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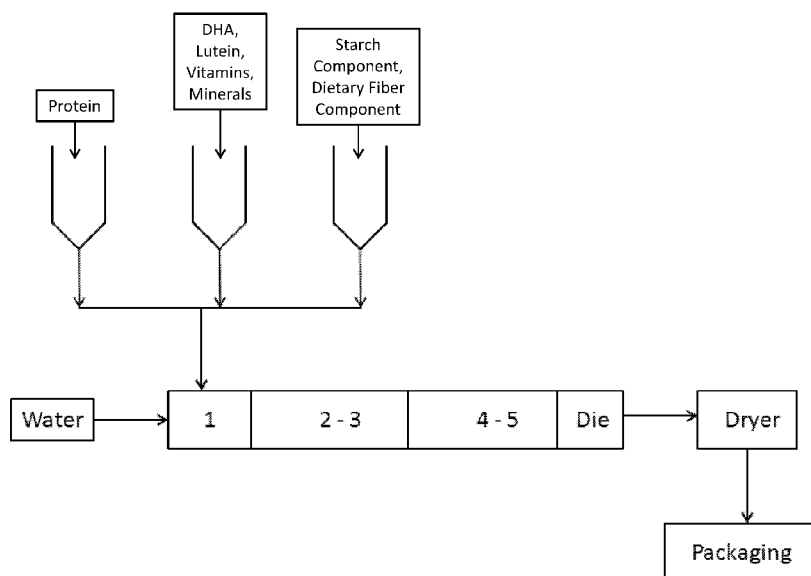


FIGURE 1

(57) Abstract: An extruded nutritional product and a method of making an extruded nutritional product are provided. The extruded nutritional product includes from 15 wt.% to 75 wt.% protein and at least one of a carotenoid and an omega-3 fatty acid. The extruded nutritional product has a bulk density of from 30 g/L to 200 g/L.

EXTRUDED NUTRITIONAL PRODUCT AND METHOD OF MAKING THE SAME**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims priority to and the benefit of U.S. Provisional Patent Application No. 62/268,772, filed December 17, 2015, the entire content of which is incorporated by reference herein.

FIELD

[0002] The present disclosure relates to nutritional products and methods of preparing nutritional products. More particularly, the present disclosure relates to extruded nutritional products and methods of making the extruded nutritional products.

BACKGROUND

[0003] Snack foods are very popular among all age groups. Examples of such snack foods include cereal crisps, corn chips, cheese puffs, potato chips, and the like. However, these snack foods often tend to be high in carbohydrates or fat, and low in protein, vitamins, and minerals. Furthermore, snack foods that are high in protein often have a hard texture, which may be undesirable for certain age groups, such as toddlers.

SUMMARY

[0004] Disclosed herein is an extruded nutritional product and a method of making the extruded nutritional product. To illustrate various aspects of the present disclosure, several exemplary embodiments of the extruded nutritional product and the method of making the extruded nutritional product are provided herein.

[0005] In one exemplary embodiment, an extruded nutritional product is provided. The extruded nutritional product comprises from 15 wt.% to 75 wt.% protein and at least one of a carotenoid and an omega-3 fatty acid. The extruded nutritional product has a bulk density of from 30 g/L to 200 g/L.

[0006] In certain exemplary embodiments, the extruded nutritional product comprises a carotenoid selected from the group consisting of lutein, beta-carotene, lycopene, zeaxanthin, and combinations thereof. In certain exemplary embodiments, the carotenoid comprises lutein.

[0007] In certain exemplary embodiments, the extruded nutritional product comprises an omega-3 fatty acid selected from the group consisting of docosahexaenoic acid, alpha-linolenic acid, eicosapentaenoic acid, and combinations thereof. In certain exemplary embodiments, the omega-3 fatty acid comprises docosahexaenoic acid.

[0008] In certain exemplary embodiments, the extruded nutritional product further comprises from 20 wt.% to 80 wt.% of a starch component. In certain exemplary embodiments, the extruded nutritional product further comprises from 1 wt.% to 40 wt.% of a dietary fiber component.

[0009] In one exemplary embodiment, a method of making an extruded nutritional product is provided. The method includes mixing water, a protein, and at least one of a carotenoid and an omega-3 fatty acid within an extruder to form a nutritional dough. The extruder has at least one screw and a die. The nutritional dough is extruded through the die and expands upon exiting the die. After exiting the die, the expanded nutritional dough is cut to form a plurality of extruded nutritional product pieces. The extruded nutritional product pieces are subsequently dried. The dried extruded nutritional product pieces have a bulk density of from 30 g/L to 200 g/L and comprise from 15 wt.% to 75 wt.% protein.

[0010] In certain exemplary embodiments, the method further comprises flavoring the extruded nutritional product pieces. In certain exemplary embodiments, the extruded nutritional product pieces are flavored by mixing the extruded nutritional product pieces with a powdered flavorant either before or after drying the extruded nutritional product pieces. In certain exemplary embodiments, the extruded nutritional product pieces are flavored by spraying a liquid flavorant onto the extruded nutritional product pieces either before or after drying the extruded nutritional product pieces.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a schematic diagram of an embodiment of a method of making an extruded nutritional product as described herein.

DETAILED DESCRIPTION

[0012] Disclosed herein are extruded nutritional products and methods of making extruded nutritional products. While the present disclosure describes certain embodiments of the extruded nutritional products and methods in detail, the present disclosure is to be considered exemplary and is not intended to be limited to the disclosed embodiments.

[0013] The terminology as set forth herein is for description of the embodiments only and should not be construed as limiting the disclosure as a whole. All references to singular characteristics or limitations of the present disclosure shall include the corresponding plural characteristic or limitation, and vice versa, unless otherwise specified or clearly implied to the contrary by the context in which the reference is made. Furthermore, as used in the description and the appended claims, the singular forms “a,” “an,” and “the” are inclusive of their plural forms, unless the context clearly indicates otherwise.

