SUMMARY

[0012] In one aspect, the present disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from 6.0 to 8.0, the composition comprising a total protein content of at least 9 g per 100 mL of the composition, the total protein content comprising a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least 55% is present in a denatured state, and b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins, wherein the whey protein has a degree of hydrolysis of less than 4%, and the whey protein and the non-whey protein are present in a weight ratio of from 35:65 to 80:20.

[0012a] In another aspect, the present disclosure relates to a method of preparing a heat-treated liquid nutritional composition, the method comprising a) providing a liquid composition having a pH of between 6.0 and 8.0, the composition comprising a total protein content of at least 9 g per 100 mL of the composition, the total protein content comprising i) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least 55% is present in a denatured state, and ii) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins, wherein the whey protein has a degree of hydrolysis of less than 4%, and they whey protein and the non-whey protein are present in a weight ratio of from 35:65 to 80:20, b) subjecting the liquid composition to a heat treatment having an F_0-value of at least 3 to prepare the heat-treated liquid nutritional composition, and c) optionally drying the heat-treated liquid nutritional composition.

[0012b] In another aspect, the present disclosure relates to a liquid nutritional composition as described herein for use in therapy. In another aspect, the present disclosure relates to a use of a liquid nutritional composition as described herein in the manufacture of a composition for maintaining or increasing muscle protein synthesis, maintaining or increasing muscle mass, preventing or reducing loss of muscle mass, maintaining or increasing growth, preventing or decreasing muscle catabolism, preventing or treating cachexia, preventing or treating sarcopenia, increasing rate of glycogen resynthesis, modulating blood sugar levels, increasing insulin response to raised blood glucose concentration, reducing satiety, reducing satiation, reducing food intake, reducing calorie intake, improving glucose metabolism, increasing rate of recovery following surgery, increasing prehabilitation efficacy prior to surgery or chemotherapy, increasing rate of recovery following injury, increasing rate of recovery following exercise, increasing sports performance, and/or providing nutrition to a subject in need thereof.

[0012c] In one example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins.

[0013] In another example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins,

wherein the whey protein has a degree of hydrolysis of less than about 4%, and the whey protein and the non-whey protein are present in a weight ratio of at least about 35:65, preferably from about 35:65 to about 80:20.

[0014] In another example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins

wherein the composition comprises at least about 4 g whey protein per 100 mL of the composition.

[0015] In a further example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins,

wherein the whey protein comprises at least about 40% by weight of the total protein in the composition.

[0016] In another example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) casein.

[0017] In another example the disclosure relates to a heat-treated, shelf-stable liquid nutritional composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

b) casein,

wherein the whey protein and casein are present in a weight ratio of at least about 35:65, preferably from about 35:65 to about 80:20.

[0018] In one example the disclosure provides a method of preparing a liquid nutritional composition, the method comprising

a) providing a liquid composition having a pH of from about 6.0 and 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

i. whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and

ii. non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins, and

b) subjecting the liquid composition to a heat treatment having an F_0-value of at least 3 to prepare the heat-treated liquid nutritional composition.

[0019] In another example the disclosure relates to a method of preparing a heat-treated, shelf-stable liquid nutritional composition, the method comprising

a) providing a liquid composition having a pH of from about 6.0 to about 8.0, the composition comprising

a total protein content of at least about 6 g per 100 mL of the composition, the total protein content comprising

i. whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least about 55% is present in a denatured state, and the whey protein in a denatured state comprising microparticles having a volume weighted mean diameter D[4,3] of less than about 10 μm,

ii. non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins,

wherein the whey protein has a degree of hydrolysis of less than about 4%, and the whey protein and the non-whey protein are present in a weight ratio of at least about 35:65, preferably from about 35:65 to about 80:20, and

b) subjecting the liquid composition to a heat treatment having an F_0-value of at least 3 to prepare the heat-treated liquid nutritional composition.

[0020] In one example the disclosure provides a heat-treated liquid nutritional composition prepared according to a method described herein.

[0021] In one example the disclosure provides a method of maintaining or increasing muscle protein synthesis, maintaining or increasing muscle mass, preventing or reducing loss of muscle mass, maintaining or increasing growth, preventing or decreasing muscle catabolism, preventing or treating cachexia, preventing or treating sarcopenia, increasing rate of glycogen resynthesis, modulating blood sugar levels, increasing insulin response to raised blood glucose concentration, reducing satiety, reducing satiation, reducing food intake, reducing calorie intake, improving glucose metabolism, increasing rate of recovery following surgery, increasing prehabilitation efficacy prior to surgery or chemotherapy, increasing rate of recovery following injury, increasing rate of recovery following exercise, increasing sports performance, and/or providing nutrition to a subject in need thereof, the method comprising the steps of administering to the subject a liquid nutritional composition described herein.

