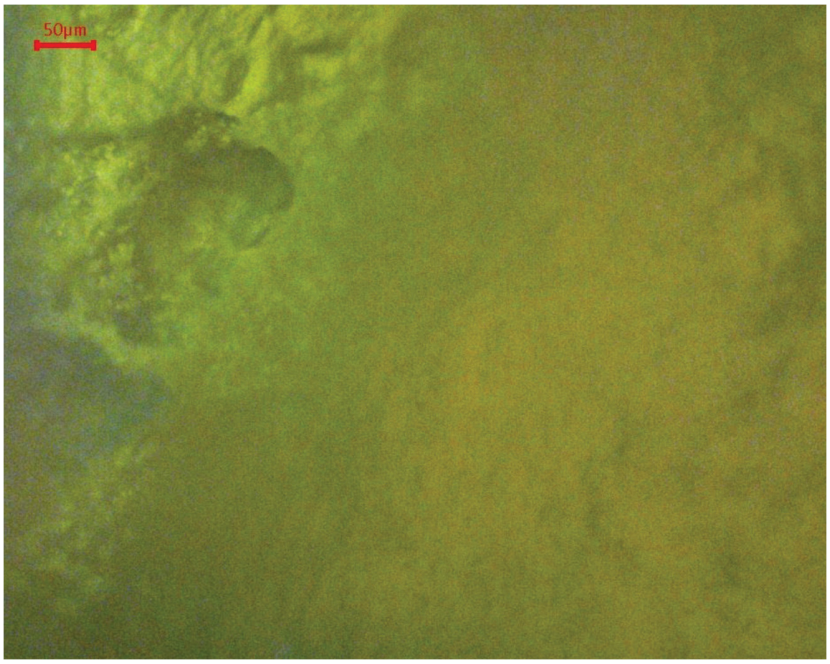


FIG. 4B

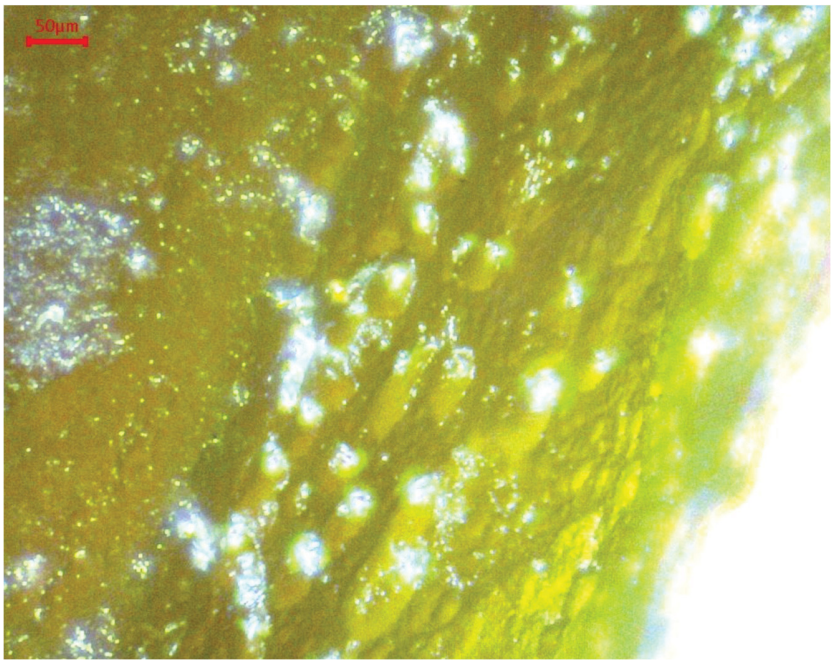


FIG. 5A

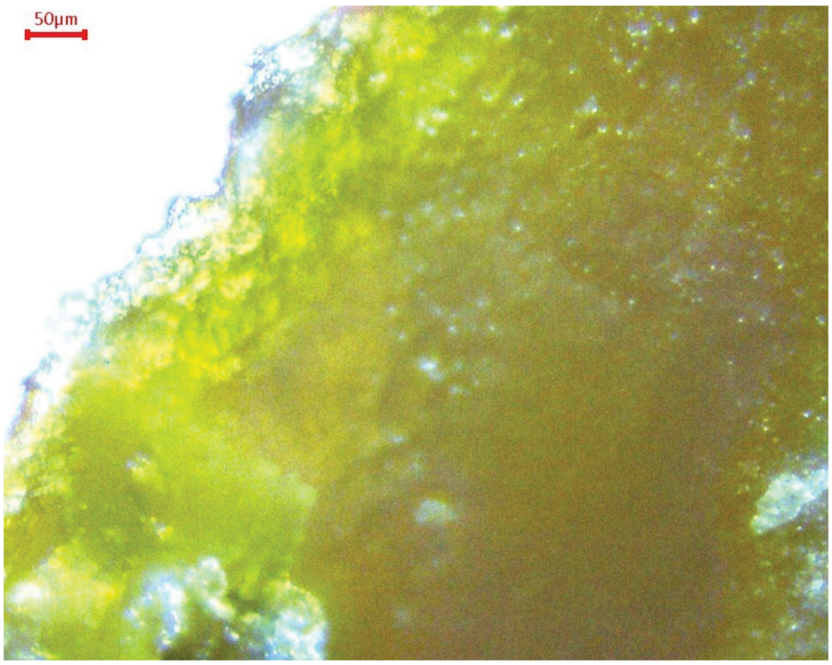


FIG. 5B



FIG. 6A



FIG. 6B

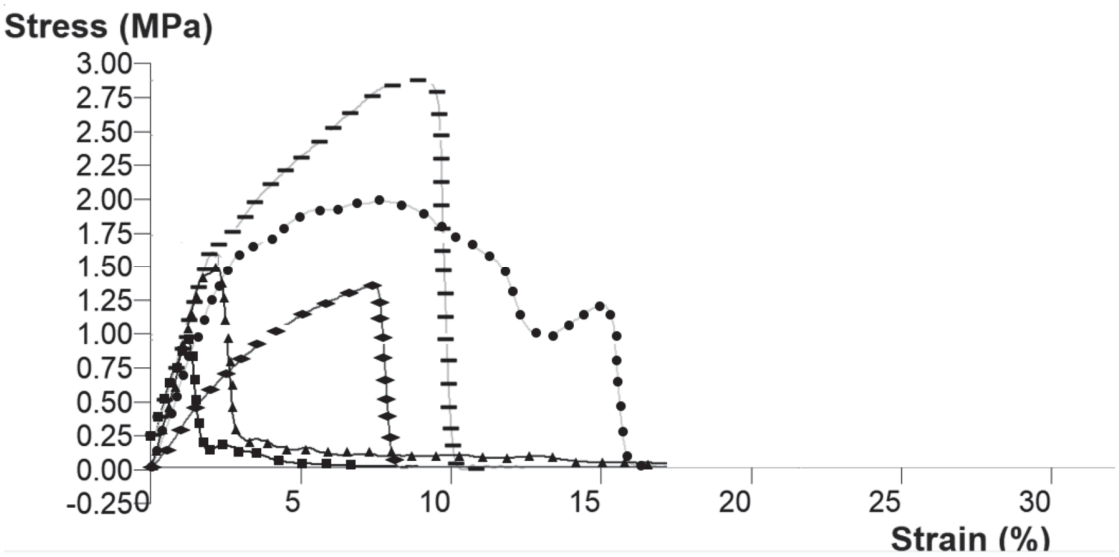

Stress (MPa)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.250
5
10
15
20
25
30
Strain (%)