[0014] The extruded nutritional products and methods of making extruded nutritional products as described in the present disclosure can comprise, consist of, or consist essentially of the essential elements of the disclosure as described herein, as well as any additional or optional element described herein or which is otherwise useful in the nutritional arts.

[0015] All percentages, parts, and ratios as used herein are by weight of the total formulation, unless otherwise specified. All such weights as they pertain to listed ingredients are based on the active level and, therefore, do not include solvents or by-products that may be included in commercially available materials, unless otherwise specified.

[0016] All ranges and parameters, including but not limited to percentages, parts, and ratios, disclosed herein are understood to encompass any and all sub-ranges assumed and subsumed therein, and every number between the endpoints. For example, a stated range of “1 to 10” should be considered to include any and all sub-ranges beginning with a minimum value of 1 or

more and ending with a maximum value of 10 or less (*e.g.*, 1 to 6.1, or 2.3 to 9.4), and to each integer (1, 2, 3, 4, 5, 6, 7, 8, 9, and 10) contained within the range.

[0017] Any combination of method or process steps as used herein may be performed in any order, unless otherwise specified or clearly implied to the contrary by the context in which the referenced combination is made.

[0018] In one exemplary embodiment, an extruded nutritional product is provided. The extruded nutritional product comprises from 15 wt.% to 75 wt.% protein and at least one of a carotenoid and an omega-3 fatty acid. The extruded nutritional product has a bulk density of from 30 g/L to 200 g/L.

[0019] The exemplary embodiments of the extruded nutritional product described herein provide a protein rich product suitable for virtually all age groups of consumers. In particular, the exemplary embodiments of the extruded nutritional product described herein are well suited for toddlers having an age of about 12 months to about 36 months, since the extruded nutritional product provides protein to support the growth of toddlers.

[0020] A wide variety of proteins or protein sources may be used in the various embodiments of the extruded nutritional product and method described herein. For example, the protein may include, but is not limited to, intact, hydrolyzed, or partially hydrolyzed protein, which may be derived from any known or otherwise suitable source such as milk (*e.g.*, casein, whey), animal (*e.g.*, meat, fish), cereal (*e.g.*, rice, corn), vegetable (*e.g.*, soy, pea), and combinations thereof. The protein may also include one or more amino acids (often described as free amino acids) in combination with the intact, hydrolyzed, or partially hydrolyzed proteins described herein. The amino acids may be naturally occurring or synthetic amino acids.

[0021] The extruded nutritional products disclosed herein comprise from 15 wt.% to 75 wt.% protein. In certain exemplary embodiments, the extruded nutritional products comprise from 15 wt.% to 60 wt.% protein, including from 15 wt.% to 55 wt.%, from 20 wt.% to 50 wt.%, from 25 wt.% to 45 wt.%, from 30 wt.% to 40 wt.%, and also including from 40 wt.% to 75 wt.% protein.

[0022] In certain exemplary embodiments, the protein comprises at least one of whey protein concentrate, whey protein isolate, whey protein hydrolysate, acid casein, sodium caseinate,

calcium caseinate, potassium caseinate, casein hydrolysate, milk protein concentrate, milk protein isolate, milk protein hydrolysate, nonfat dry milk, condensed skim milk, skim milk powder, soy protein concentrate, soy protein isolate, soy protein hydrolysate, pea protein concentrate, pea protein isolate, pea protein hydrolysate, collagen protein, collagen protein isolate, potato protein, rice protein, and quinoa protein. In certain exemplary embodiments, the protein comprises soy protein isolate. The extruded nutritional product may include any individual source of protein or combination of the various sources of protein listed above.

[0023] In certain exemplary embodiments, the extruded nutritional product includes a carotenoid. By including carotenoids, the exemplary extruded nutritional products may provide certain health benefits to consumers, such as immune function support and eye health support. In certain exemplary embodiments, the extruded nutritional product comprises from 0.0005 wt.% to 0.004 wt.% of a carotenoid, including from 0.001 wt.% to 0.0035 wt.%, from 0.0015 wt.% to 0.003 wt.%, and also including from 0.002 wt.% to 0.003 wt.%.

[0024] In certain exemplary embodiments, the extruded nutritional product comprises a carotenoid selected from the group consisting of lutein, beta-carotene, lycopene, zeaxanthin, and combinations thereof. In certain exemplary embodiments, the carotenoid is lutein. In certain exemplary embodiments, the extruded nutritional product is formulated with an amount of lutein sufficient to provide from 200 micrograms to 300 micrograms of lutein per serving of the extruded nutritional product, including from 225 micrograms to 275 micrograms, from 235 micrograms to 265 micrograms, and also including from 245 micrograms to 255 micrograms of lutein per serving of the extruded nutritional product.

[0025] According to certain exemplary embodiments, the extruded nutritional product includes an omega-3 fatty acid. Omega-3 fatty acids provide a number of health benefits including, but not limited to, reducing inflammation, promoting visual development, and promoting neurological development. In certain exemplary embodiments, the extruded nutritional product comprises from 0.02 wt.% to 0.4 wt.% of an omega-3 fatty acid, including from 0.05 wt.% to 0.4 wt.%, from 0.1 wt.% to 0.35 wt.%, from 0.15 wt.% to 0.35 wt.%, from 0.2 wt.% to 0.3 wt.%, and also including from 0.25 wt.% to 0.4 wt.% of an omega-3 fatty acid.