[0022] In another example the disclosure provides use of a liquid nutritional composition described herein in the preparation of a composition, preferably a supplement or medicament for maintaining or increasing muscle protein synthesis, maintaining or increasing muscle mass, preventing or reducing loss of muscle mass, maintaining or increasing growth, preventing or decreasing muscle catabolism, preventing or treating cachexia, preventing or treating sarcopenia, increasing rate of glycogen resynthesis, modulating blood sugar levels, increasing insulin response to raised blood glucose concentration, reducing satiety, reducing satiation, reducing food intake, reducing calorie intake, improving glucose metabolism, increasing rate of recovery following surgery,

increasing prehabilitation efficacy prior to surgery or chemotherapy, increasing rate of recovery following injury, increasing rate of recovery following exercise, increasing sports performance, and/or providing nutrition to a subject in need thereof.

[0023] In a further example the disclosure provides a liquid nutritional composition described herein for maintaining or increasing muscle protein synthesis, maintaining or increasing muscle mass, preventing or reducing loss of muscle mass, maintaining or increasing growth, preventing or decreasing muscle catabolism, preventing or treating cachexia, preventing or treating sarcopenia, increasing rate of glycogen resynthesis, modulating blood sugar levels, increasing insulin response to raised blood glucose concentration, reducing satiety, reducing satiation, reducing food intake, reducing calorie intake, improving glucose metabolism, increasing rate of recovery following surgery, increasing prehabilitation efficacy prior to surgery or chemotherapy, increasing rate of recovery following injury, increasing rate of recovery following exercise, increasing sports performance, and/or providing nutrition to a subject in need thereof.

[0024] Any of the examples or preferences described herein may relate to any of the examples herein alone or in combination with any one or more examples or preferences described herein, unless stated or indicated otherwise.

[0025] In various examples the liquid nutritional composition has a pH of about 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9 or about 8.0, and various ranges can be selected from between these values, for example, from about 6.0 to about 8.0, about 6.0 to about 7.5, about 6.0 to about 7.2, about 6.0 to about 7.0, about 6.2 to about 8.0, about 6.2 to about 7.5, about 6.2 to about 7.2, about 6.2 to about 7.0, about 6.4 to about 8.0, about 6.4 to about 7.5, about 6.4 to about 7.2, about 6.4 to about 7.0, or from about 6.5 to about 8.0, about 6.5 to about 7.5, about 6.5 to about 7.2, or from about 6.5 to about 7.0.

[0026] In various examples the liquid nutritional composition comprises a total protein content of at least about 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27 or at least about 30 g per 100 mL of the composition, and various ranges can be selected from between these values, for example, from about 6 to about 30 g, about 7 to about 30, about 8 to about 30, about 9 to about 30, about 10 to about 30, 6 to about 25 g, about 7 to about 25, about 8 to about 25, about 9 to about 25, about 10 to about 25, about 11 to 25, about 12 to 25, about 13 to about 25, about 14 to about 25, about 15 to about 25, about 6 to about 20 g, about 7 to about 20, about 8 to about 20, about 9 to about 20, about 10 to about 20, or about 10 to about 15 g total protein per 100 mL of the composition. In various examples the liquid nutritional composition comprises a total protein content of at least about 9 g protein per 100 mL of the composition, or at least

about 10 g protein per 100 mL of the composition, or at least about 12 g protein per 100 mL of the composition.

[0027] In various examples the whey protein and non-whey protein, the whey protein and casein, or the whey protein and one or more non-dairy proteins are present in the composition in a weight ratio of at least about 20:80, 25:75, 30:70, 35:65, 40:60, 45:55, 50:50, 55:45, 60:40, 65:35, 70:30, 75:25, 80:20, 85:15, 90:10, 95:5 or at least about 99:1 and various ranges can be selected from between these values, for example, from about 30:70 to about 80:20, about 35:65 to about 80:20, about 40:60 to about 80:20, about 45:55 to about 80:20, about 50:50 to about 80:20, about 30:70 to about 75:25, about 35:65 to about 75:25, about 40:60 to about 75:25, about 45:55 to about 75:25, about 50:50 to about 75:25, about 30:70 to about 70:30, about 35:65 to about 70:30, about 40:60 to about 70:30, about 45:55 to about 70:30 or about 50:50 to about 70:30, about 30:70 to about 65:35, about 35:65 to about 65:35, about 40:60 to about 65:35, about 45:55 to about 65:35, about 50:50 to about 65:35, about 30:70 to about 60:40, about 35:65 to about 60:40, about 40:60 to about 60:40, about 45:55 to about 60:40, or about 50:50 to about 60:40. In one preferred example, the ratio may be at least about 35:65, more preferably from about 35:65 to about 80:20.