FIG. 7



FIG. 3A



FIG. 3B



FIG. 3C

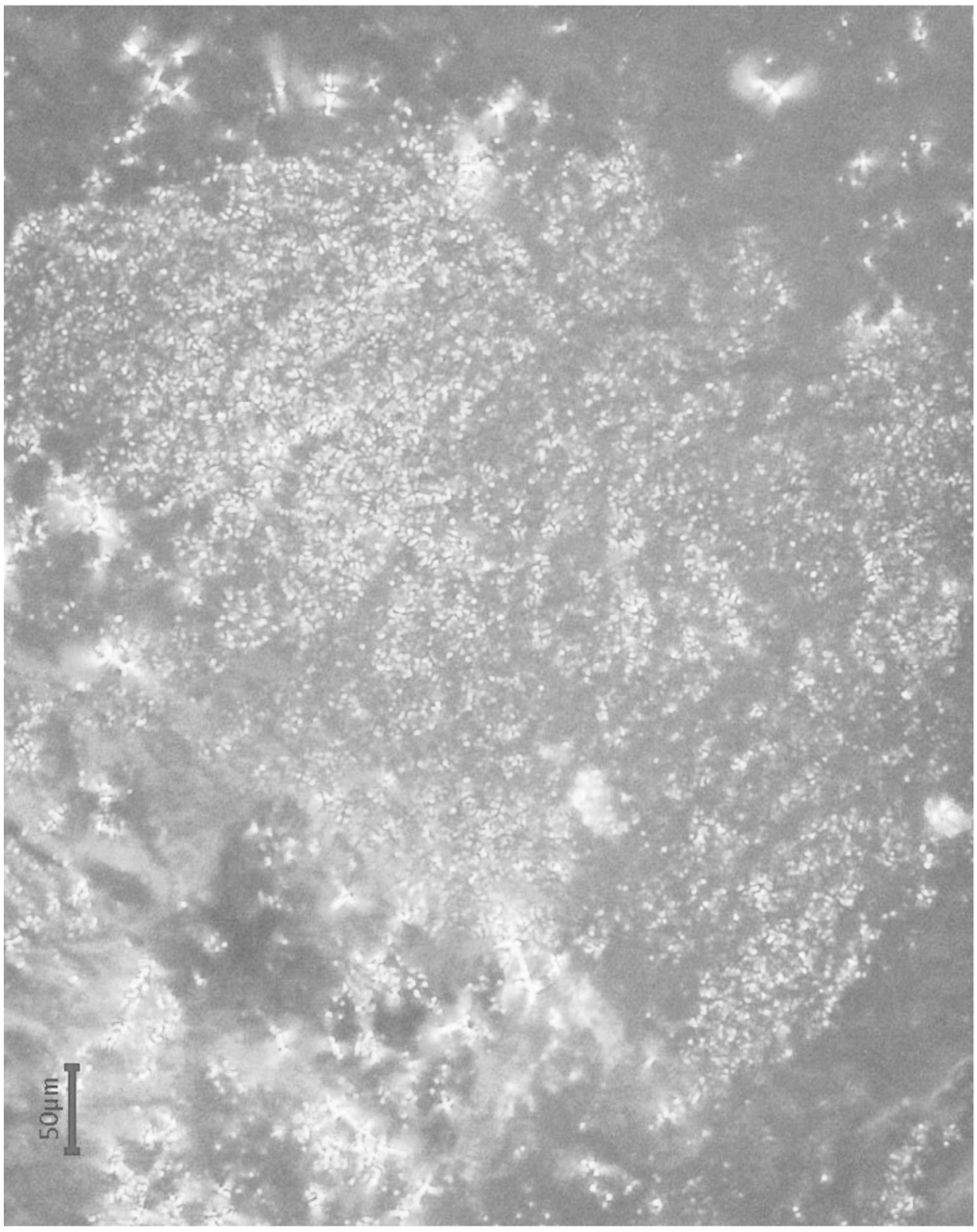


FIG. 4A



FIG. 4B

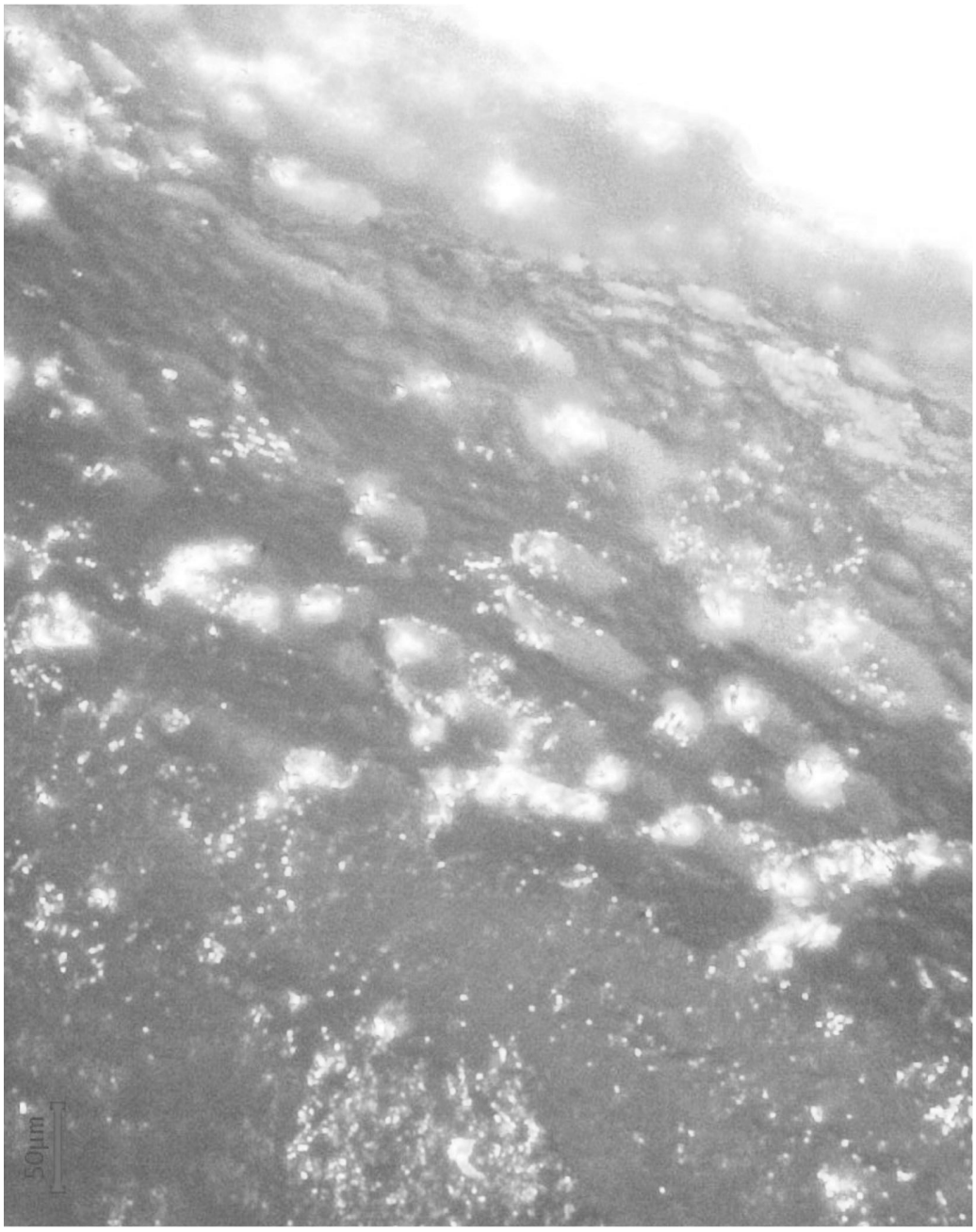


FIG. 5A

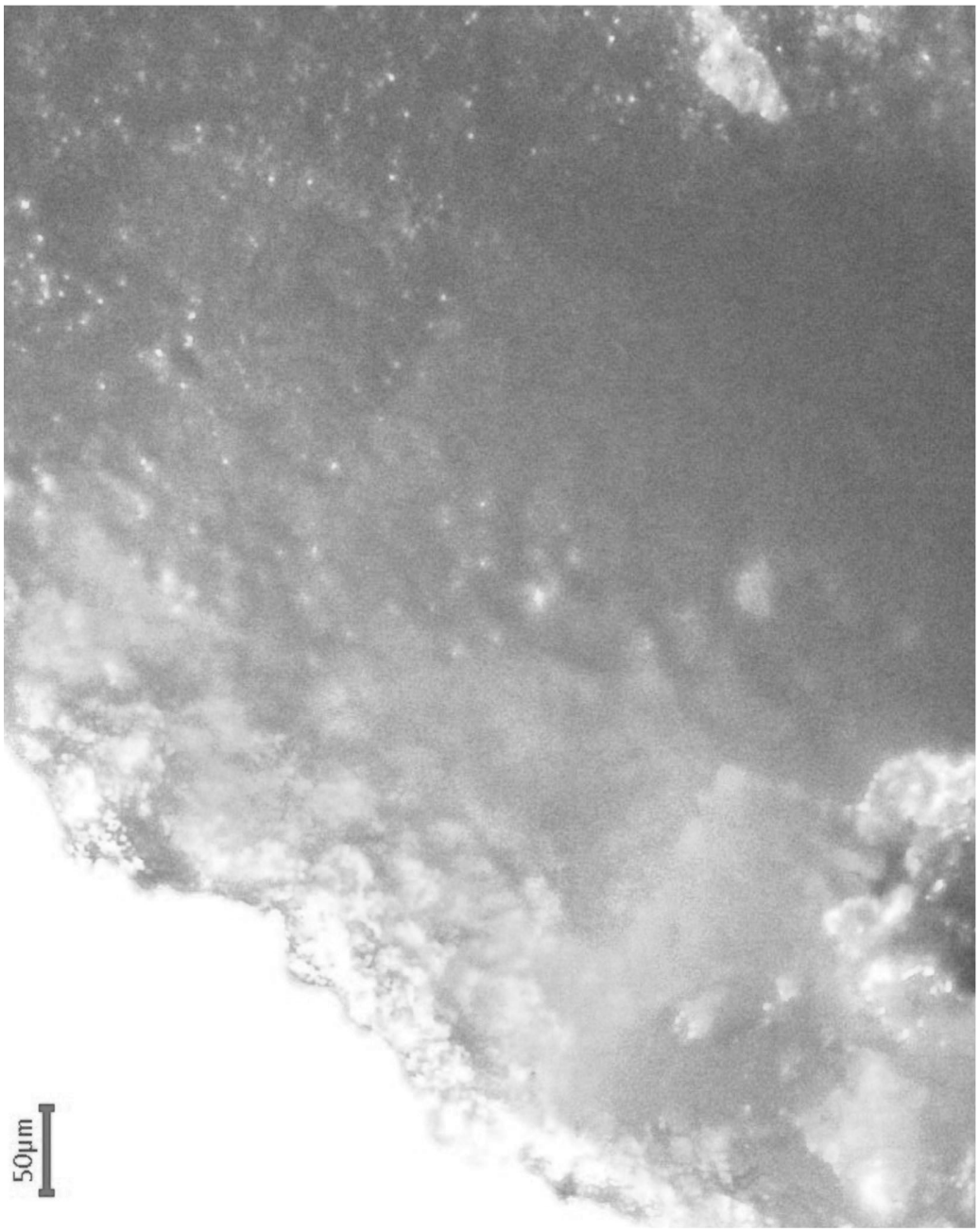


FIG. 5B



FIG. 6A

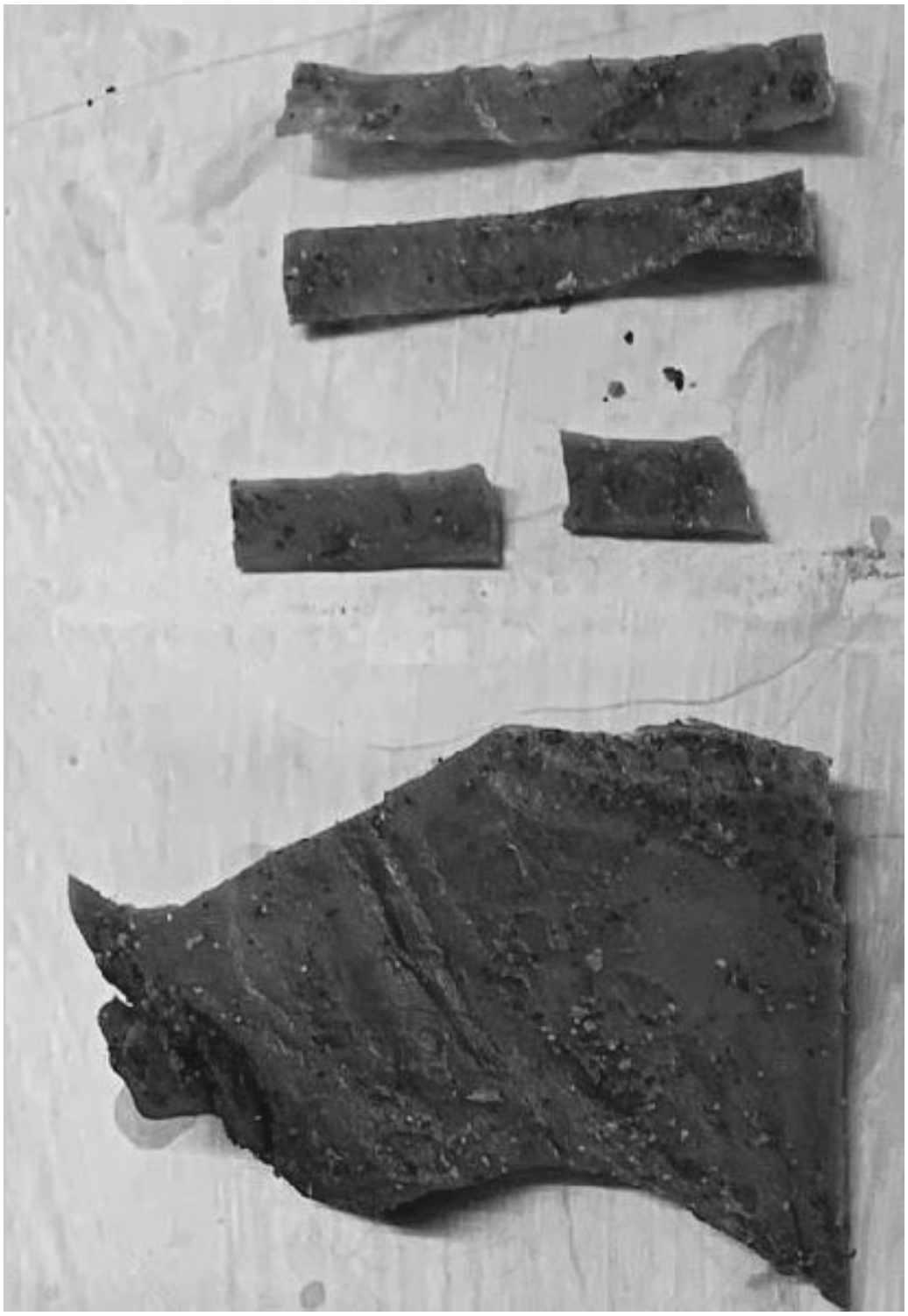


FIG. 6B

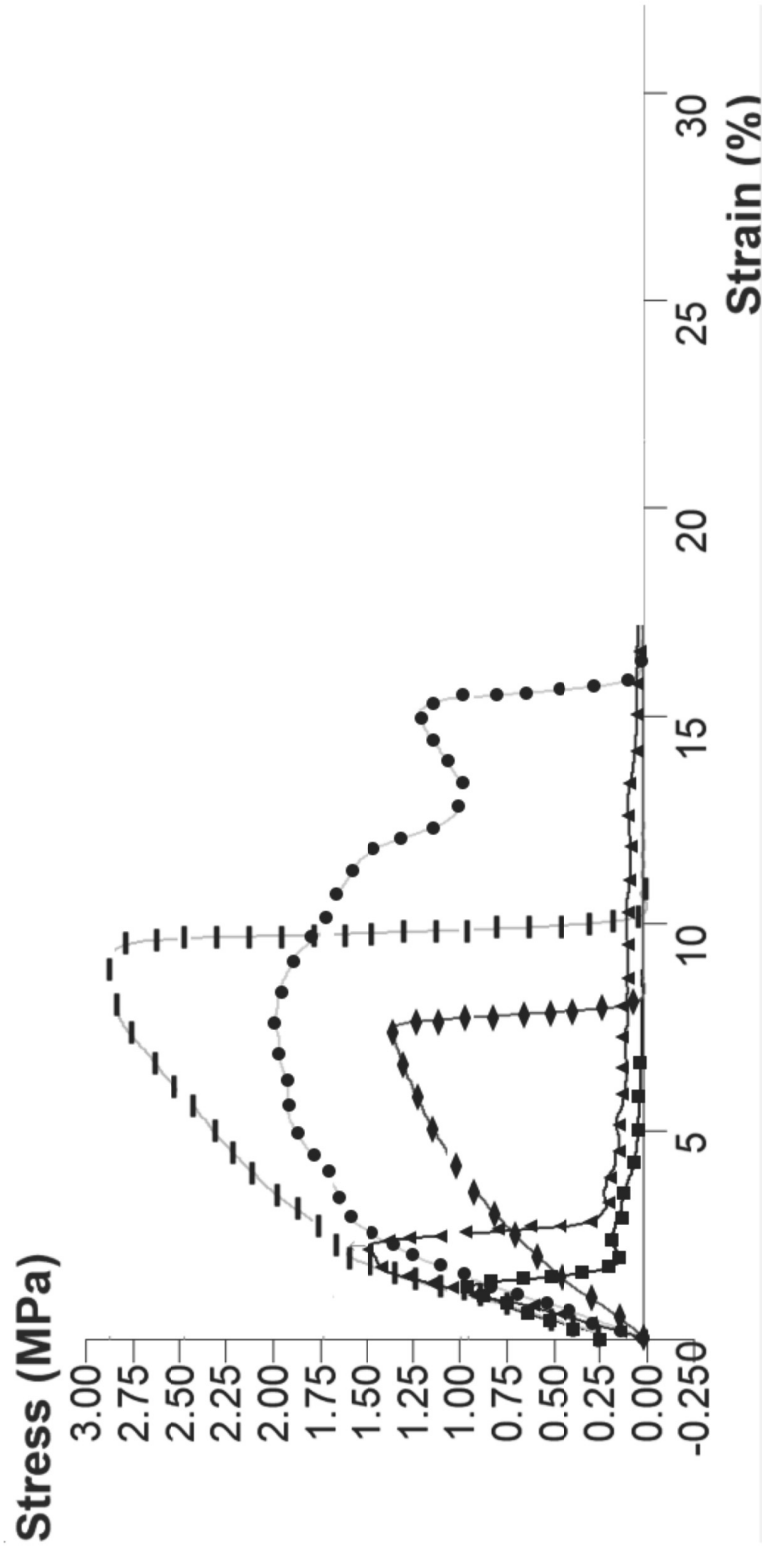

Stress (MPa)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.250
5
10
15
20
25
30
Strain (%)

FIG. 7

WIPO
WORLD
INTELLECTUAL PROPERTY
ORGANIZATION

DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

International application number:		**PCT/US2022/021369**
International filing date:		**22 March 2022 (22.03.2022)**
Document type:		**Certified copy of priority document**
Document details:	Country/Office:	**US**
	Number:	**63/164,466**
	Filing date:	**22 March 2021 (22.03.2021)**
Date of receipt at the International Bureau:		**07 April 2022 (07.04.2022)**

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-*bis*)

34, chemin des Colombettes
1211 Geneva 20, Switzerland
www.wipo.int

1199000

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

April 06, 2022

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *63/164,466*
FILING DATE: *March 22, 2021*
RELATED PCT APPLICATION NUMBER: *PCT/US22/21369*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US63/164,466*

Certified by

Performing the Functions and Duties of the
Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Baljit		Ghotra	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	Chicago	State/Province	IL	Country of Residence	US

Mailing Address of Inventor:

Address 1	315 West Pershing Road		
Address 2	Suite 4		
City	Chicago	State/Province	IL
Postal Code	60609	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Yuval		Avniel	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	Chicago	State/Province	IL	Country of Residence	US

Mailing Address of Inventor:

Address 1	315 West Pershing Road		
Address 2	Suite 4		
City	Chicago	State/Province	IL
Postal Code	60609	Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Brian		Klopf	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

City	Chicago	State/Province	IL	Country of Residence	US

Mailing Address of Inventor:

Address 1	315 West Pershing Road		
Address 2	Suite 4		
City	Chicago	State/Province	IL
Postal Code	60609	Country	US

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jessica		Kawabata	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Chicago	State/Province	IL	Country of Residence	US

Mailing Address of Inventor:

Address 1	315 West Pershing Road		
Address 2	Suite 4		
City	Chicago	State/Province	IL
Postal Code	60609	Country	US

Inventor 5 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Eric		Carre	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Grayslake	State/Province	IL	Country of Residence	US

Mailing Address of Inventor:

Address 1	1486 Prairie Trail		
Address 2			
City	Grayslake	State/Province	IL
Postal Code	60030	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

Customer Number	158864		
Email Address	docketing@sheridanross.com	Add Email	Remove Email

Application Information:

Title of the Invention	Food products comprising filamentous fungal material		
Attorney Docket Number	10087-35-PROV	**Small Entity Status Claimed**	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	158864		

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status [ ] Remove

Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Applicant:

Address 1			
Address 2			
City		**State/Province**	
Country		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet must be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Tyler J. Boschert/			Date (YYYY-MM-DD)	2021-03-22
First Name	Tyler	Last Name	Boschert	Registration Number	70791

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	10087-35-PROV
	Application Number	
Title of Invention	Food products comprising filamentous fungal material	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

FOOD PRODUCTS COMPRISING FILAMENTOUS FUNGAL MATERIAL

FIELD OF THE INVENTION

This application relates generally to food products comprising filamentous fungal material and methods for the manufacture thereof, and particularly to food products that may serve as analogs or replicas of conventional food products but having improved properties relative thereto.

BACKGROUND OF THE INVENTION

Many conventional processed food products, such as smoked meats or dehydrated meats e.g. meat jerky, include an allergenic substance and/or a substance that is derived or obtained from animals, and may therefore be unsuitable for consumption by persons with dietary restrictions, e.g. persons wishing to reduce or eliminate animal meat intake or with allergic sensitivities. Existing hypoallergenic or vegan alternatives to conventional processed food products often suffer from poor stability, unappealing taste or texture, and so on. Moreover, many of these conventional processed food products, as a result of processing conditions or requirements for attaining a particular taste, texture, or shelf life, have nutritional drawbacks; by way of non-limiting example, conventional meat jerky is often high in humectants, e.g. sugar, salt, etc. (which must be used in significant quantities during processing as a stabilizer and for its plasticizing effect to achieve jerky's characteristic tough texture), and smoked or otherwise processed conventional meat products are often high in fat (as a result of the fatty tissues from which they are obtained) and/or salt (for flavoring). Furthermore, because meat has a high moisture content and water activity, meat products either suffer from short shelf lives or must be dehydrated to a very substantial degree.

There is thus a need in the art for food products that are analogous in taste, texture, and other aesthetic and sensory characteristics to conventional processed food products, but that can be provided at lower cost and/or with an improved nutritional profile. It is further advantageous for such processed food products to be optionally free of allergenic or animal-derived products to allow these products to appeal to a wider range of potential consumers, and to remain stable over extended periods to provide for a longer usable shelf life, for example by having lower activity or moisture content and/or by including a coating or sealing layer to retain internal moisture and

provide a substantially hermetic barrier while avoiding colonization by microbes, while still retaining a desired texture.

SUMMARY OF THE INVENTION

In one aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomat with a solution; (b) size-reducing the filamentous fungal biomat to form a plurality of filamentous fungal pieces; and (c) treating the plurality of filamentous fungal pieces to form the food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomat prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomat.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomat together with the solution.

In embodiments, the filamentous fungal biomat may absorb or otherwise take up an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomat.