[0026] In certain exemplary embodiments, the extruded nutritional product comprises an omega-3 fatty acid selected from the group consisting of docosahexaenoic acid, alpha-linolenic acid, eicosapentaenoic acid, and combinations thereof. It should be understood that the omega-3 fatty acid may be provided by one or more oils that contain omega-3 fatty acids, such as fish oil, algal oil, canola oil, soy oil, and so forth. In certain exemplary embodiments, the omega-3 fatty acid is docosahexaenoic acid. In certain exemplary embodiments, the extruded nutritional product is formulated with an amount of docosahexaenoic acid sufficient to provide from 20 milligrams to 50 milligrams of docosahexaenoic acid per serving of the extruded nutritional product, including from 25 milligrams to 45 milligrams, and also including from 30 milligrams to 35 milligrams of docosahexaenoic acid per serving of the extruded nutritional product. In certain exemplary embodiments, In certain exemplary embodiments, the omega-3 fatty acid is incorporated into the extruded nutritional product or applied to the extruded nutritional product as an external coating, such as by spraying, dipping, or tumbling the extruded nutritional product with the omega-3 fatty acid.

[0027] In certain exemplary embodiments, the extruded nutritional product also comprises a starch component. The starch component serves as a filler and provides additional nutritional value to the extruded nutritional product. According to certain exemplary embodiments, the extruded nutritional product comprises from 20 wt.% to 80 wt.% of a starch component, including from 30 wt.% to 80 wt.%, from 35 wt.% to 75 wt.%, from 45 wt.% to 75 wt.%, from 50 wt.% to 70 wt.%, from 55 wt.% to 65 wt.%, and also including from 50 wt.% to 80 wt.% of a starch component.

[0028] A wide variety of starches or sources of starch may be used as the starch component in various exemplary embodiments of the extruded nutritional product and method described herein. The starch component can be a native starch or a modified starch. The modified starch may be, for example, physically, chemically, or enzymatically modified. In certain exemplary embodiments, the starch component comprises at least one of rice flour, tapioca flour, corn flour, wheat flour, oat flour, soy flour, barley flour, buckwheat flour, chick pea flour, legume flour, and potato flour. When a starch component is used, the extruded nutritional product may include any individual source of starch or combination of the various sources of starch listed above.

[0029] According to certain exemplary embodiments, the extruded nutritional product comprises a dietary fiber component. Dietary fibers assist with the regulation of digestion and may also provide positive effects on cardiovascular health, diabetes, weight management, and the immune system. In certain exemplary embodiments, the extruded nutritional product comprises from 1 wt.% to 40 wt.% of a dietary fiber component, including from 5 wt.% to 35 wt.%, from 10 wt.% to 30 wt.%, from 15 wt.% to 25 wt.%, from 20 wt.% to 40 wt.%, and also including from 1 wt.% to 10 wt.% of a dietary fiber component.

[0030] Various types and sources of dietary fiber may be used in the exemplary extruded nutritional products and methods disclosed herein. In certain exemplary embodiments, the dietary fiber component may comprise a soluble dietary fiber, an insoluble dietary fiber, or a mixture of soluble and insoluble dietary fiber. In certain exemplary embodiments, the dietary fiber component comprises at least one of fructooligosaccharides, inulin, corn dextrin, wheat dextrin, carboxymethyl cellulose, oat bran, corn bran, wheat bran, rice bran, fruit fiber, vegetable fiber, soy fiber, chicory flour, chia fiber, microcrystalline cellulose, and sugar beet fiber. When a dietary fiber component is used, the extruded nutritional product may include any individual source of dietary fiber or combination of the various sources of dietary fiber listed above.

[0031] In certain exemplary embodiments, the extruded nutritional product also comprises at least one of a fruit material and a vegetable material. In certain exemplary embodiments, the fruit material may comprise dried fruit pieces, fruit powder, fruit puree, and combinations thereof that are incorporated into the extruded nutritional product or applied to the extruded nutritional product as an external coating. Various types of fruit may be used including, but not limited to, strawberries, bananas, apples, grapes, and so forth. In certain exemplary embodiments, the extruded nutritional product comprises from 0.5 wt.% to 10 wt.% of a fruit material, including from 1 wt.% to 8 wt.%, from 3 wt.% to 6 wt.%, from 0.5 wt.% to 5 wt.%, and also including from 5 wt.% to 10 wt.% of a fruit material. In certain exemplary embodiments, the vegetable material may comprise dried vegetable pieces, vegetable powder, vegetable puree, and combinations thereof that are incorporated into the extruded nutritional product or applied to the extruded nutritional product as an external coating. A wide variety of vegetables may be used including, but not limited to, sweet potatoes, carrots, pumpkin, squash, and so forth. In certain exemplary embodiments, the extruded nutritional product comprises from 0.5 wt.% to 10 wt.%

of a vegetable material, including from 1 wt.% to 8 wt.%, from 3 wt.% to 6 wt.%, from 0.5 wt.% to 5 wt.%, and also including from 5 wt.% to 10 wt.% of a vegetable material.

[0032] The extruded nutritional products described herein will typically contain some amount of water. In certain exemplary embodiments, the dried extruded nutritional product has a moisture content of less than 15 wt.%, including less than 10 wt.%, and also including less than 8 wt.%. In certain exemplary embodiments, the dried extruded nutritional product has a moisture content of from 1 wt.% to 15 wt.%, including from 1 wt.% to 10 wt.%, from 2 wt.% to 8 wt.%, from 2 wt.% to 6 wt.%, from 5 wt.% to 8 wt.%, and also including from 1 wt.% to 5 wt.%. Such a moisture content provides the extruded nutritional product with a low water activity level, which slows or inhibits microbiological growth during storage. The moisture content of the dried extruded nutritional product may be determined by a variety of methods known to those skilled in the art. For example, the moisture content of the dried extruded nutritional product may be determined by a vacuum-oven drying method in which a sample (with a known weight) of the extruded nutritional product is heated in a vacuum oven at a temperature of about 98 °C to 102 °C for a period of 1 hour to 6 hours at a pressure of about 25 mm Hg to 100 mm Hg. The moisture content is then determined by the loss of weight of the sample divided by the original weight of the sample.