In embodiments, step (a) may comprise contacting at least two filamentous fungal biomats with the solution; the method may further comprise, between steps (a) and (b), aggregating the at least two filamentous fungal biomats to form a filamentous fungal aggregate; and step (b) may comprise size-reducing the filamentous fungal aggregate. The aggregate may, but need not, comprise a casing that encases the at least two filamentous fungal biomats. The aggregating step may, but need not, be carried out under sub-atmospheric pressure, which may, but need not, be a pressure of no more than about 0.1 pascals. The aggregating step may, but need not, comprise crust-freezing the at least two filamentous fungal biomats.

In embodiments, step (b) may comprise at least one of cutting, shredding, and shaving the filamentous fungal biomat. The plurality of filamentous fungal pieces may, but need not, comprise at least one of strips, shreds, and shavings of the filamentous fungal biomat.

In embodiments, at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces may be between about 0.5 mm and about 1.0 mm.

In embodiments, step (c) may comprise at least one of steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a filamentous fungal biomat with a solution; and (b) dehydrating the filamentous fungal biomat.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomat prior to contacting the solution.

In embodiments, step (a) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, step (a) may comprise the sub-step of removing water from the filamentous fungal biomat.

In embodiments, step (a) may be carried out by agitating the filamentous fungal biomat together with the solution.

In embodiments, the filamentous fungal biomat may absorb or otherwise take up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

In another aspect of the present invention, a method for preparing a food product comprises (a) contacting a first filamentous fungal biomat, or portion thereof, with a first solution; (b) size-

reducing the first filamentous fungal biomat, or portion thereof, to form a plurality of filamentous fungal pieces; (c) contacting a second filamentous fungal biomat, or portion thereof, with a second solution; (d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomat, or portion thereof; and (e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomat, or portion thereof, to form the food product.

In embodiments, the food product may be a meat jerky analog food product.

In embodiments, at least one of the first and second solutions may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, at least one of the following may be true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomat, or portion thereof, prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomat, or portion thereof, prior to step (c).

In embodiments, at least one of step (a) and step (c) may be carried out under sub-atmospheric pressure. The sub-atmospheric pressure may, but need not, be a pressure of no more than about 0.1 pascals.

In embodiments, at least one of the following may be true: (i) step (a) comprises the sub-step of removing water from the first filamentous fungal biomat, or portion thereof; and (ii) step (c) comprises the sub-step of removing water from the second filamentous fungal biomat, or portion thereof.

In embodiments, at least one of the following may be true: (i) step (a) is carried out by agitating the first filamentous fungal biomat, or portion thereof, together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomat, or portion thereof, together with the second solution.

In embodiments, at least one of the following may be true: (i) the first filamentous fungal biomat, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomat, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

In embodiments, at least one of the first and second solutions may be an aqueous solution.

In embodiments, at least one of the first and second solutions may be a non-aqueous solution.

In another aspect of the present invention, a meat jerky analog food product is made according to a method as described herein.

In embodiments, the meat jerky analog food product may have a water activity of less than about 0.45.

In embodiments, the meat jerky analog food product may have a shelf life of at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

In another aspect of the present invention, an intermediate food composition comprises a filamentous fungal biomat or a portion thereof; and a solution, absorbed or otherwise taken up by the filamentous fungal biomat or portion thereof.

In embodiments, the solution may comprise at least one of sodium chloride, a food seasoning, and an edible protein.

In embodiments, a mass of the solution may be between about 1% and about 30% of a mass of the filamentous fungal biomat or portion thereof.

In embodiments, the solution may be an aqueous solution.

In embodiments, the solution may be a non-aqueous solution.

The advantages of the present invention will be apparent from the disclosure contained herein.

As used herein, "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B, and C," "at least one of A, B, or C," one or more of A, B, and C," "one or more of A, B, or C," and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B, and C together.

It is to be noted that the term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more," and "at least one" can be used interchangeably herein. It is

also to be noted that the terms "comprising," "including," and "having" can be used interchangeably.

The embodiments and configurations described herein are neither complete nor exhaustive. As will be appreciated, other embodiments of the invention are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flowchart depicting a method for processing filamentous fungal material into a food product or material for use in a food product, according to embodiments of the present disclosure.

Figures 2A and 2B are flowchart depicting methods for processing a filamentous fungal food material, derived from a fungal biomat and processed according to the method depicted in Figure 1, into a meat jerky analog food product, according to embodiments of the present disclosure.

Figures 3A, 3B, and 3C are images of pieces of three jerky analog food products, according to embodiments of the present invention.

Figures 4A and 4B are microscopic images of a hydrophilic side of a jerky analog food product, according to embodiments of the present invention.

Figure 5A and 5B are microscopic images of a hydrophobic side and a hydrophilic side, respectively, of a jerky analog food product, according to embodiments of the present invention.

Figures 6A and 6B are images of fractured tensile strength testing specimens of jerky analog food products, according to embodiments of the present invention.

Figure 7 is a graph of tensile strength testing results of the specimens illustrated in Figures 6A and 6B.

DETAILED DESCRIPTION OF THE INVENTION

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art. All patents, applications, published applications, and other publications to which reference is made herein are incorporated by reference in their entirety. If there is a plurality of definitions for a term herein, the definition provided in the Summary of the Invention prevails unless otherwise stated.

As used herein, unless otherwise specified, the term "analog" or "analog food product" refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to an identified non-fungal food product. By way of non-limiting example, an "jerky food analog product," as that term is used herein, refers to a food product comprising edible fungi that bears an aesthetic, culinary, nutritional, and/or sensory equivalence or resemblance to conventional jerky made from animal meats.

As used herein, unless otherwise specified, the term "free water" refers to water molecules within a mass of material that are not chemically or physically hindered from being removed from the mass of material.

As used herein, unless otherwise specified, the term "physically bound water" refers to water molecules within a mass of material that are in physical contact with molecules of the material but are not chemically bound to the material.

As used herein, unless otherwise specified, the term "tightly bound water" refers to water molecules within a mass of material that are chemically bound by intermolecular forces, e.g. hydrogen bonding, ionic bonding, ion-dipole forces, van der Waals forces, etc., to molecules of the material.

As used herein, unless otherwise specified, the term "vegan" refers to a food product that is substantially free of food components or ingredients, such as protein, derived from animals. Specific examples of non-vegan food ingredients or products include blood, eggs, isinglass, meat (and components thereof, e.g. animal proteins or fats), milk, rennet, and foods made using any one or more of these ingredients (e.g. ice cream, mayonnaise, etc.). As disclosed herein, some vegan food products may be analogs of non-vegan food products.

As used herein, unless otherwise specified, the term "vegetarian" refers to a food product that is substantially free of meat and components thereof. "Vegetarian" food products, as that term is used herein, may (but need not) include food components or ingredients other than meat that are derived from animals (e.g. eggs, milk, etc.). Thus, as the terms are used herein, all "vegan" food products are "vegetarian," but not all "vegetarian" are necessarily "vegan."

Embodiments of the present invention include compositions comprising filamentous fungi, typically compositions comprising edible filamentous fungi, and most typically filamentous fungal food compositions, i.e. edible filamentous fungal compositions that are adapted for consumption by humans or domesticated, farmed (e.g. agriculture or aquaculture), or livestock animals, that

include filamentous fungal biomass. In some embodiments, the filamentous fungal food composition may be a food product that is analogous to a conventional or known food product comprising meat or another animal-derived ingredient, wherein the filamentous fungal biomass is provided in addition to or in lieu of the animal-derived ingredient. In embodiments, the filamentous fungal food composition of the present invention may be an analog of a meat product, such as, by way of non-limiting example, whole cuts of meat, ground meat (and products formed therefrom, e.g. meatballs), meatloaves, burger patties, shredded meat, jerky, and so on.

Embodiments of the present invention include food compositions comprising filamentous fungal biomass and a solution, commonly but not always an aqueous solution, comprising one or more food additives, such as, by way of non-limiting examples, salt, flavorings, vitamins, and nutritional components (e.g. carbohydrates, fats, proteins, etc.), in which the solution comprises about 5 wt%, about 10 wt%, about 15 wt%, about 20 wt%, about 25 wt%, about 30 wt%, about 35 wt%, about 40 wt%, about 45 wt%, or about 50 wt%, or alternatively in any range between 5 wt% and 50 wt%, or in any range from any whole number percentage by weight between 5 wt% and 50 wt% to any other whole number percentage by weight between 5 wt% and 50 wt% of the total food composition. One significant advantage and benefit of the present invention is that the filamentous fungal biomass present in the food compositions of the invention may have significantly greater ability to absorb or otherwise take up a solution, e.g. a "marinade" or similar solution applied to the fungal biomass to achieve a seasoning, flavoring, and/or nutritional objective and/or to define a textural property (e.g. chewiness, elasticity, mechanical behavior characteristics such as tendency to rip or tear, etc.), than conventional meat ingredients. Because the filamentous fungal biomass itself may have a moisture content of as much as 80 wt%, higher than most whole cuts of meat, even before a solution is applied thereto, the water content of food compositions, and particularly meat analog food products, of the invention may be advantageously high. Embodiments of the present invention further include methods of forming a food composition comprising filamentous fungal biomass and a solution as described above (e.g. by contacting filamentous fungal biomass with the solution and allowing the filamentous fungal biomass to absorb or otherwise take up the solution), and food compositions made by such methods. It is to be expressly understood that "food compositions," as that term is used herein unless otherwise specified, of the present invention may be "final" food compositions (i.e. compositions that are intended to be consumed by a human or a domesticated, farmed, or livestock

animal without further processing) or "intermediate" food compositions (i.e. compositions that are intended to be further processed and consumed by a human or a domesticated, farmed, or livestock animal only after further processing). Processing steps by which "intermediate" food compositions may become "final" food compositions according to the present invention include, but are by no means limited to, dehydration.

In embodiments, the filamentous fungal biomass may have a moisture content of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. In some embodiments, very little or none of the moisture present in the filamentous fungal biomass may be free water, or, in other words, the filamentous fungal biomass may have a total content of physically bound water and tightly bound water of at least about 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, or at least about 75 wt%. Without wishing to be bound by any particular theory, it is believed that the ability of the filamentous fungal food compositions of the invention to absorb or otherwise take up a solution is related primarily to the content of physically bound and tightly bound water and not necessarily to the total moisture content. Thus, even high-moisture filamentous fungal biomass may suitably be used in filamentous fungal food compositions of the invention and may absorb or take up a solution in significant quantities, so long as the proportion of moisture that is present as free water is relatively low.

One particular advantage and benefit of the methods and compositions of the present invention is that food compositions according to the invention may have advantageously high shelf stability, or, in other words, an advantageously long shelf life, especially as compared to conventional food products to which the filamentous fungal food compositions may be analogous (e.g. meat products), while reducing, or in some embodiments even eliminating, the use of preservatives or stabilizers that may adversely affect the aesthetic or nutritional properties of the food product. Without wishing to be bound by any particular theory, it is hypothesized that this advantage and benefit is, in at least some embodiments, a result of the precise control over the moisture content of the filamentous fungal biomass enabled by the methods of the invention, and in particular the ability to remove as much or as little of the free water within the filamentous fungal biomass (and optionally to replace the removed free water with other chemistries) as desired. By way of non-limiting example, conventional meat jerky products are extremely shelf-stable and may, under ambient conditions, have a shelf life of many months, but achieve this

stability only by including significant quantities of sugar, which acts as a plasticizer and stabilizer for the jerky product. Addition of sugar, however, has well-known nutritional drawbacks. The filamentous fungal food compositions of the present invention can overcome this drawback in any one of several ways, for example by using salt rather than sugar as a stabilizer, by using stabilizers in lesser amounts than analogous conventional food products, or by virtue of having a lower fat content (or other nutritional advantage) relative to true meat. In embodiments, food compositions of the present invention comprise filamentous fungal biomass and one or more food additives (e.g. salt, flavorings, vitamins, added carbohydrates, added fats, added proteins, etc.) and have a shelf life of at least about one week, at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months, while also including no more than 15 grams, no more than 14 grams, no more than 13 grams, no more than 12 grams, no more than 11 grams, no more than 10 grams, no more than 9 grams, no more than 8 grams, no more than 7 grams, no more than 6 grams, no more than 5 grams, no more than 4 grams, no more than 3 grams, no more than 2 grams, or no more than 1 gram of sugar per serving and/or a sugar content of no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, no more than about 5 wt%, no more than about 4 wt%, no more than about 3 wt%, no more than about 2 wt%, or no more than about 1 wt%. Particularly, food compositions of the present invention may have an "elastic" or "chewy" consistency and texture, and/or a "juiciness" or perceived amount or extent of moisture, analogous to conventional meat jerky products, while still possessing both an advantageously long shelf life and an advantageously low sugar content. These advantageously long shelf lives may, in embodiments, be a consequence of a low water activity, e.g. a water activity of less than about 0.95, less than about 0.90, less than about 0.85, less than about 0.80, less than about 0.75, less than about 0.70, less than about 0.65, less than about 0.60, less than about 0.55, less than about 0.50, less than about 0.45, less than about 0.40, less than about 0.35, less than about 0.30, less than about 0.25, less than about 0.20, less than about 0.15, less than about 0.10, or less than about 0.05.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavoring ingredients added to the filamentous fungal biomass may be enhanced relative to their perceptibility in both analogous conventional meat and dairy products and current vegan or vegetarian meat analog or dairy analog products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when salt is added to filamentous fungal biomass to form a food composition of the present invention, the resulting food composition is subjectively much "saltier" (i.e. has a greater gustatory perception of salt flavor) than a conventional meat product containing the same concentration of salt. Without wishing to be bound by any particular theory, it is believed that this result may be due to a lower fat content in filamentous fungal biomass than in meat (as fat may dull the perceptibility of salt in a food product) and/or due to the inherently "mild" or "neutral" flavor of filamentous fungal biomass compared to many types of meat. Regardless of the mechanism, however, this advantageous result allows flavoring additives to be used in lower quantities in the food compositions of the present invention than in conventional food products to which they may be analogous. In embodiments, filamentous fungal food compositions of the present invention may have a perceived saltiness comparable to a conventional meat product while including less than about 200 milligrams, less than about 190 milligrams, less than about 180 milligrams, less than about 170 milligrams, less than about 160 milligrams, less than about 150 milligrams, less than about 140 milligrams, less than about 130 milligrams, less than about 120 milligrams, less than about 110 milligrams, or less than about 100 milligrams of sodium per serving.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the perceptibility of flavors imparted to the food compositions due to a cooking or preparation process may be enhanced relative to their perceptibility in analogous conventional food products. By way of non-limiting example, the present inventors have unexpectedly discovered that, when filamentous fungal biomass is smoked to form a smoked food composition of the present invention, the resulting food composition is subjectively much "smokier" (i.e. has a greater gustatory perception of smoke flavor) than a conventional meat product smoked in the same way. Without wishing to be bound by any particular theory, it is believed that this result may be a result of either or both of (1) the use of porous filamentous fungal material, e.g. a filamentous fungal biomat, to allow molecules present in smoke, marinades, etc. to travel through the fungal material and adhere to surfaces thereof, and/or (2) the filamentous fungal biomass absorbing or

otherwise taking up smoke or components thereof (e.g. phenols, such as syringol, guaiacol, and pyrocatechol, and alkyl derivatives thereof) during the smoking process, which may in turn be due to a lower water content in the filamentous fungal biomass (whether inherently or as a result of a drying/dehydration process prior to smoking) making the filamentous fungal biomass more amenable to absorption of hydrophobic compounds in smoke than high-moisture cuts of meat. It may also be the case that, because filamentous fungal biomass has a lower fat content than meat, molecules present in smoke, marinades, etc. that impart flavor may adhere to, become entrenched in, or otherwise become present in the food composition in different locations or by different mechanisms. Regardless of the mechanism, however, this advantageous result allows filamentous fungal biomass in the food compositions of the present invention to be smoked or otherwise prepared for shorter times, at lesser intensity, with lesser environmental impact, etc. than in conventional food products to which they may be analogous, and/or for the food compositions of the present invention to have an enhanced, heightened, or intensified flavor relative to identically prepared conventional meat products. Further, filamentous fungal food compositions of the present invention may have a subjectively "smoky" flavor even when a fat content (which contributes to smoky flavor) of the food composition is much lower than that of an analogous meat product. In embodiments, filamentous fungal food compositions of the present invention may have a perceived smokiness comparable to a conventional smoked meat product while having a fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%. By comparison, smoked pork generally has a fat content of about 15 wt%, and beef brisket generally has a fat content of about 33 wt%.

Another advantage and benefit of the filamentous fungal food compositions of the present invention is that the filamentous fungal biomass may be more readily processed into a desired physical form, and thus require a lower content, or may even allow the complete omission, of binders, fillers, or similar functional materials, compared to meat or other plant- or fungus-based meat analog materials. Particularly, the present inventors have demonstrated that filamentous fungal biomass produced according to the present invention can be repeatedly frozen, thawed, dehydrated, etc. (as may be desirable for particular applications), and may in either fresh or frozen

form (or both) be amenable to pressing, molding, or otherwise shaping into a desired physical configuration without the addition of any binder. In embodiments, filamentous fungal food compositions of the present invention, and in embodiments, meat analog filamentous fungal food compositions, may comprise at least about 50 wt%, at least about 60 wt%, at least about 70 wt%, at least about 80 wt%, at least about 90 wt%, at least about 91 wt%, at least about 92 wt%, at least about 93 wt%, at least about 94 wt%, or at least about 95 wt% fungal biomass, and/or may comprise no more than about 10 wt%, no more than about 9 wt%, no more than about 8 wt%, no more than about 7 wt%, no more than about 6 wt%, or no more than about 5 wt% of binders, fillers, or similar functional materials. In some embodiments, the filamentous fungal food compositions of the present invention are substantially free of binders, fillers, or similar functional materials. This feature may be particularly advantageous where the filamentous fungal food composition is a meat analog food product, in which the total content of ingredients other than fungal biomass must be minimized.

Filamentous fungal food compositions according to the present invention may comprise any one or more forms or types of filamentous fungal biomass. By way of non-limiting example, forms or types of filamentous fungal biomass suitable for use in the food compositions of the present invention include, but are not limited to, processed biomats, fungal paste formed from biomats, unprocessed or "raw" biomats, and combinations and mixtures of these. By way of further non-limiting example, filamentous fungal biomass suitable for use in the food compositions of the present invention may be produced, instead of or in addition to surface fermentation processes that yield fungal biomats, any one or more other methods, e.g. a submerged fermentation process yielding a fungal paste, etc.; in some embodiments, it may even be possible to combine forms or types of filamentous fungal biomass produced by two or more different processes, e.g. any two or more of a liquid surface fermentation process, a solid surface fermentation process, an air-medium colloid fermentation process, a submerged fermentation process, etc. The ability to incorporate any of several forms or types of filamentous fungal biomass is therefore another advantage and benefit of the compositions and methods of the present invention.

Filamentous fungal food compositions according to the present invention may, in embodiments, comprise a highly dense fungal biomass, and in some embodiments a highly dense fungal biomat or portion thereof. Depending on the fungus and growth conditions, the filamentous fungal biomass may also exhibit a fibrous texture, which is an important consideration when

producing food compositions that require texture to simulate meat (i.e. a meat analog food product). The dense nature of the biomass can also enable easy harvesting, without the need for a concentration step (e.g., centrifugation, filtration) between harvesting of the biomass and processing into a food composition. The density of the biomass can range from about 0.01 g dry weight/cm^3 to about 1 g/cm^3, and any subrange within this range. In some embodiments, the density can be greater than about 0.01, greater than about 0.02, greater than about 0.03, greater than about 0.04, greater than about 0.05, greater than about 0.06, greater than about 0.07, greater than about 0.08, greater than about 0.09, greater than about 0.1, greater than about 0.2, greater than about 0.3, greater than about 0.4, greater than about 0.5, greater than about 0.6, greater than about 0.7, greater than about 0.8, greater than about 0.9, or greater than about 1 g/cm^3. In some embodiments, relatively dry fungal biomass may be ground or otherwise size-reduced into relatively fine particles, e.g. a filamentous fungal "flour," before being incorporated into the food composition of the invention; in these embodiments, densities in the above-referenced ranges or even higher may be achieved due to the packing density of the dry fungal flour.

Another advantage and benefit of the methods of manufacture of filamentous fungal food compositions according to the present invention is that material and/or mechanical properties of the filamentous fungal biomass as it is produced (e.g. in the form of a fungal biomat) may be preserved, or even enhanced, during processing into the filamentous fungal food composition. By way of first non-limiting example, the methods of manufacture disclosed herein may preserve or enhance a filamentous structure or network of a filamentous fungal biomat used to produce the food composition, which may be advantageous, for example, to maintain a high internal surface area suitable for absorption or other uptake of, e.g., flavoring or nutritional additives, smoke, etc. By way of second non-limiting example, the methods of manufacture disclosed herein may preserve or enhance the tensile strength of a filamentous fungal biomat used to produce the food composition. In embodiments, the filamentous fungal food composition, or a portion thereof comprising filamentous fungal biomass, may have a tensile strength of at least about 30 g/cm^2, at least about 40 g/cm^2, at least about 50 g/cm^2, at least about 60 g/cm^2, at least about 70 g/cm^2, at least about 80 g/cm^2, at least about 90 g/cm^2, at least about 100 g/cm^2, at least about 150 g/cm^2, at least about 200 g/cm^2, at least about 250 g/cm^2, at least about 300 g/cm^2, at least about 350 g/cm^2, at least about 400 g/cm^2, at least about 450 g/cm^2, at least about 500 g/cm^2, at least about 550 g/cm^2, or at least about 600 g/cm^2, or at least about 650 g/cm^2, or at least about 700 g/cm^2, or at

least about 750 g/cm^2, or at least about 800 g/cm^2, or at least about 850 g/cm^2, or at least about 900 g/cm^2, or at least about 950 g/cm^2, or at least about 1000 g/cm^2, or at least about 1500 g/cm^2, or at least about 2000 g/cm^2, or at least about 2500 g/cm^2, or at least about 3000 g/cm^2, or at least about 3500 g/cm^2, or at least about 4000 g/cm^2. In other embodiments, biomass of the invention (e.g. a fungal biomat) can have a tensile strength of greater than any whole number greater than 30 g/cm^2. Alternatively, the tensile strength of biomass of the invention (e.g. a fungal biomat) can be in a range of between about 30 g/cm^2 and about 4000 g/cm^2 or any whole number range between about 30 g/cm^2 and about 4000 g/cm^2. In embodiments in which the filamentous fungal biomass is produced as a biomat, the biomat may have sufficient tensile strength to be lifted essentially intact from the surface of a growth medium at the end of a growth period.

In many embodiments, the filamentous fungal biomass of the food composition will provide a substantial fraction of the protein in the food composition. Particularly, the filamentous fungal biomass may provide at least about 20 wt%, at least about 25 wt%, at least about 30 wt%, at least about 35 wt%, at least about 40 wt%, at least about 45 wt%, 50 wt%, at least about 55 wt%, at least about 60 wt%, at least about 65 wt%, at least about 70 wt%, at least about 75 wt%, at least about 80 wt%, at least about 85 wt%, at least about 90 wt%, at least about 95 wt%, at least about 96 wt%, at least about 97 wt%, at least about 98 wt%, at least about 99 wt%, or substantially all of the protein in the food composition. In some embodiments, the protein content of the filamentous fungal biomass may allow the filamentous fungal biomass to take the place of a protein-rich ingredient found in an analogous conventional food product, particularly an animal-derived ingredient (e.g. meat), whereas in other embodiments the filamentous fungal biomass may be provided in addition to or as a partial replacement for a protein-rich ingredient to augment the protein content of the food product. The filamentous fungal biomass may comprise at least about 20 wt%, at least about 21 wt%, at least about 22 wt%, at least about 23 wt%, at least about 24 wt%, at least about 25 wt%, at least about 26 wt%, at least about 27 wt%, at least about 28 wt%, at least about 29 wt%, at least about 30 wt%, at least about 31 wt%, at least about 32 wt%, at least about 33 wt%, at least about 34 wt%, at least about 35 wt%, at least about 36 wt%, at least about 37 wt%, at least about 38 wt%, at least about 39 wt%, at least about 40 wt%, at least about 41 wt%, at least about 42 wt%, at least about 43 wt%, at least about 44 wt%, at least about 45 wt%, at least about 46 wt%, at least about 47 wt%, at least about 48 wt%, at least about 49 wt%, at least about 50 wt%, at least about 51 wt%, at least about 52 wt%, at least about 53 wt%, at least about 54 wt%, at least

about 55 wt%, at least about 56 wt%, at least about 57 wt%, at least about 58 wt%, at least about 59 wt%, at least about 60 wt%, at least about 61 wt%, at least about 62 wt%, at least about 63 wt%, at least about 64 wt%, at least about 65 wt%, at least about 66 wt%, at least about 67 wt%, at least about 68 wt%, at least about 69 wt%, at least about 70 wt%, at least about 71 wt%, at least about 72 wt%, at least about 73 wt%, at least about 74 wt%, at least about 77 wt%, at least about 76 wt%, at least about 77 wt%, at least about 78 wt%, at least about 79 wt%, or at least about 80 wt% protein content. Alternatively, in embodiments of the invention, filamentous fungi can comprise protein in a range between 20 wt% and 80 wt% or in any whole number percentage range between 20 wt% and 80 wt%. As a result, the filamentous fungal food compositions of the present invention may thus have a notably high or enriched protein content. Thus, on a dry weight basis (or, in other words, at the same moisture content), the food compositions of the invention may be higher in protein than analogous conventional food products, and/or, by the same token, the food compositions of the invention may provide the same protein content as an analogous conventional food product in a smaller mass and/or serving size.

In addition to having a high overall protein content, filamentous fungal biomass in food compositions of the present invention may provide advantageous protein compositions or chemistries. By way of first non-limiting example, the filamentous fungal biomass may represent a "complete" protein source by providing all nine essential amino acids. By way of second non-limiting example, the filamentous fungal biomass may comprise at least one branched-chain amino acid (e.g. leucine, isoleucine, valine), and may in some embodiments contain such amino acids in amounts of at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may be lower in fat than analogous conventional food products. Particularly, the filamentous fungal food compositions of the present invention may have a total fat content of less than about 30 wt%, less than about 25 wt%, less than about 20 wt%, less than about 19 wt%, less than about 18 wt%, less than about 17 wt%, less than about 16 wt%, less than about 15 wt%, less than about 14 wt%, less than about 13 wt%, less than about 12 wt%, less than about 11 wt%, less than about 10 wt%, less than about 9 wt%, less than about 8 wt%, less than about 7 wt%, less than about 6 wt%, or less than about 5 wt%.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the filamentous fungi may be produced by methods that enable the filamentous fungi to contain functional compounds that may not be present in, or cannot be delivered by, conventional food products. By way of first non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more beneficial nutrients or compounds (vitamins, lipids, glycolipids, polysaccharides, sugar alcohols, ω-3 fatty acids, etc.) that may be taken up by the fungus and thus passed on to the consumer of the food composition. By way of second non-limiting example, the growth media in which filamentous fungi are produced may be imparted with any one or more compounds (e.g. pigments, inks, dyes, fragrances, etc.) that may be taken up by the fungus and improve an aesthetic or sensory quality of the filamentous fungus.

A further nutritional or compositional advantage provided by the food compositions of the present invention is that the compositions may be free of allergens, antibiotics, and/or animal-derived products that may otherwise prevent persons with allergenic sensitivities or dietary restrictions (e.g. vegans or vegetarians) from consuming analogous conventional food products. By way of non-limiting example, analogs of a wide variety of conventional meat products (e.g. smoked meat products, meat jerky, etc.) that are meat-free, that are optionally also lactose-free, egg-free, soy-free, and/or dairy-free, and/or that are further optionally vegan, may be produced according to the present invention. Even more advantageously, these problematic ingredients can in some embodiments be replaced by components having nutritional benefits, e.g. red meat may be replaced by fungal filaments or mycelia (i.e. tissues not having the potential adverse effects on cardiovascular health presented by red meat).

A further nutritional or compositional advantage provided by the food compositions of the present invention is that they may have an advantageously high content of dietary fiber to allow for the creation of high-fiber food products (and in particular high-fiber alternatives to or analogs of conventional food products, particularly conventional meat products, that may have lower fiber contents); in some embodiments, the filamentous fungal particles may comprise at least about 6 wt%, at least about 7 wt%, at least about 8 wt%, at least about 9 wt%, or at least about 10 wt% dietary fiber. A high fiber content may be advantageous for any one or more additional reasons not directly related to nutritional composition, e.g. improved hydration properties (such as decreased water activity to allow for easier preparation/storage and longer shelf life), increased

satiation or "fullness" upon eating (which may encourage consumers to eat more moderate portions and thereby aid in preventing or mitigating adverse health effects such as high cholesterol), improved digestibility, etc. Particularly, increased satiation or "fullness" may allow consumers to consume fewer total calories and thereby aid, for example, a dieting consumer in losing weight. The filamentous fungal food compositions of the invention may therefore be particularly suitable or advantageous for inclusion in known and/or commercially available weight loss diets or regimens.

In embodiments of the present invention, methods for preparing a filamentous fungal food composition comprise dehydrating a filamentous fungal biomass, in some embodiments a fungal biomat, at relatively low temperature, e.g. no more than about 165 °F, over a period of, e.g., between about 20 minutes and about 12 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydration of the filamentous fungal biomass, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal biomass while otherwise retaining the fungal material's basic structure.

The filamentous fungi suitable for use in the invention may be selected from the phyla or divisions zygomycota, glomermycota, chytridiomycota, basidiomycota or ascomycota. The phylum (or division) basidiomycota comprises, *inter alia*, the orders Agaricales, Russulales, Polyporales and Ustilaginales; the phylum ascomycota comprises, *inter alia*, the orders Pezizales and Hypocreales; and the phylum zygomycota comprises, *inter alia*, the order Mucorales. The edible filamentous fungi of the present invention may belong to an order selected from Ustilaginales, Russulales, Polyporales, Agaricales, Pezizales, Hypocreales and Mucorales.

In some embodiments, the filamentous fungi of the order Ustilaginales are selected from the family Ustilaginaceae. In some embodiments, the filamentous fungi of the order Russulales are selected from the family Hericiaceae. In some embodiments, the filamentous fungi of the order Polyporales are selected from the families Polyporaceae or Grifolaceae. In some embodiments, the filamentous fungi of the order Agaricales are selected from the families Lyophyllaceae, Strophariaceae, Lycoperdaceae, Agaricaceae, Pleurotaceae, Physalacriaceae, or Omphalotaceae. In some embodiments, the filamentous fungi of the order Pezizales are selected from the families

Tuberaceae or Morchellaceae. In some embodiments, the filamentous fungi of the order Mucorales are selected from the family Mucoraceae.

In some embodiments, the filamentous fungi may be selected from the genera Fusarium, Aspergillus, Trichoderma, Rhizopus, Ustilago, Hericululm, Polyporous, Grifola, Hypsizygus, Calocybe, Pholiota, Calvatia, Stropharia, Agaricus, Hypholoma, Pleurotus, Morchella, Sparassis, Disciotis, Cordyceps, Ganoderma, Flammulina, Lentinula, Ophiocordyceps, Trametes, Ceriporia, Leucoagaricus, Handkea, Monascus and Neurospora.