[0033] As previously mentioned, the exemplary extruded nutritional products described herein have a bulk density of from 30 g/L to 200 g/L, including from 30 g/L to 150 g/L, from 30 g/L to 100 g/L, and also including from 50 g/L to 75 g/L. The bulk density of the extruded nutritional products may be determined by a variety of methods known to those skilled in the art. One such method for measuring the bulk density includes: providing a container of a known volume (*e.g.*, 1 liter) and mass; filling the container with the extruded nutritional product; determining the mass of the filled container; subtracting the mass of the container from the mass of the filled container to determine the mass of the extruded nutritional product; and expressing the bulk density as mass of the extruded nutritional product per volume.

[0034] The extruded nutritional products described herein are typically referred to in the nutritional arts as puffs, bites, nuggets, or crisps, and are intended for use as a snack food. In certain embodiments, a serving of the extruded nutritional products described herein is from 5

grams to 150 grams, including from 10 grams to 75 grams, from 10 grams to 50 grams, from 10 grams to 20 grams, from 5 grams to 15 grams, and also including from 5 grams to 10 grams. The extruded nutritional products may be provided in appropriate packaging that contains a single serving or multiple (*e.g.*, two, three, four) servings of the product.

[0035] The extruded nutritional products, according to certain embodiments, may include optional components or ingredients that may modify the physical, chemical, aesthetic, or processing characteristics of the extruded nutritional product or serve as an additional nutritional component. Many such optional ingredients are known or otherwise suitable for nutritional products and may also be used in the exemplary extruded nutritional products described herein, provided that such optional ingredients are safe for oral consumption and are compatible with the essential and other ingredients described herein.

[0036] Non-limiting examples of such optional ingredients include vitamins, minerals, sweetening agents (*e.g.*, high-intensity sweeteners), prebiotics, probiotics, additional macronutrients (*e.g.*, carbohydrates, fats), colorants, flavorants, thickening agents, stabilizers, emulsifying agents (*e.g.*, monoglycerides), and so forth.

[0037] In certain exemplary embodiments, the extruded nutritional product may include any of a variety of vitamins, including water soluble vitamins, fat soluble vitamins, or a mixture of water soluble and fat soluble vitamins. In certain exemplary embodiments, the extruded nutritional product comprises at least one vitamin selected from the group consisting of vitamin B₁, vitamin B₃, vitamin B₅, vitamin B₆, vitamin B₇, vitamin B₉, vitamin B₁₂, vitamin C, vitamin A, vitamin E, vitamin D, and vitamin K. In certain exemplary embodiments, the extruded nutritional product includes natural vitamin E, or RRR- α -tocopherol. The RRR- α -tocopherol may be provided in ester form as d- α -tocopheryl acetate. In certain exemplary embodiments, the extruded nutritional product is formulated with an amount of RRR- α -tocopherol sufficient to provide from 2 milligrams to 4 milligrams of RRR- α -tocopherol (or 3 IU to 6 IU of vitamin E) per serving of the extruded nutritional product.

[0038] The extruded nutritional products described herein may also include a wide variety of minerals. In certain exemplary embodiments, the extruded nutritional product comprises at least one mineral selected from the group consisting of calcium, potassium, sodium, manganese,

chromium, molybdenum, selenium, copper, iron, iodide, magnesium, phosphorus, zinc, and chloride. In certain exemplary embodiments, the extruded nutritional product may comprise any combination of the foregoing vitamins and minerals.

[0039] In certain exemplary embodiments, the extruded nutritional product includes a flavorant. In certain exemplary embodiments, the flavorant is incorporated into the extruded nutritional product. In certain exemplary embodiments, the flavorant is applied to the extruded nutritional product as an external coating. Any suitable flavorant may be used, such as fruit flavor, cheese flavor, barbecue flavor, ranch flavor, and so forth.

[0040] It should be understood that the various components, ingredients, and amounts thereof previously described with respect to the exemplary embodiments of the extruded nutritional product apply equally to the various components, ingredients, and amounts thereof used in connection with the exemplary embodiments of the method of making the extruded nutritional product. It should also be understood that the exemplary embodiments of the method of making an extruded nutritional product described herein may be used to make any of the previously described embodiments of the extruded nutritional product.

[0041] According to one exemplary embodiment, an extruded nutritional product is made by mixing water, a protein, and at least one of a carotenoid and an omega-3 fatty acid within an extruder to form a nutritional dough. The extruder has at least one screw and a die. The nutritional dough is extruded through the die and expands upon exiting the die. After exiting the die, the expanded nutritional dough is cut to form a plurality of extruded nutritional product pieces. The extruded nutritional product pieces are subsequently dried. The dried extruded nutritional product pieces have a bulk density of from 30 g/L to 200 g/L and comprise from 15 wt.% to 75 wt.% protein.

[0042] The exemplary embodiments of the method of making an extruded nutritional product described herein utilize an extruder. Any suitable extruder known for use in the nutritional arts may be used in accordance with the embodiments of the method of the present disclosure. For example, in certain exemplary embodiments, the extruder may be a single screw extruder, multi-screw extruder, ring screw extruder, planetary gear extruder, and the like.

[0043] In certain exemplary embodiments, the method of making an extruded nutritional product uses a co-rotating, twin-screw extruder. Generally, twin-screw extruders comprise a barrel having one or more inlets for adding ingredients, two screws, and a die or other outlet. The extruder screws are positioned inside of the barrel and may comprise a wide variety of functional elements including, but not limited to, shear elements, mixing elements, homogenizing elements, conveying elements, reverse elements, kneading elements, emulsifying elements, disc elements, or any combination of the foregoing in any interchangeable order. In certain embodiments, the twin-screws are operated at 100 revolutions per minute (RPM) to 450 RPM, including from 150 RPM to 425 RPM, from 200 RPM to 400 RPM, and also including from 300 RPM to 400 RPM. The barrel of the extruder may comprise a number of segments that are bolted, clamped, or otherwise joined together. The barrel or barrel segments may be jacketed to permit indirect, controlled heating or cooling of the material being processed within the extruder. In addition, the barrel or barrel segments may include one or more inlets for adding ingredients into the extruder. The extruder also includes one or more outlets (*e.g.*, a die) to allow the material within the extruder to flow out of the extruder. In certain embodiments, the die is configured to impart a desired shape to the material as it exits the extruder.