Examples of the species of filamentous fungi include, without limitation, Ustilago esculenta, Hericululm erinaceus, Polyporous squamosus, Grifola fondrosa, Hypsizygus marmoreus, Hypsizygus ulmariuos (elm oyster) Calocybe gambosa, Pholiota nameko, Calvatia gigantea, Agaricus bisporus, Stropharia rugosoannulata, Hypholoma lateritium, Pleurotus eryngii, Pleurotus ostreatus (pearl), Pleurotus ostreatus var. columbinus (Blue oyster),Tuber borchii, Morchella esculenta, Morchella conica, Morchella importuna, Sparassis crispa (cauliflower), Fusarium venenatum, Fusarium strain *MK7* (ATCC Accession Deposit No. PTA-10698), Disciotis venosa, Cordyceps militaris, Ganoderma lucidum (reishi), Flammulina velutipes, Lentinula edodes, Ophiocordyceps sinensis. Additional examples include, without limitation, Trametes versicolor, Ceriporia lacerate, Pholiota gigantea, Leucoagaricus holosericeus, Pleurotus djamor, Calvatia fragilis, Handkea utriformis, Rhizopus oligosporus, and Neurospora crassa.

In some embodiments, the filamentous fungus is a Fusarium species. In some embodiments, the filamentous fungus is the Fusarium strain MK7 (ATCC PTA-10698 deposited with the American Type Culture Collection, 1081 University Boulevard, Manassas, Virginia, USA). Strain MK7 was previously reported to be a *Fusarium oxysporum* strain. However, it has subsequently been identified as not being an *oxysporum* strain and is considered a novel strain of *Fusarium* that has been provisionally named *Fusarium* str. *flavolapis*. In some embodiments, the filamentous fungus is the Fusarium strain *Fusarium venenatum*.

Fungal biomass from which the filamentous fungal material in food compositions of the invention is derived may be produced by any known fermentation processes, such as, e.g., submerged, solid-state, or surface fermentation processes as described in PCT Application Publications WO 2017/151684, WO 2019/046480, or WO 2020/176758 or PCT Application PCT/US2020/064208, and/or a method as disclosed in PCT Application Publication

WO2019/099474. The entireties of all of the PCT applications referred to in this paragraph are incorporated herein by reference.

Food compositions, including but not necessarily limited to meat analog food products, according to the present invention may further include proteins, such as a hydrophobin. These are low molecular weight proteins, ranging from about 100 to 150 amino acids in length, and are amphipathic molecules that are capable of self-assembly at a hydrophobic-hydrophilic interface into amphipathic films. Various uses for hydrophobins have been described in the art, including as emulsifiers, thickeners, or surfactants; for hydrophilizing hydrophobic surfaces; for improving the water stability of hydrophilic substrates; and for preparing oil-in-water emulsions or water-in-oil emulsions, and they have applications in pharmaceutical and cosmetic as well as food compositions. In food products, hydrophobins have been shown to impact the formation and stability of air bubbles, thus assisting in foamability and foam stabilization (for instance, hydrophobins provide foam volume stability and inhibition of coarsening of foods), inhibiting growth of ice crystals in frozen food products, and affecting agglomeration of fats, thus improving the texture, stability, and storage time of aerated and/or frozen food compositions.

Accordingly, some embodiments of the present invention may include a hydrophobin. Hydrophobins are generally classified into class I and class II; while class I hydrophobins are relatively insoluble, class II hydrophobins readily dissolve in a variety of solvents and therefore are generally preferred. Hydrophobins and like proteins have been identified in filamentous fungi and bacteria, and their sequences are described in the art. All of these proteins, including class I and class II hydrophobins, are encompassed by the present invention. Hydrophobins suitable for use in the present invention may be isolated from natural sources, or by recombinant means. In some embodiments, the hydrophobins may be added to the food compositions as purified proteins. In some embodiments, the hydrophobins may be expressed by the filamentous fungal species used in the food composition and thus supplied as part of the fungal biomass.

Referring now to Figure 1, a method 100 for making a shredded meat analog food product, according to an embodiment of the present invention, is illustrated. As shown in Figure 1, the method 100 comprises a biomat production step 110, a steaming step 120, a refrigeration step 130, a solution preparation step 135, a cold vacuum agitation step 140, a vacuum shaping step 150, a crust freezing step 160, a size reduction step 170, and an optional post-processing step 180.

In the biomat production step 110 of the method 100, a biomat of filamentous fungus is produced by any suitable method as known and described in the art, such as, by way of non-limiting example, a surface fermentation method as described in PCT Application Publication 2020/176758.

In the steaming step 120 of the method 100, the filamentous fungal biomass produced in step 110 is steamed to inactivate the filamentous fungus. The filamentous fungal biomass may be the filamentous fungal biomat itself, or may be relatively large (e.g. about 3 to about 5 inches wide) pieces thereof; it is to be expressly understood that size reduction of the biomat, if carried out at this stage of the method 100, may be undertaken before, simultaneous with, and/or after steaming step 120.

In the refrigeration step 130 of the method 100, the filamentous fungal biomass is cooled to a temperature of about 34 °F. The refrigeration step 130 ensures complete inactivation of the filamentous fungus and hardens (and thereby improves the workability) of the filamentous fungal biomass for downstream processing steps.

In the solution preparation step 135 of the method 100, one or more food additives (e.g. salt, seasonings, nutritional additions, etc.) are dissolved and/or suspended in water. Preferably, the solution prepared in solution preparation step 135 is provided below room temperature (e.g. at a temperature of about 40 °F; the solution may be cooled before, simultaneous with, or after addition of the food additive solutes to water. Solution preparation step 135 may be carried before, simultaneous with, or after refrigeration step 130.

It is to be expressly understood that, although not illustrated in Figure 1 or provided for in the embodiment of the method 100 depicted therein, the solution prepared in solution preparation step 135 need not always be aqueous, and/or may include one or more solvents in addition to water. By way of non-limiting example, such solvents may include cooking oils, an oleovitamin solution, and the like. Embodiments in which the solution prepared in solution preparation step 135 is non-aqueous are therefore expressly contemplated as within the scope of the present invention.

In the cold vacuum agitation step 140 of the method 100, the refrigerated filamentous fungal biomass produced in step 130 and the cold aqueous solution prepared in step 135 and placed together in a vacuum tumbler under refrigeration (i.e. at a temperature of no more than about 40 °F). The atmosphere in the vacuum tumbler is then evacuated to leave a low vacuum (i.e. an absolute pressure of between about 3 kilopascals and about 100 kilopascals), a medium vacuum

(i.e. an absolute pressure of between about 100 millipascals and about 3 kilopascals), a high vacuum (i.e. an absolute pressure of between about 100 nanopascals and about 100 millipascals), an ultra-high vacuum (i.e. an absolute pressure of between about 100 picopascals and about 100 nanopascals), or an extremely high vacuum (i.e. an absolute pressure of less than about 100 picopascals) in the tumbler. The filamentous fungal biomass and the aqueous solution are then agitated together to allow the aqueous solution to permeate the filamentous fungal biomass. Those skilled in the art will understand how to select appropriate agitation times, methods, and speeds; by way of non-limiting example, the vacuum tumbler may be a rotary tumbler, and the filamentous fungal biomass and aqueous solution may be rotated together at a speed of between about 7 RPM and about 10 RPM for a total time of about 40 minutes. It is to be expressly understood that the filamentous fungal biomass and aqueous solution may be agitated two or more times, with rest periods between periods of agitation, as may be appreciated by those skilled in the art. As a result of cold vacuum agitation step 140, the filamentous fungal biomass will absorb or otherwise take up at least a portion of the aqueous solution.

Where the filamentous fungal biomass is in the form of a biomat or relatively large pieces thereof, the sub-atmospheric pressure of cold vacuum agitation step 140 may affect any one or more of several physical properties of the biomat. By way of non-limiting example, exposure to this high-vacuum environment may enlarge spaces between fungal mycelia in the matrix of the biomat, increasing the surface area of mycelia available for contact with the aqueous solution. This effect may, without wishing to be bound by any particular theory, explain the observation by the present inventors that filamentous fungal biomass agitated with an aqueous solution comprising salt in cold vacuum agitation step 140 tasted much saltier than expected; it is possible that increased mycelial surface area in contact with the salty aqueous solution allowed for a greater proportion of salt to be deposited on the surface of fungal mycelia, and/or increased the time required for the salt deposited on the surface of fungal mycelia to be transferred to the taste buds of the consumer upon consumption. In this way, it may be possible for filamentous fungal food compositions according to the present invention to have the further advantage and benefit of delivering a flavor to a consumer over a longer time.

In the vacuum shaping step 150 of the method 100, the filamentous fungal biomass, having absorbed or otherwise taken up at least some portion of the aqueous solution, is placed in a cavity or mold, and the atmosphere surrounding the cavity or mold is evacuated to leave a high vacuum

(i.e. an absolute pressure of no more than about 0.1 pascals). This allows the filamentous fungal biomass to be placed in a desired physical configuration and/or to undergo various physical deformations or operations; by way of non-limiting example, where it is desired to produce a sausage analog food product, the filamentous fungal biomass may be stuffed into a casing. The vacuum shaping step 150 may also affect the density of the filamentous fungal biomass and/or properties of a mycelial network thereof, which may, by way of non-limiting example, further increase mycelial surface area and/or permeability of the fungal biomass for application of further functional or nutritional additives. It is therefore to be expressly understood that the filamentous fungal biomass may, but need not, be contacted with one or more flavorings or other functional or nutritional additives, whether in a solid, liquid, or gas form, as part of vacuum shaping step 150.

It is to be expressly understood that, in the practice of the method 100, cold vacuum agitation step 140 and vacuum shaping step 150 may be repeated as many times as necessary. Particularly, where it is desirable to coat or impregnate a functional coating or additive onto or into any one or more of (1) spaces between fungal filaments, e.g. pores in a fungal biomat, (2) the surfaces of fungal filaments, and/or (3) the interiors of fungal filaments, repeated vacuum agitation steps 140 and/or vacuum shaping steps 150 may be necessary to ensure complete absorption by, or coating or coverage of, the fungal mycelia.

Without wishing to be bound by any particular theory, it is believed that one functional benefit of the sub-atmospheric pressure applied to filamentous fungal biomass in cold vacuum agitation step 140 and vacuum shaping step 150 is that these pressures cause the fungal biomass to expand, thereby increasing the volume of interstitial spaces between hyphae and other fungal structures. As a result, additives applied during these steps may more readily infiltrate these spaces. Subsequently, when the mat is once again exposed to ambient or atmospheric pressures, the fungal biomass contracts, thus causing the additive(s) present in the interstitial spaces to be firmly entrapped within the fungal biomass.

In the crust freezing step 160 of the method 100, the shaped filamentous fungal biomass is placed in a blast freezer and rapidly cooled to an internal temperature of between about 25 °F and about 27 °F. This temperature range has been found by the present inventors to provide optimum conditions for the processing steps of the method 100 that follow.

In the size reduction step 170 of the method 100, the blast-frozen filamentous fungal biomass is cut, shredded, and/or shaved into smaller pieces suitable for use as a shredded meat

analog. Most typically, the strips, shreds, or shavings of filamentous fungal biomass will preferably have a thickness of between about 0.5 millimeters and about 1 millimeter, as this range is most analogous to conventional shredded meat products. Any size-reducing means, including but not necessarily limited to a gravity slicer or conventional deli meat slicer, may be used to carry out size reduction step 170.

In the optional post-processing step 180 of the method 100, the size-reduced filamentous fungal biomass may be subjected to any one or more forms of post-processing analogous to those used to prepare smoked or cured meat products or similar. By way of first non-limiting example, the size-reduced filamentous fungal biomass may be vacuum-steamed (e.g. to an internal temperature of about 85 °C for a period of about 12 minutes) to form a steamed meat analog food product. By way of second non-limiting example, the size-reduced filamentous fungal biomass may be cold-smoked (e.g. for a period of about four hours at a temperature of about 90 °F) to form a cold-smoked meat analog food product. By way of third non-limiting example, the size-reduced filamentous fungal biomass may be hot-smoked (e.g. for a period of about two hours at a temperature of about 230 °F) to form a hot-smoked meat analog food product. In general, any form(s) of post-processing to which a raw whole cut of meat or raw shredded meat may be subjected can be applied, *mutatis mutandis*, to the size-reduced filamentous fungal biomass to form an analogous filamentous fungal food product.

In some embodiments, size reduction step 170 and/or post-processing step 180 may comprise extruding a fungal paste into long strips. This extrusion step may be carried out by any suitable device or method and may be particularly suitable or advantageous, by way of non-limiting example, to provide a food composition having a desired cross-sectional shape (especially if the desired cross-sectional shape is intricate or complex), to prevent (or deliberately impart) a selected type of physical stress (e.g. compressive stress, shear stress, etc.) to the food composition, to improve a finished appearance of the food composition, and/or to create a food composition that is analogous in appearance or structure to a conventional food product that is ordinarily provided in thin or narrow strips (e.g. jerky, bacon, etc.).

Referring now to Figures 2A and 2B, a method 200 for making a meat jerky analog food product according to an embodiment of the present invention, is illustrated. As shown in Figures 2A and 2B, the method 200 comprises a marinade preparation step 210, a coating step 220, and a dehydrating step 230.

In the marinade preparation step 210 of the method 200, a marinade in which a filamentous fungal food material produced according to the method 100 illustrated in Figure 1 will be marinated, is prepared. Such a marinade can include any one or more ingredients commonly found in marinades for conventional meat products, including but not necessarily limited to meat jerky. As in conventional meat marination processes, marinades prepared according to marinade preparation step 210 will be liquids adapted to impart flavor to and/or tenderize or otherwise impart texture to the filamentous fungal biomass; as such, the marinades may (but need not) include one or more acidic ingredients (e.g. vinegar, lemon juice, wine) and/or one or more enzymatic ingredients (e.g. pineapple, papaya, yogurt, ginger), and may further include oils, herbs, and/or spices to further flavor the filamentous fungal biomass. Those skilled in the culinary arts will readily understand how to prepare an appropriate marinade according to marinade preparation step 210.

In the coating step 220 of the method 200, a filamentous fungal food material produced according to the method 100 illustrated in Figure 1 is marinated in, i.e. coated with, the marinade prepared in marinade preparation step 210, either at room temperature or under refrigeration. (Thus, any one or more steps 210, 220, 230 of method 200 can be considered a post-processing step 180 of method 100.) Most commonly, the coating step 220 may be carried out for a period of between about two seconds and about two days (i.e. as is typical of marination processes for conventional meat jerky products) at any temperature within a wide range (e.g. under refrigeration to at least as low as about 0 °C, at ambient temperatures, and/or under elevated temperatures of at least as high as about 40 °C), but in some embodiments, because filamentous fungal biomass does not spoil as readily as meat (whether at room temperature or under refrigeration), the coating step 220 may be carried out for a longer time to further impart flavor and/or tenderize the biomass. Without wishing to be bound by any particular theory, variations in coating step 220 temperatures and times may affect the internal structure of the filamentous fungal biomass and thus allow for different extents to which marinade is "entrapped" within the biomass. Coating step 220 may or may not include agitation or mixing of the filamentous fungal food material with the marinade, but it is generally desirable to ensure that substantially all sides and/or surfaces of the filamentous fungal food material are coated with the marinade, whether by agitation/mixing or by providing enough of the marinade in an appropriate vessel to completely soak or submerge the filamentous fungal food material. The coating step 220 may additionally or alternatively comprise any other

means of coating the fungal biomass with the marinade, e.g. dipping the fungal biomass in the marinade, spraying the fungal biomass with the marinade (with or without subsequent drying), etc.

In some embodiments, coating step 220 optionally may, but need not, comprise application of a stabilizer or mold inhibitor, e.g. potassium sorbate, to further increase the shelf life of the resulting food composition; in some embodiments, the stabilizer or mold inhibitor may also have an aesthetic or sensory benefit (e.g. potassium sorbate is a salty-tasting compound that stimulates salivation and contributes to a salty flavor). It is to be expressly understood, however, that application of a stabilizer and/or mold inhibitor may be omitted, and it may be preferable to omit this application in some embodiments.

In the dehydrating step 230 of the method 200, the filamentous fungal food material produced according to the method 100 illustrated in Figure 1 is dehydrated at relatively low temperature, e.g. no more than about 165 °F, over a period of between about 20 minutes and about 12 hours, and most commonly between about 2 hours and about 5 hours. Typically, a low-temperature drying oven or dehydrator may be employed to carry out dehydrating step 230, as may a smoker, a vacuum dehydration system, tumble-drying (at either ambient pressure or under vacuum), or any other suitable apparatus or method for lowering the moisture content and water activity of the filamentous fungal food material while otherwise retaining the fungal material's basic structure.

The difference between the two embodiments of the method 200 illustrated in Figures 2A and 2B is in the ordering of steps—coating step 220 may be carried out before dehydrating step 230, as in Figure 2A, or vice versa, as in Figure 2B. Which method 200 is employed will depend on the desired texture of the resulting meat jerky analog food product; the method illustrated in Figure 2A will generally yield a "chewy" texture akin to a true meat jerky, whereas the method illustrated in Figure 2B will generally yield a "crispy" texture like that of a potato or tortilla chip. This flexibility in the ordering of steps is yet another benefit of the present invention, in that the method 200 can be used to produce a true jerky analog food product, or alternatively a novel food product having a combination of meat jerky flavor with a "crispy," chip-like texture that may not be attainable using meat. In practice, the methods 200 of Figures 2A and 2B are, or may be, generally identical, with the exception that, because the marinade prepared in marinade preparation step 210 generally has a high moisture content, dehydrating step 230 may be carried out for a

longer time (typically four to five hours) if preceded by the coating step 220 and for a shorter time (typically two to three hours) if preceding the coating step 220.

The invention is further described by the following illustrative, non-limiting Examples.

Example 1

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1. Subsequently, a marinade comprising 8.6 wt% nutritional yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The pieces of marinated filamentous fungal food material were then placed on trays, with care taken to ensure that no two pieces touched each other, and dehydrated in a conventional dehydrator at 160 °F for between four and five hours. The resulting meat jerky analog food product had a taste like that of a conventional beef jerky and a similarly analogous chewy texture.

The meat jerky analog food product was found to have a water activity of 0.4894 and a moisture content of 14.09 wt%. These values are comparable to, or even better (i.e. drier) than, a conventional meat jerky food product.

Example 2

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1 and placed on trays, with care taken to ensure that no two pieces touched each other. The pieces of filamentous fungal food material were then dehydrated in a conventional dehydrator at 160 °F for between two and four hours. Subsequently, a marinade comprising 8.6 wt% nutritional yeast, 5.2 wt% garlic powder, 25 wt% olive oil, 47 wt% tamari soy sauce, 9.4 wt% maple syrup, 4 wt% ground black pepper, and 0.8 wt% paprika was prepared by mixing all ingredients together until homogeneous. The dehydrated filamentous fungal food material was then thoroughly coated with this marinade such that the marinated filamentous fungal food material comprised a fungal biomass : marinade weight ratio of 19:1 (i.e. 95 wt% fungal biomass to 5 wt% marinade). The resulting meat jerky analog food product had a taste like that of a

conventional beef jerky, but, rather than exhibiting a typical "chewy" meat jerky texture, instead had a "crispy" texture like that of a potato or tortilla chip.

Example 3

Pieces of a filamentous fungal food material were produced according to the method 100 illustrated in Figure 1 and subsequently dehydrated in a conventional dehydrator at 160 °F for two hours, without prior marination. After dehydration, some pieces of Jerky A were marinated with the marinade of Examples 1 and 2 ("Jerky A"), while others were left unmarinated and instead placed in a bath of room-temperature water for two hours ("unmarinated Jerky A"). The marinated pieces made according to this Example are referred to hereinafter as "Jerky A." Separately, two other jerky analog products were produced: a jerky analog product produced according to a second run of the method described in Example 1 ("Jerky C") and a jerky analog product produced according to the method described in Example 1, except that the filamentous fungal biomass was vacuum-tumbled with the marinade for 30 minutes rather than being surface-coated ("Jerky B"). In Jerkies B and C, the amount of marinade relative to the fungal biomass was also varied relative to the method described in Example 1; specifically, the fungal biomass was marinated in an equal (1:1) mass of marinade.

Samples of each of marinated Jerky A, Jerky B, and Jerky C were weighed before marination (i.e. fungal biomass only), with applied marinade before dehydration, and after dehydration. The water activity and moisture content of each jerky after dehydration was then assessed. All three jerkies were made using filamentous fungal biomass taken from a fungal biomat having a starting moisture content of 79.84%. The results of these tests are given in Table 1.

Table 1

	Jerky A	**Jerky B**	**Jerky C**
Pre-marination mass (fungus only)	95.4 g	95 g	91.5 g
Post-marination mass (before dehydration)	n/a	165.5 g	165.7 g
Post-dehydration mass	24.7 g	67.72 g	73.14 g
Post-dehydration water activity	0.64	0.371	0.459
Post-dehydration moisture content	28.89%	20.17%	23.58%

Images of samples of unmarinated Jerky A, Jerky B, and Jerky C are shown in Figures 3A, 3B, and 3C, respectively. The densities of Jerkies B and C were recorded as 0.74 and 0.73 g/cm^3, respectively.

The three jerkies differed greatly in their qualitative sensory impressions. Jerky A was observed to extremely crispy and brittle, with a tendency to undergo glass-like shattering, and had the least flavor even when marinade was applied. Jerky B was thin and crispy (though less so than Jerky A), with increased marinade flavor compared to Jerky A. Jerky C was by far the most similar in sensory evaluation to a conventional, shelf-stable, soft, chewy meat jerky; it was chewier and softer than Jerkies A and B and had a strong spicy and smoky flavor imparted by the marinade.

Example 4

Three unmarinated samples of Jerky A produced in Example 3 were placed into a room-temperature water bath for 30 minutes, 1 hour, and 2 hours, respectively, and weighed both before and after rehydration to determine the water reuptake capabilities of Jerky A. The results are given in Table 2.

Table 2

Time in water	30 minutes	1 hour	2 hours
Pre-dehydration mass	NR	NR	5.04 g
Pre-rehydration mass	2.01 g	2.72 g	1.37 g
Post-rehydration mass	4.89 g	7.44 g	3.77 g
% mass increase	243%	274%	275%
% original water	NR	NR	74.8%

Air bubbles were observed when dry jerky products were immersed in water, showing very active rehydration of all samples tested.

Without wishing to be bound by any particular theory, the present inventors hypothesize that tightly bound water is, for the most part, not removed during dehydration in all samples. However, physically bound water and free water, held in, e.g., the capillaries and porous structure of the fungal biomass adds to the range of texture development in jerky products. While the moisture content of the dried jerky products is 24% ± 4%, their water activities (reported in Example 3) show that jerkies with a wide range of textures can be produced. The subsequent rehydration of the jerky products highlights the novel porous structure of the jerky products, where water droplets can be held and contribute to the plasticized properties of the jerky products. During this subsequent rehydration, liquid can enter the fungal structure where free water was previously present, but some physically bound water (~25 wt% of the total water) cannot be regained due to loss of fungal structures during dehydration. This mechanism would account for reuptake of less

than all of the starting mass of moisture during rehydration. Thus, the present invention can be viewed as providing a method to maintain the porous structure of filamentous fungal biomass during dehydration, and particularly to leverage this porous structure to precisely control and/or select a desired extent of liquid removal from the fungal material. In this way, a desired water activity, e.g. of less than about 0.45, can be selected.

Example 5

Microscopic images of a whole piece of Jerky C were taken from a portion of the piece corresponding to a hydrophilic side of the filamentous fungal biomat. These images are shown as Figures 4A (light both above and below the sample) and 4B (light below the sample only). These images show small holes in the post-dehydration biomat. Without wishing to be bound by any particular theory, these images support the hypothesis that, while some fungal mat structure may be destroyed during processing, most of the mat structure may remain intact.

The Jerky C piece was then laid flat, and two parallel lines, lying close to one another, were cut using a utility knife. The sample was then turned onto the side on which the knife passed. This procedure allowed the capture of two microscopic images: one of a hydrophobic side of the jerky piece (Figure 5A) and one from a hydrophilic side (Figure 5B).

In Figure 5A, the center or innermost part of the sample is on the left side of the image, while the edge of the sample is on the right side of the image. As Figures 5A and 5B illustrate, the smallest degree of structural deformation is observed near the center of the sample, with deformation increasing (e.g. larger pores) toward the edge of the sample.

In Figure 5B, the left side of the image represents the opposite edge of the sample relative to Figure 5A. The structure appears significantly denser. Without wishing to be bound by any particular theory, it is believed that the hydrophilic side of a filamentous fungal biomat, which grows submersed in or on the surface of a liquid (aqueous) growth medium, grows to have a denser structure because the hydrophobic (i.e. atmosphere-facing) side of the biomat is where aerial hyphae, having a filamentous structure, are formed.

Example 6

Pieces of unmarinated Jerky A, Jerky B, and Jerky C were prepared for tensile strength and strain-at-break testing. It was quickly discovered that pieces of unmarinated Jerky A could not be

tested due to their brittleness; these samples were either impossible to cut for testing or would shatter when placed in the grips of the testing apparatus. Pieces of Jerky B were noticeably brittle, but flat sections of the pieces were malleable enough to allow for cutting of testing samples, and Jerky B was found to have a maximum tensile strength of 1.10 ± 0.51 MPa and a strain at break of $1.75\% \pm 0.71\%$. Pieces of Jerky C were much more malleable, making them much easier to cut samples from, and Jerky C was found to have a maximum tensile strength of 1.98 ± 0.66 MPa and a strain at break of $8.08\% \pm 0.81\%$.

The specimens tested for tensile strength and strain at break are shown in Figure 6 (Jerky B on left, Jerky C on right). As Figure 6 clearly illustrates, Jerky B exhibited brittle fractures, while Jerky C exhibited more elastic fractures. The stress-strain curves for two tested samples of Jerky B and three tested samples of Jerky C, shown in Figure 7, confirm this observation.

The invention illustratively disclosed herein suitably may be practiced in the absence of any element which is not specifically disclosed herein. It is apparent to those skilled in the art, however, that many changes, variations, modifications, other uses, and applications of the invention are possible, and changes, variations, modifications, other uses, and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is limited only by the claims which follow.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description of the Invention, for example, various features of the invention are grouped together in one or more embodiments for the purpose of streamlining the disclosure. The features of the embodiments of the invention may be combined in alternate embodiments other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description of the Invention, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations, combinations, and modifications are within the scope of the invention, e.g. as may be within the skill and knowledge

of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps to those claimed, regardless of whether such alternate, interchangeable, and/or equivalent structures, functions, ranges, or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

CLAIMS

1. A method for preparing a food product, comprising:

(a) contacting a filamentous fungal biomat with a solution;

(b) size-reducing the filamentous fungal biomat to form a plurality of filamentous fungal pieces; and

(c) treating the plurality of filamentous fungal pieces to form the food product.

2. The method of claim 1, wherein the solution comprises at least one of sodium chloride, a food seasoning, and an edible protein.

3. The method of claim 1, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomat prior to contacting the solution.

4. The method of claim 1, wherein step (a) is carried out under sub-atmospheric pressure.

5. The method of claim 4, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

6. The method of claim 1, wherein step (a) comprises the sub-step of removing water from the filamentous fungal biomat.

7. The method of claim 1, wherein step (a) is carried out by agitating the filamentous fungal biomat together with the solution.

8. The method of claim 1, wherein the filamentous fungal biomat absorbs or otherwise takes up an amount of the solution equal to at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the weight of the filamentous fungal biomat.

9. The method of claim 1, wherein step (a) comprises contacting at least two filamentous fungal biomats with the solution, wherein the method further comprises, between steps (a) and (b), aggregating the at least two filamentous fungal biomats to form a filamentous fungal aggregate, and wherein step (b) comprises size-reducing the filamentous fungal aggregate.

10. The method of claim 9, wherein the aggregate comprises a casing that encases the at least two filamentous fungal biomats.

11. The method of claim 9, wherein the aggregating step is carried out under sub-atmospheric pressure.

12. The method of claim 11, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

13. The method of claim 9, wherein the aggregating step comprises crust-freezing the at least two filamentous fungal biomats.

14. The method of claim 1, wherein step (b) comprises at least one of cutting, shredding, and shaving the filamentous fungal biomat.

15. The method of claim 14, wherein the plurality of filamentous fungal pieces comprises at least one of strips, shreds, and shavings of the filamentous fungal biomat.

16. The method of claim 1, wherein at least one of an average length, an average width, and an average depth of the plurality of filamentous fungal pieces is between about 0.5 mm and about 1.0 mm.

17. The method of claim 1, wherein step (c) comprises at least one of steaming the plurality of filamentous fungal pieces, cold-smoking the plurality of filamentous fungal pieces, and hot-smoking the plurality of filamentous fungal pieces.

18. The method of claim 1, wherein the solution is an aqueous solution.

19. The method of claim 1, wherein the solution is a non-aqueous solution.

20. A method for preparing a food product, comprising:
(a) contacting a filamentous fungal biomat with a solution; and
(b) dehydrating the filamentous fungal biomat.

21. The method of claim 20, wherein the food product is a meat jerky analog food product.

22. The method of claim 20, wherein the solution comprises at least one of sodium chloride, a food seasoning, and an edible protein.

23. The method of claim 20, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomat prior to contacting the solution.

24. The method of claim 20, wherein step (a) is carried out under sub-atmospheric pressure.

25. The method of claim 24, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

26. The method of claim 20, wherein step (a) comprises the sub-step of removing water from the filamentous fungal biomat.

27. The method of claim 20, wherein step (a) is carried out by agitating the filamentous fungal biomat together with the solution.

28. The method of claim 20, wherein the filamentous fungal biomat absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the solution.

29. The method of claim 20, wherein the solution is an aqueous solution.

30. The method of claim 20, wherein the solution is a non-aqueous solution.

31. A method for preparing a food product, comprising:

(a) contacting a first filamentous fungal biomat, or portion thereof, with a first solution;

(b) size-reducing the first filamentous fungal biomat, or portion thereof, to form a plurality of filamentous fungal pieces;

(c) contacting a second filamentous fungal biomat, or portion thereof, with a second solution;

(d) combining the plurality of filamentous fungal pieces and the second filamentous fungal biomat, or portion thereof; and

(e) treating the plurality of filamentous fungal pieces and the second filamentous fungal biomat, or portion thereof, to form the food product.

32. The method of claim 31, wherein the food product is a meat jerky analog food product.

33. The method of claim 31, wherein at least one of the first and second solutions comprises at least one of sodium chloride, a food seasoning, and an edible protein.

34. The method of claim 31, wherein at least one of the following is true: (i) a mass of the first solution is between about 1% and about 30% of a mass of the first filamentous fungal biomat, or portion thereof, prior to step (a); and (ii) a mass of the second solution is between about 1% and about 30% of a mass of the second filamentous fungal biomat, or portion thereof, prior to step (c).

35. The method of claim 31, wherein at least one of step (a) and step (c) is carried out under sub-atmospheric pressure.

36. The method of claim 35, wherein the sub-atmospheric pressure is a pressure of no more than about 0.1 pascals.

37. The method of claim 31, wherein at least one of the following is true: (i) step (a) comprises the sub-step of removing water from the first filamentous fungal biomat, or portion thereof; and (ii) step (c) comprises the sub-step of removing water from the second filamentous fungal biomat, or portion thereof.

38. The method of claim 31, wherein at least one of the following is true: (i) step (a) is carried out by agitating the first filamentous fungal biomat, or portion thereof, together with the first solution; and (ii) step (c) is carried out by agitating the second filamentous fungal biomat, or portion thereof, together with the second solution.