[0044] In certain embodiments of the method, the various components added to the extruder (excluding water) are in powder form. For example, in certain embodiments, the protein, the carotenoid, the omega-3 fatty acid, the starch component, the dietary fiber component, and any optional ingredients added to the extruder are in powder form. The various powdered components may be added to the extruder by a variety of techniques including, but not limited to, gravity feeding from a hopper, loss-in-weight feeders, pumping from a storage tank, and the like. In certain embodiments, the various powdered components used to form the extruded nutritional product are pre-blended and then added to the extruder.

[0045] In other embodiments of the method, one or more of the various components added to the extruder are in liquid form. For example, the protein may be mixed with water to form an aqueous protein slurry, which is then added to the extruder. The carotenoid and omega-3 fatty acid may be added to the extruder as oils. The water and any of the other various components in liquid form may be added to the extruder by a variety of methods including, but not limited to, pumping the liquid into the extruder from a storage tank or other vessel.

[0046] In certain embodiments, the various components used to form the extruded nutritional product, whether in powder form or liquid form, are added into one or more inlets of the extruder. The term “inlet” as used herein refers to an opening on the extruder through which material can be introduced into the extruder. An inlet of the extruder may be positioned anywhere along the length of the extruder. In certain embodiments, the various components are added to the extruder through one or more inlets positioned within the first quarter of the length of the extruder. In certain embodiments, the extruder is a multi-barrel extruder and the various components used to form the extruded nutritional product are added to the multi-barrel extruder through one or more inlets positioned on the first barrel of the multi-barrel extruder.

[0047] When added to the extruder, the water, the protein, the carotenoid (if present), the omega-3 fatty acid (if present), and any other added component are mixed within the extruder to form a nutritional dough. In certain embodiments, the nutritional dough comprises from 10 wt.% to 30 wt.% water, including from 15 wt.% to 30 wt.%, and also including from 20 wt.% to 30 wt.% water. As the nutritional dough is further mixed and conveyed within the extruder, heat is generated by the shear within the extruder, which cooks the nutritional dough.

[0048] The mixing and cooking of the nutritional dough within the extruder may be carried out at various temperatures and pressures. In certain embodiments of the method disclosed herein, the nutritional dough is mixed and cooked within the extruder at a temperature of from 35 °C to 200 °C, including from 70 °C to 195 °C, from 90 °C to 190 °C, from 100 °C to 190 °C, from 110 °C to 190 °C, and also including from 125 °C to 190 °C. In addition to the heat generated by shear within the extruder, the barrel or barrel segments of the extruder may be jacketed to permit indirect, controlled heating (*e.g.*, by steam or hot water) of the contents within the extruder. In certain embodiments of the methods disclosed herein, the pressure in the extruder is from 0.1 bar to 90 bar, including from 5 bar to 80 bar, from 5 bar to 75 bar, from 10 bar to 50 bar, from 10 bar to 40 bar, from 10 bar to 35 bar, from 15 bar to 90 bar, from 25 bar to 90 bar, from 50 bar to 90 bar, from 75 bar to 90 bar, and also including from 25 bar to 45 bar. The pressure in the extruder is typically measured at the die.

[0049] In certain embodiments of the methods disclosed herein, the nutritional dough has a temperature of from 110 °C to 190 °C prior to exiting the die. Upon exiting the die, the water

within the nutritional dough changes to steam due to the reduction in pressure, which causes the nutritional dough to expand or puff when exiting the die. The expanded nutritional dough is then cut to form a plurality of extruded nutritional product pieces. For example, the expanded nutritional dough may be cut at an appropriate length by a rotating cutter, rotating knife, or the like. After cutting, the extruded nutritional product pieces are dried. For example, the extruded nutritional product pieces may be dried in a drying apparatus, such as convection belt dryer in which hot air at 65 °C to 125 °C is circulated to dry the product. In certain exemplary embodiments, the extruded nutritional product pieces are dried to have a moisture content of less than 15 wt.%. In certain exemplary embodiments, the extruded nutritional product pieces are dried to have a moisture content of less than 12 wt.%, including less than 10 wt.%, and also including less than 8 wt.%. In certain exemplary embodiments, extruded nutritional product pieces are dried to have a moisture content of from 1 wt.% to 15 wt.%, including from 1 wt.% to 12 wt.%, from 2 wt.% to 10 wt.%, from 2 wt.% to 8 wt.%, from 2 wt.% to 6 wt.%, from 5 wt.% to 8 wt.%, and also including from 1 wt.% to 5 wt.%. The dried extruded nutritional product pieces may then be transferred to a packaging line for placing the finished product into sealed packages.

[0050] In certain exemplary embodiments, the method further comprises flavoring the extruded nutritional product pieces. In certain exemplary embodiments, the extruded nutritional product pieces are flavored by mixing the extruded nutritional product pieces with a powdered flavorant before or after drying the extruded nutritional product pieces. In certain exemplary embodiments, the extruded nutritional product pieces are coated with an edible oil (*e.g.*, an oil containing an omega-3 fatty acid) prior to mixing the extruded nutritional product pieces with the powdered flavorant. The oil coating assists in the powdered flavorant adhering to the extruded nutritional product pieces. The mixing of the extruded nutritional product pieces (either with or without the edible oil coating) and the powdered flavorant may be carried out in a tumbler or similar equipment. Alternatively, the powdered flavorant may be dusted onto the extruded nutritional product pieces.

[0051] In certain exemplary embodiments, the extruded nutritional product pieces are flavored by spraying a liquid flavorant onto the extruded nutritional product pieces. The liquid flavorant may be sprayed onto the extruded nutritional product pieces either before or after drying the

extruded nutritional product pieces. In certain exemplary embodiments, the liquid flavorant may be oil-based and comprise an omega-3 fatty acid.

[0052] Referring now to FIG. 1, an exemplary embodiment of a method of making an extruded nutritional product is shown in schematic form. In this exemplary embodiment, protein, docosahexaenoic acid (DHA), lutein, vitamins, minerals, a starch component, and a dietary fiber component, all in powder form, are added to the first barrel of a five barrel twin-screw extruder along with water. The powder components are added to the first barrel of the extruder at a total rate of about 142.6 kg/h and the water is added to the first barrel of the extruder at a rate of about 42.9 kg/h. In the extruder, the powder components and the water are mixed together in the first three barrels to form a nutritional dough. The screws of the extruder are operated at about 374 RPM and have conventional conveying and kneading elements. The specific mechanical energy (SME) input is about 149.4 W-h/kg. As the nutritional dough is conveyed within the extruder, heat is generated by the shear in the extruder, which cooks the nutritional dough as it is conveyed through barrels four and five. The nutritional dough reaches a temperature of about 110 °C to 190 °C and a pressure of about 0.1 bar to 90 bar at the die. Upon exiting the die, the water within the nutritional dough changes to steam due to the reduction in pressure at elevated temperature, which causes the nutritional dough to expand or puff when exiting the die. The die imparts a shape to the expanded nutritional dough, which is then cut by a knife blade rotating at about 500 RPM to 2,000 RPM to form a plurality of extruded nutritional product pieces. The extruded nutritional product pieces are dried in a convection belt dryer, in which air is circulated at about 65 °C to 125 °C. The dried extruded nutritional product pieces are then conveyed to a packaging line where the finished product is placed into sealed packages.

EXAMPLES

[0053] The following examples illustrate specific exemplary embodiments and features of the extruded nutritional product as disclosed herein. The examples are given solely for the purpose of illustration and are not to be construed as limiting the present disclosure, as many variations thereof are possible without departing from the spirit and scope of the disclosure.

Example 1

[0054] Example 1 illustrates an exemplary embodiment of the extruded nutritional product described herein. All ingredient amounts listed in Table 1 are listed per 1,000 kilogram batch of the extruded nutritional product, unless otherwise indicated. The extruded nutritional product of Example 1 contains 5 grams of protein per 14 gram serving.

TABLE 1		
INGREDIENTS	Example 1	
	Amount per 1,000 kg	
Whole Grain Rice Flour	544.6 kg	
Soy Protein Isolate	420.0 kg	
Docosahexaenoic (DHA) Powder (10% DHA)	23.0 kg	
Mono-glycerides	10.0 kg	
Water Dispersible Natural Vitamin E and Lutein Premix	1.10 kg	
d-Alpha-Tocopheryl Acetate		613 g
Lutein		330 g
Dextrose (carrier)		q.s.
Vitamin/Mineral Premix	1.32 kg	
Niacinamide		188.8 g
Calcium d-Pantothenate		142.6 g
Thiamin Hydrochloride		18.9 g
Manganese Sulfate		18.9 g
Pyridoxine Hydrochloride		23.6 g
Potassium Iodide		2.3 g
Biotin		1.5 g
Chromium Chloride		1.1 g
Sodium Molybdate		792.0 mg
Sodium Selenate		660.0 mg
Cyanocobalamin		94.4 mg
Maltodextrin		q.s.

Example 2

[0055] Example 2 illustrates an exemplary embodiment of the extruded nutritional product described herein. All ingredient amounts listed in Table 2 are listed per 1,000 kilogram batch of the extruded nutritional product, unless otherwise indicated. The extruded nutritional product of Example 2 contains 3 grams of protein per 14 gram serving.

TABLE 2		
INGREDIENTS	Example 2	
	Amount per 1,000 kg	
Whole Grain Rice Flour	713.9 kg	
Soy Protein Isolate	252.0 kg	
Docosahexaenoic (DHA) Powder (10% DHA)	23.0 kg	
Mono-glycerides	10.0 kg	
Water Dispersible Natural Vitamin E and Lutein Premix	1.10 kg	
d-Alpha-Tocopheryl Acetate		613 g
Lutein		330 g
Dextrose (carrier)		q.s.
Vitamin/Mineral Premix	1.32 kg	
Niacinamide		188.8 g
Calcium d-Pantothenate		142.6 g
Thiamin Hydrochloride		18.9 g
Manganese Sulfate		18.9 g
Pyridoxine Hydrochloride		23.6 g
Potassium Iodide		2.3 g
Biotin		1.5 g
Chromium Chloride		1.1 g
Sodium Molybdate		792.0 mg
Sodium Selenate		660.0 mg
Cyanocobalamin		94.4 mg
Maltodextrin		q.s.

Example 3

[0056] Example 3 illustrates an exemplary embodiment of the extruded nutritional product described herein. All ingredient amounts listed in Table 3 are listed per 100 kilograms of the extruded nutritional product, unless otherwise indicated. The nutrient profile for a 7 gram serving of the extruded nutritional product is also provided in Table 3.

TABLE 3	
INGREDIENTS	Example 3
	Amount per 100 kg
Soy Protein Isolate	51.84 kg
Brown Rice Flour	38.94 kg
Docosahexaenoic (DHA) Powder	4.29 kg
Water	2.41 kg
Vitamin ADEK and Lutein Premix	243.5 g
Vitamin Premix	49.2 g
Vitamin D3	1.7 g
Flavor	0.5 g
NUTRIENT PROFILE	Amount per Serving (7 grams)
Carbohydrates	3.25 g
Protein	3.25 g
Fiber	0.1 g
Water	0.18 g
DHA	32 mg
Lutein	0.25 mg
Vitamin E	3 mg
Vitamin B1	70 mcg
Vitamin B5	50 mcg
Vitamin B6	70 mcg
Vitamin B12	0.3 mcg
Biotin	0.15 mcg
Vitamin D	4 mcg
Vitamin K	12 mcg

Iodine	7 mcg
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[0057] To the extent that the term “includes” or “including” is used in the specification or the claims, it is intended to be inclusive in a manner similar to the term “comprising” as that term is interpreted when employed as a transitional word in a claim. Furthermore, to the extent that the term “or” is employed (*e.g.*, A or B) it is intended to mean “A or B or both.” When the applicants intend to indicate “only A or B but not both” then the term “only A or B but not both” will be employed. Thus, use of the term “or” herein is the inclusive, and not the exclusive use.