39. The method of claim 31, wherein at least one of the following is true: (i) the first filamentous fungal biomat, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the first solution; and (ii) the second filamentous fungal biomat, or portion thereof, absorbs or otherwise takes up at least about 5 wt%, at least about 10 wt%, at least about 15 wt%, at least about 20 wt%, at least about 25 wt%, or at least about 30 wt% of the second solution.

40. The method of claim 31, wherein at least one of the first and second solutions is an aqueous solution.

41. The method of claim 31, wherein at least one of the first and second solutions is a non-aqueous solution.

42. A meat jerky analog food product made according to the method of claim 21 or claim 32.

43. The meat jerky analog food product of claim 42, having a water activity of less than about 0.45.

44. The meat jerky analog food product of claim 42, having a shelf life of at least about two weeks, at least about three weeks, at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, at least about six months, at least about seven months, at least about eight months, at least about nine months, at least about ten months, at least about eleven months, at least about twelve months, at least about fifteen months, at least about eighteen months, at least about 21 months, or at least about 24 months.

45. An intermediate food composition, comprising:

a filamentous fungal biomat or a portion thereof; and

a solution, absorbed or otherwise taken up by the filamentous fungal biomat or portion thereof.

46. The intermediate food composition of claim 45, wherein the solution comprises at least one of sodium chloride, a food seasoning, and an edible protein.

47. The intermediate food composition of claim 45, wherein a mass of the solution is between about 1% and about 30% of a mass of the filamentous fungal biomat or portion thereof.

48. The intermediate food composition of claim 45, wherein the solution is an aqueous solution.

49. The intermediate food composition of claim 45, wherein the solution is a non-aqueous solution.

ABSTRACT

Filamentous fungal food compositions are disclosed, as are methods of making such filamentous fungal food compositions. The filamentous fungal food compositions may serve as analogs of conventional non-fungal food products, particularly meat products such as meat jerky. The methods of manufacture of the filamentous fungal food compositions may include processing of filamentous fungal biomass under sub-atmospheric pressure.

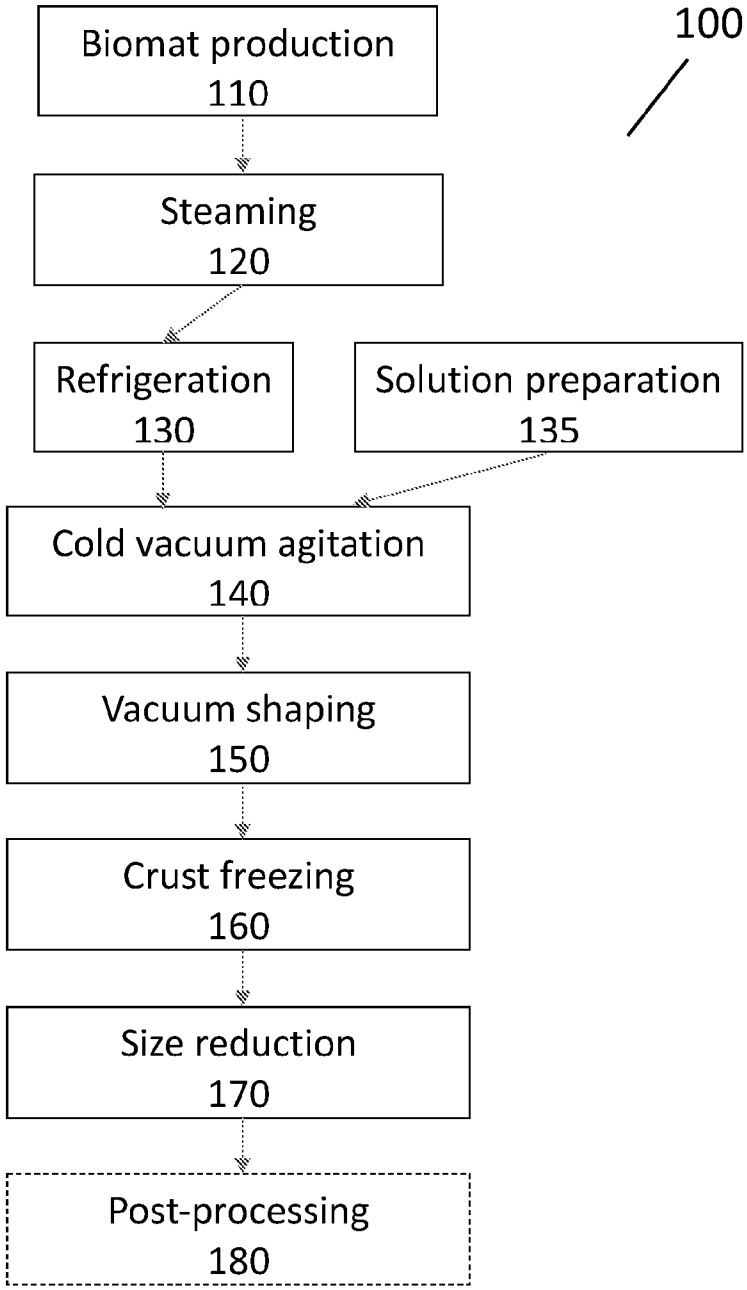

100
Biomat production
110
Steaming
120
Refrigeration
130
Solution preparation
135
Cold vacuum agitation
140
Vacuum shaping
150
Crust freezing
160
Size reduction
170
Post-processing
180