[0058] While the present application has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the application, in its broader aspects, is not limited to the specific details, the representative compositions or formulations, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the general disclosure described herein.

WHAT IS CLAIMED IS:

1. An extruded nutritional product comprising:
from 15 wt.% to 75 wt.% protein;
at least one of a carotenoid and an omega-3 fatty acid;
wherein the extruded nutritional product has a bulk density of from 30 g/L to 200 g/L.
2. The extruded nutritional product according to claim 1, wherein the extruded nutritional product comprises a carotenoid selected from the group consisting of lutein, beta-carotene, lycopene, zeaxanthin, and combinations thereof.
3. The extruded nutritional product according to either claim 1 or claim 2, wherein the extruded nutritional product comprises an omega-3 fatty acid selected from the group consisting of docosahexaenoic acid, alpha-linolenic acid, eicosapentaenoic acid, and combinations thereof.
4. The extruded nutritional product according to claim 1, wherein the carotenoid comprises lutein and the omega-3 fatty acid comprises docosahexaenoic acid.
5. The extruded nutritional product according to any one of claims 1 to 4, wherein the protein comprises at least one of whey protein concentrate, whey protein isolate, whey protein hydrolysate, acid casein, sodium caseinate, calcium caseinate, potassium caseinate, casein hydrolysate, milk protein concentrate, milk protein isolate, milk protein hydrolysate, nonfat dry milk, condensed skim milk, skim milk powder, soy protein concentrate, soy protein isolate, soy protein hydrolysate, pea protein concentrate, pea protein isolate, pea protein hydrolysate, collagen protein, collagen protein isolate, potato protein, rice protein, and quinoa protein.
6. The extruded nutritional product according to any one of claims 1 to 5, further comprising from 20 wt.% to 80 wt.% of a starch component.

7. The extruded nutritional product according to claim 6, wherein the starch component comprises at least one of rice flour, tapioca flour, corn flour, wheat flour, oat flour, soy flour, barley flour, buckwheat flour, chick pea flour, legume flour, and potato flour.
8. The extruded nutritional product according to any one of claims 1 to 7, further comprising from 1 wt.% to 40 wt.% of a dietary fiber component.
9. The extruded nutritional product according to claim 8, wherein the dietary fiber component comprises at least one of fructooligosaccharides, inulin, corn dextrin, wheat dextrin, carboxymethyl cellulose, oat bran, corn bran, wheat bran, rice bran, fruit fiber, vegetable fiber, soy fiber, chicory flour, chia fiber, microcrystalline cellulose, and sugar beet fiber.
10. The extruded nutritional product according to any one of claims 1 to 9, further comprising RRR- α -tocopherol.
11. The extruded nutritional product according to any one of claims 1 to 10, further comprising at least one vitamin selected from the group consisting of vitamin B₁, vitamin B₃, vitamin B₅, vitamin B₆, vitamin B₇, vitamin B₉, vitamin B₁₂, vitamin C, vitamin A, vitamin D, and vitamin K.
12. The extruded nutritional product according to any one of claims 1 to 11, further comprising at least one mineral selected from the group consisting of calcium, potassium, sodium, manganese, chromium, molybdenum, selenium, copper, iron, iodide, magnesium, phosphorus, zinc, and chloride.
13. The extruded nutritional product according to any one of claims 1 to 12, further comprising at least one of a fruit material and a vegetable material.
14. A method of making an extruded nutritional product comprising:

a) mixing water, a protein, and at least one of a carotenoid and an omega-3 fatty acid within an extruder to form a nutritional dough, wherein the extruder has at least one screw and a die;

d) extruding the nutritional dough through the die, wherein the nutritional dough expands upon exiting the die;

e) cutting the expanded nutritional dough to form a plurality of extruded nutritional product pieces; and

f) drying the extruded nutritional product pieces;

wherein the dried extruded nutritional product pieces have a bulk density of from 30 g/L to 200 g/L and comprise from 15 wt.% to 75 wt.% protein.

15. The method according to claim 14, further comprising flavoring the extruded nutritional product pieces.

16. The method according to claim 15, wherein flavoring the extruded nutritional product pieces comprises mixing the extruded nutritional product pieces with a powdered flavorant before or after drying the extruded nutritional product pieces.

17. The method according to claim 15, wherein flavoring the extruded nutritional product pieces comprises spraying a liquid flavorant onto the extruded nutritional product pieces, wherein the liquid flavorant is sprayed onto the extruded nutritional product pieces before or after drying the extruded nutritional product pieces.

18. The method according to any one of claims 14 to 17, wherein the nutritional dough has a temperature of 110 °C to 190 °C prior to exiting the die.

19. The method according to any one of claims 14 to 18, wherein the extruder has two screws and the screws are operated at 100 to 450 revolutions per minute.

20. The method according to any one of claims 14 to 19, wherein the carotenoid comprises lutein.
21. The method according to any one of claims 14 to 20, wherein the omega-3 fatty acid comprises docosahexaenoic acid.
22. The method according to any one of claims 14 to 21, wherein step a) further comprises mixing RRR-alpha-tocopherol with the water, protein, and at least one of the carotenoid and the omega-3 fatty acid.
23. The method according to any one of claims 14 to 22, wherein step a) further comprises a mixing a starch component with the water, protein, and at least one of the carotenoid and the omega-3 fatty acid, wherein the starch component comprises at least one of rice flour, tapioca flour, corn flour, wheat flour, oat flour, soy flour, barley flour, buckwheat flour, chick pea flour, legume flour, and potato flour.
24. The method according to any one of claims 14 to 23, wherein step a) further comprises a mixing a dietary fiber component with the water, protein, and at least one of the carotenoid and the omega-3 fatty acid, wherein the dietary fiber component comprises at least one of fructooligosaccharides, inulin, corn dextrin, wheat dextrin, carboxymethyl cellulose, oat bran, corn bran, wheat bran, rice bran, fruit fiber, vegetable fiber, soy fiber, chicory flour, chia fiber, microcrystalline cellulose, and sugar beet fiber.
25. The method according to any one of claims 14 to 24, wherein the protein comprises at least one of whey protein concentrate, whey protein isolate, whey protein hydrolysate, acid casein, sodium caseinate, calcium caseinate, potassium caseinate, casein hydrolysate, milk protein concentrate, milk protein isolate, milk protein hydrolysate, nonfat dry milk, condensed skim milk, skim milk powder, soy protein concentrate, soy protein isolate, soy protein hydrolysate, pea protein concentrate, pea protein isolate, pea protein hydrolysate, collagen protein, collagen protein isolate, potato protein, rice protein, and quinoa protein.

26. The method according to any one of claims 14 to 25, wherein the dried extruded nutritional product pieces have a moisture content of less than 15 wt.%.

27. The method according to claim 26, wherein the dried extruded nutritional product pieces have a moisture content of from 2 wt.% to 8 wt.%.

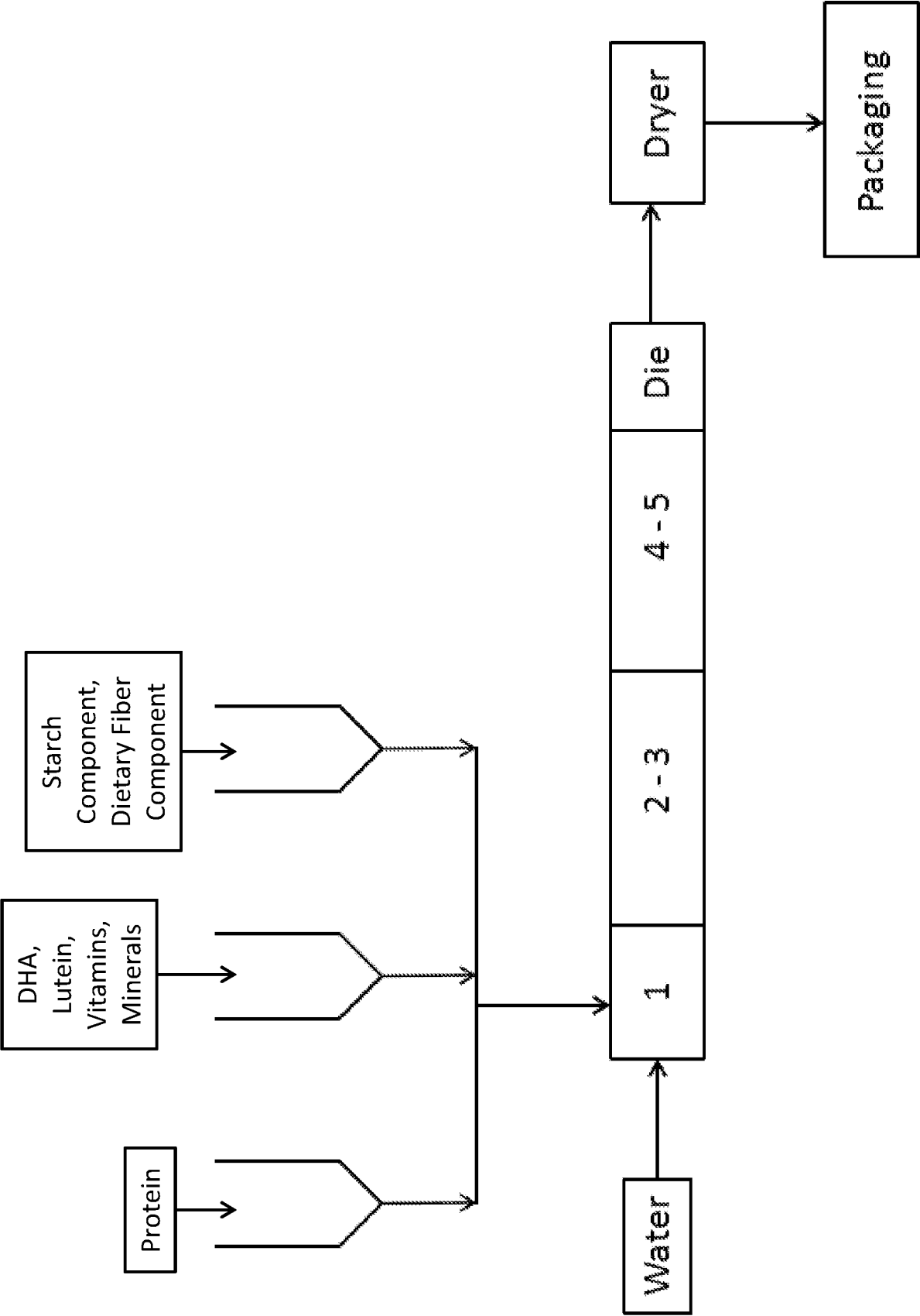


FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/067093

A. CLASSIFICATION OF SUBJECT MATTER

INV. A23L7/17 A23L33/17 A23L33/19 A23L33/185 A23L33/12
A23L33/155

ADD.

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)

A23L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	the whole document	1-27
Y	US 2005/064079 A1 (ALLEN PATRICK E [US] ET AL) 24 March 2005 (2005-03-24) paragraphs [0114], [0120]; claims 1-50; examples 1-4	1-27
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

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