FIG. 1

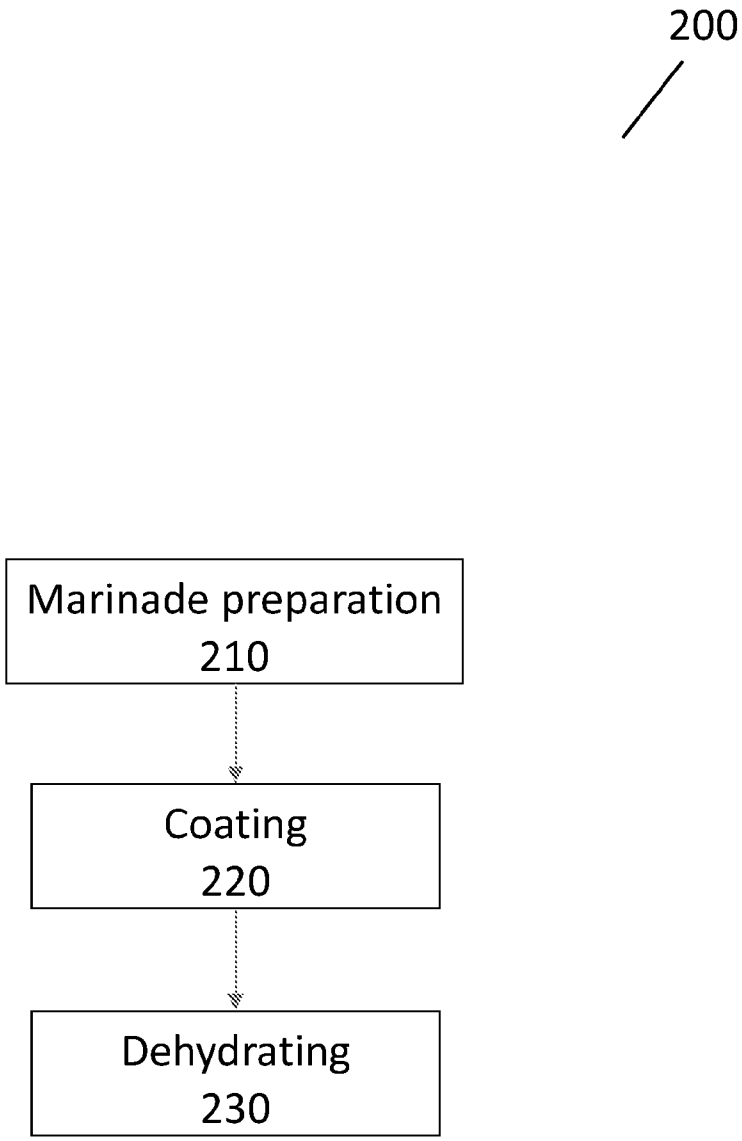


FIG. 2

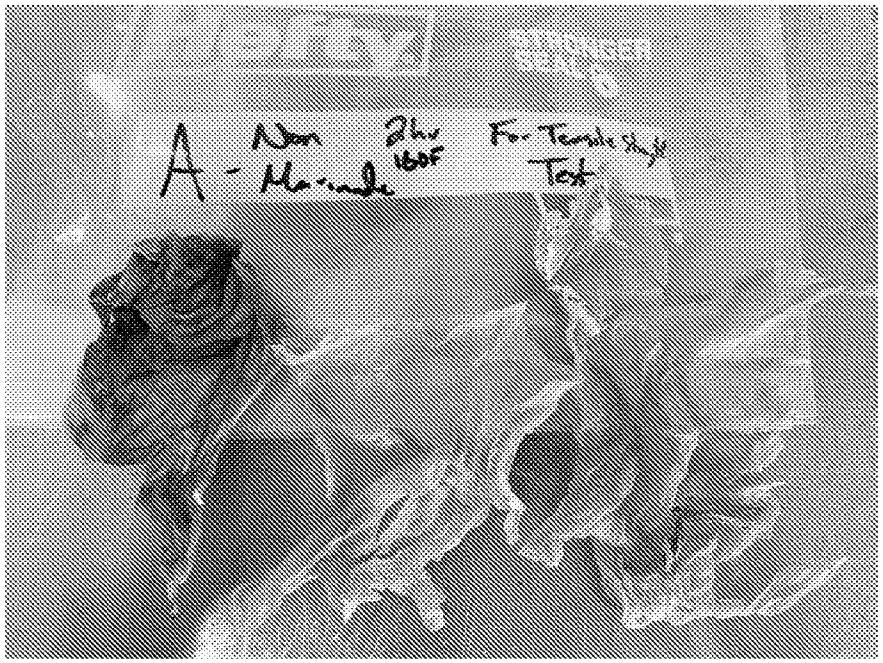

A - Non Washed
2hr 160F
For Tensile Strength Test

FIG. 3A

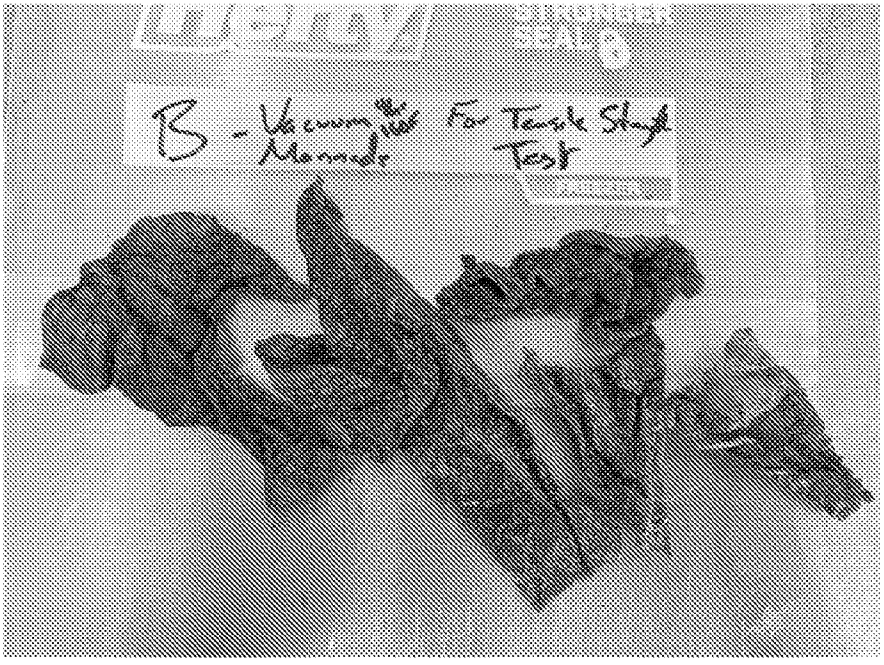

B - Washed
For Tensile Strength Test

FIG. 3B

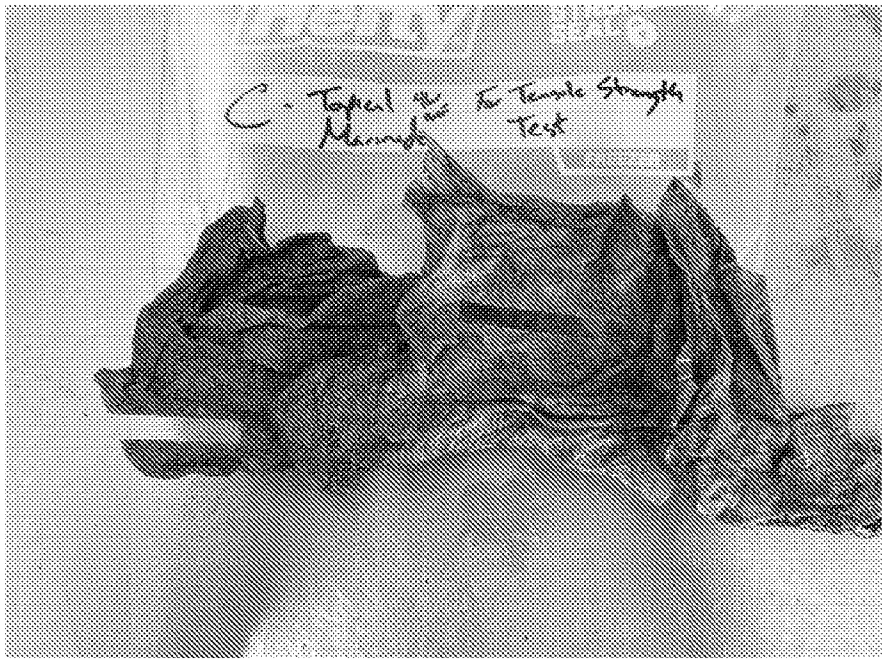


FIG. 3C

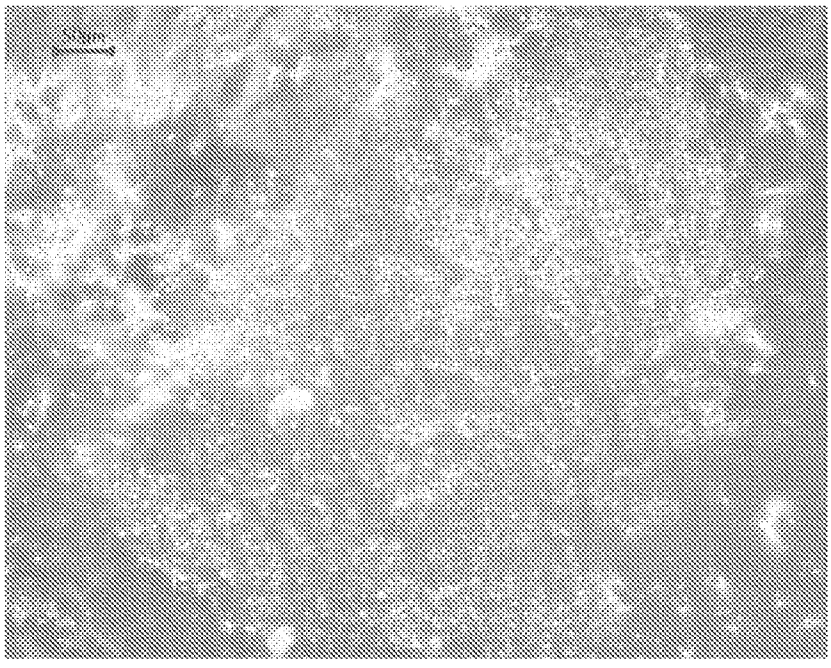


FIG. 4A

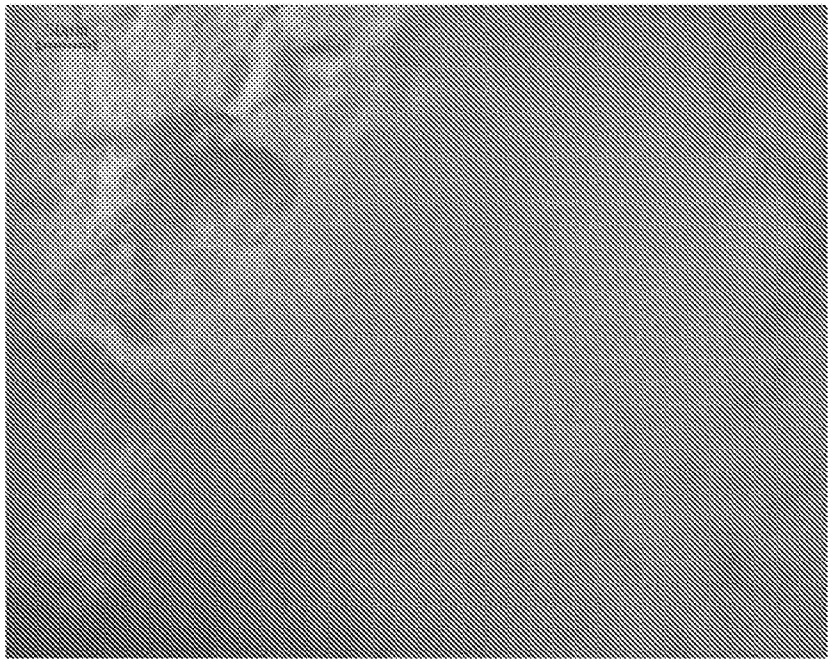


FIG. 4B

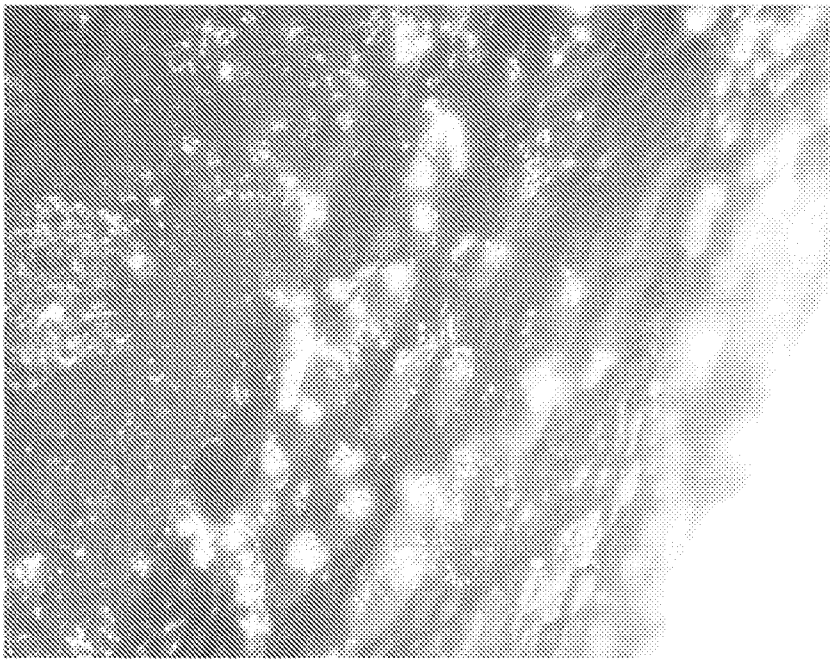


FIG. 5A

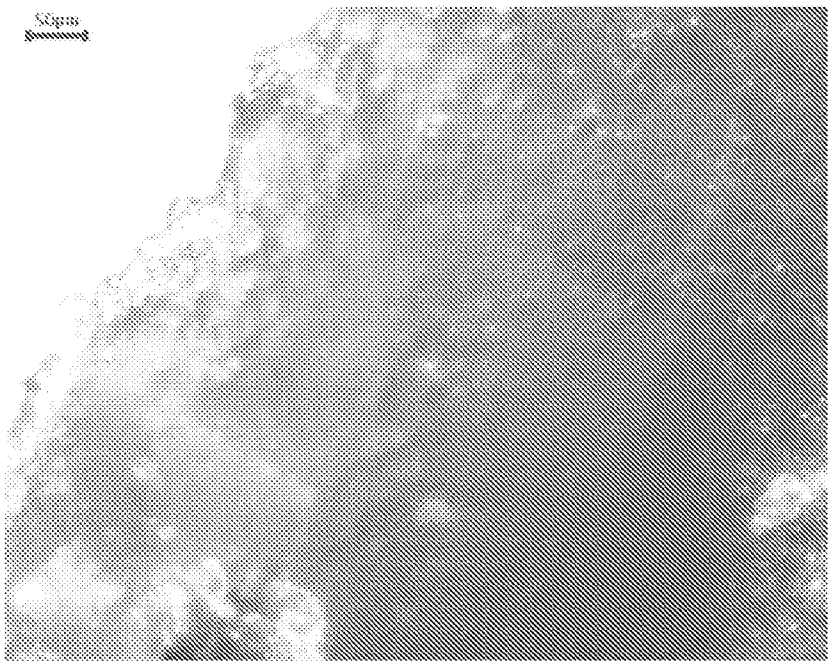


FIG. 5B

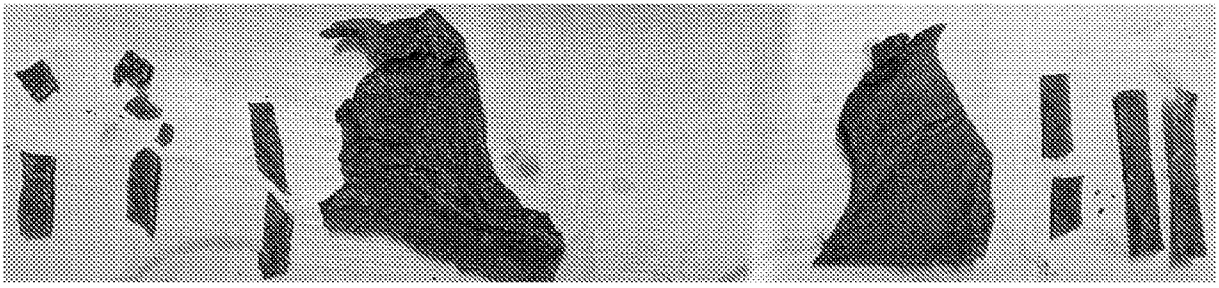


FIG. 6

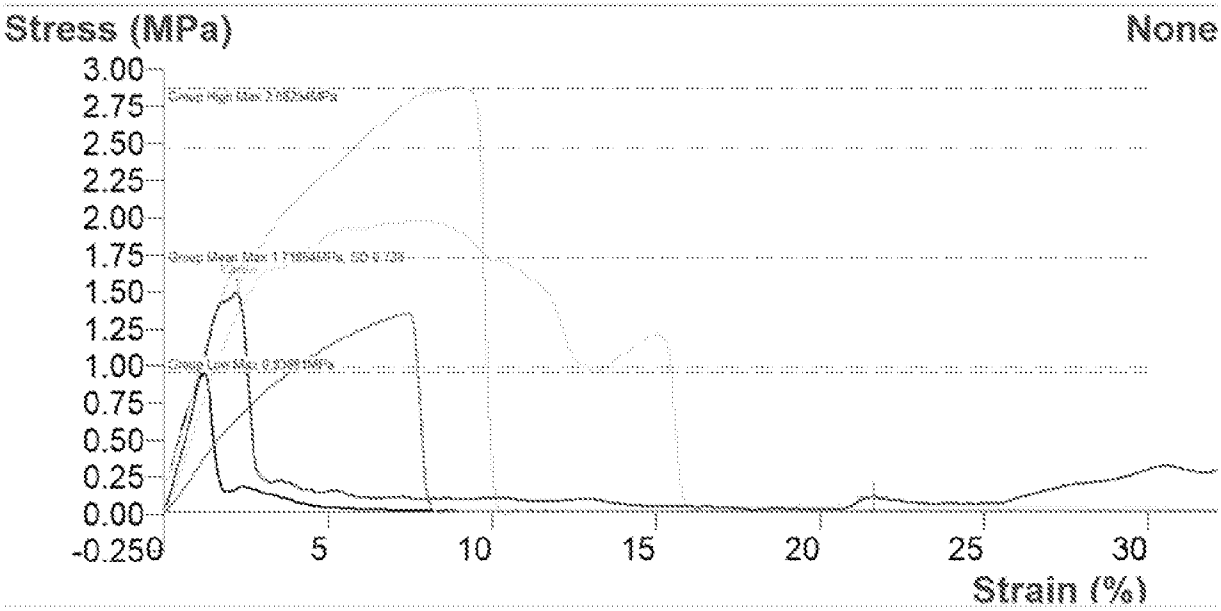

Stress (MPa)
None
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.250
5
10
15
20
25
30
Strain (%)

FIG. 7

Electronic Acknowledgement Receipt

EFS ID:	42250001
Application Number:	63164466
International Application Number:	
Confirmation Number:	3758
Title of Invention:	Food products comprising filamentous fungal material
First Named Inventor/Applicant Name:	Baljit Ghotra
Customer Number:	158864
Filer:	Tyler John Boschert
Filer Authorized By:	
Attorney Docket Number:	10087-35-PROV
Receipt Date:	22-MAR-2021
Filing Date:	
Time Stamp:	20:16:33
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$150
RAM confirmation Number	E20213LK16533621
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	20210322_ADS.pdf	1255967 1f155ac69481e88b4b373d272777b29113df487e	no	9
Warnings:					
Information:					
2		20210322_Specification_FINAL.pdf	215108 e677ca4e211f50aa3e3f8fffa190bf528b5f58d4	yes	39

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	32
	Claims	33	38
	Abstract	39	39

Warnings:					
Information:					
3	Drawings-only black and white line drawings	20210320_Figures.pdf	5350547 a0611acab051ea9b660880a9331a625f8318c69c	no	7
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29712 b63a80aa463784201005531a5da890567052afc2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	6851334		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION, OBTENTION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

BOSCHERT, Tyler J.
Sheridan Ross P.C.
1560 Broadway
Suite 1200
Denver, Colorado 80202
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing *(day/month/year)* 11 April 2022 (11.04.2022)	
Applicant's or agent's file reference 10087-35-PCT	**IMPORTANT NOTIFICATION**
International application No. PCT/US2022/021369	International filing date *(day/month/year)* 22 March 2022 (22.03.2022)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 22 March 2021 (22.03.2021)
Applicant THE FYNDER GROUP, INC. et al	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
22 March 2021 (22.03.2021)	63/164,466	US	07 April 2022 (07.04.2022)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*). Where the applicant has failed to either submit, request to prepare and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-*bis*) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-*bis*)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-*bis*), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer
Simin Baharlou
e-mail pct.team9@wipo.int
Telephone No. +41 22 338 74 09

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92*bis*.1 and Administrative Instructions, Section 422)

To:

BOSCHERT, Tyler J.
Sheridan Ross P.C.
1560 Broadway
Suite 1200
Denver, Colorado 80202
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing *(day/month/year)*
08 September 2023 (08.09.2023)

Applicant's or agent's file reference
10087-35-PCT

IMPORTANT NOTIFICATION

International application No.
PCT/US2022/021369

International filing date *(day/month/year)*
22 March 2022 (22.03.2022)

1. The following indications appeared on record concerning:

☒ the applicant ☒ the inventor ☐ the agent ☐ the common representative

Name and Address
ECKSTROM, Eleanore Brophy
1614 W. Lunt Ave
Chicago, Illinois 60626
UNITED STATES OF AMERICA

State of Nationality: US
State of Residence: US
Telephone No.
Facsimile No.
E-mail address

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address
ECKSTROM, Eleanore Brophy
1614 W. Lunt Ave
Chicago, Illinois 60626
UNITED STATES OF AMERICA

State of Nationality
State of Residence
Telephone No.
Facsimile No.
E-mail address
☐ Notifications by e-mail authorized

3. Further observations, if necessary:
The person identified above is now inventor only.

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☐ the Authority(ies) specified for supplementary search
☐ the International Preliminary Examining Authority
☒ the designated Offices concerned
☐ the elected Offices concerned
☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer
Blanc Veronique
e-mail pct.team9@wipo.int
Telephone No. +41 22 338 74 09

WO 2022/204166
PCT/US2022/021369

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

FIRST NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH DO NOT APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

BOSCHERT, Tyler J.
Sheridan Ross P.C.
1560 Broadway
Suite 1200
Denver, Colorado 80202
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing *(day/month/year)* 27 October 2022 (27.10.2022)	
Applicant's or agent's file reference 10087-35-PCT	**IMPORTANT NOTICE**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2022/021369	22 March 2022 (22.03.2022)	22 March 2021 (22.03.2021)

Applicant

THE FYNDER GROUP, INC. et al

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does apply,** please see Form PCT/IB/308(Second and Supplementary Notice) (to be issued promptly after the expiration of 28 months from the priority date).

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
29 September 2022 (29.09.2022)

   None

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   LU, TZ

   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated Office(s) listed above, and unless a demand for international preliminary examination has been filed before the expiration of **19 months** from the priority date (see Article 39(1)), the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **20 MONTHS** from the priority date.

   In practice, **time limits other than the 20-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated Offices listed above. For **regular updates on the applicable time limits** (20 or 21 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/guide/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer
Simin Baharlou
e-mail pct.team9@wipo.int
Telephone No. +41 22 338 74 09

WO 2022/204166
PCT/US2022/021369

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

SECOND AND SUPPLEMENTARY NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

BOSCHERT, Tyler J.
Sheridan Ross P.C.
1560 Broadway
Suite 1200
Denver, Colorado 80202
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing *(day/month/year)*	
27 July 2023 (27.07.2023)	
Applicant's or agent's file reference 10087-35-PCT	**IMPORTANT NOTICE**
International application No. PCT/US2022/021369	International filing date *(day/month/year)* 22 March 2022 (22.03.2022)
Priority date *(day/month/year)* 22 March 2021 (22.03.2021)	
Applicant THE FYNDER GROUP, INC. et al	

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does not apply**, please see Form PCT/IB/308(First Notice) issued previously.

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
29 September 2022 (29.09.2022)

   EP

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   AE, AG, AL, AM, AO, AP, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EA, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OA, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW

   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated or elected Office(s) listed above, the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **30 MONTHS** from the priority date.

   In practice, **time limits other than the 30-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated or elected Office(s) listed above. For **regular updates on the applicable time limits** (30 or 31 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/guide/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer
Simin Baharlou
e-mail pct.team9@wipo.int
Telephone No. +41 22 338 74 09

ePCT Action: Rule 92bis change request

IA Number: PCT/US2022/021369
International Filing Date: 22 March 2022
File reference: 10087-35-PCT
Request Date: 01 September 2023

Current data on file:

☐ the applicant ☐ the inventor ☐ the agent ☐ the common representative ☑ the applicant-inventor ☐ the correspondence address	
Type: Natural person	
Applicable designations:All	
Name and Address: ECKSTROM, Eleanore Brophy 1614 W. Lunt Ave Chicago, Illinois 60626 United States of America	
State of Nationality: US	State of Residence: US
Telephone	Fax
Email	

Data requested to be changed to:

☐ the applicant ☑ **the Inventor** ☐ the agent ☐ the common representative ☐ the applicant-inventor ☐ the correspondence address	
Type: Natural person	
☐ Change in person	
Applicable designations:All	
Name and Address: ECKSTROM, Eleanore Brophy 1614 W. Lunt Ave Chicago, Illinois 60626 United States of America	
State of Nationality:	State of Residence:
Telephone	Fax
Email	

The following documents were submitted as attachments:

- General Correspondence

Signature: /Tyler J. BOSCHERT/
Signatory: BOSCHERT, Tyler J. (Agent)
Date: 01 September 2023 23:59:41 CEST
User Name: Sylvia Cei

Authentication:	Sign-in with strong authentication