[0028] In various examples the composition comprises at least about 0.01, 0.1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or at least about 20 g non-whey protein per 100 mL of the composition, and various ranges may be selected from between any of these values, for example, from about 0.01 to about 2, 1 to about 20, 2 to about 20, 3 to about 20, 4 to about 20, 5 to about 20, 0.01 to about 15, 1 to about 15, 2 to about 15, 3 to about 15, 4 to about 15, 5 to about 15, 0.01 to about 10, 1 to about 10, 2 to about 10, 3 to about 10, 4 to about 10 or about 5 to about 10 g non-whey protein per 100 mL of the composition.

[0029] In various examples non-whey protein comprises at least about 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 or at least about 95% by weight of the total protein in the composition, and various ranges may be selected from between any of these values, for example, from about 1% to about 99%, 10% to about 95%, about 10 to about 80%, about 10% to about 70%, about 10% to about 65%, about 10% to about 60%, about 15% to about 95%, about 15 to about 80%, about 15% to about 70%, about 15% to about 65%, about 15% to about 60%, about 20 to about 80%, about 20% to about 70%, about 20% to about 65%, or about 20% to about 60% by weight of the total protein in the composition.

[0030] In one example the non-whey protein is at least partially hydrolysed. In another example the non-whey protein is non-hydrolysed. In various examples the

non-whey protein has a degree of hydrolysis of less than about 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 95 or at least about 99%, and various ranges may be selected from between any of these values, for example, from about 0 to about 99, 1 to about 99%, about 5 to about 99%, about 10 to about 99%, about 20 to about 99%, about 50 to about 99%, about 0 to about 95, about 1 to about 95%, about 5 to about 95%, about 10 to about 95%, about 20 to about 95%, about 50 to about 95%, about 0 to about 90, about 1 to about 90%, about 5 to about 90%, about 10 to about 90%, about 20 to about 90%, about 50 to about 90%, about 0% to about 50%, about 1% to about 50%, about 0% to about 25%, about 1% to about 25%, about 0% to about 20%, about 1% to about 20%, about 0% to about 10%, about 1% to about 10%, about 0% to about 5% or about 1% to about 5%.

[0031] In various examples, the whey protein comprises, consists essentially of, or consists of, or is provided by an ingredient that comprises, consists essentially of, or consists of heat-denaturable protein of which at least about 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90% or at least about 95% is present in a denatured state.

[0032] In various examples, the whey protein in a denatured state may comprise microparticles having a volume weighted mean diameter D[4,3] of less than about 10, 9.5, 9, 8.5, 8, 7.5, 7, 6.5, 6, 5.5, 5, 4.5, 4, 3.5, 3, 2.5, or 2 μm. In various preferred examples, the volume weighted mean diameter D[4,3] may be less than about 5 μm, or less than about 3 μm, or less than about 2 μm. Preferably the volume weighted mean diameter D[4,3] is less than about 10 μm, or less than about 5 μm, or less than about 3 μm, or less than about 2 μm.

[0033] In various examples the whey protein may be non-hydrolysed. In various examples the whey protein may have a degree of hydrolysis of less than about 5%, 4.75%, 4.5%, 4.25%, 4%, 3.75%, 3.5%, 3.25%, 3%, 2.75%, 2.5%, 2.25%, 2%, 1.75%, 1.5%, 1.25%, 1%, 0.75%, or less than about 0.5%. In various preferred examples, the whey protein may have a degree of hydrolysis of less than about 4%.

[0034] In certain examples the whey protein is provided by a whey protein concentrate (WPC), a whey protein isolate (WPI), or a blend of whey protein sources including a blend of WPCs or WPIs or both. In some examples the whey protein is provided by a WPC, WPI or a blend thereof, and an ingredient that comprises whey protein and non-whey protein, for example, casein. In one example the ingredient that comprises whey protein and non-whey protein is selected from the group comprising a milk protein concentrate (MPC); total milk protein (TMP); a milk co-precipitate; a micellar casein concentrate (MCC); a milk protein isolate (MPI); proteins of liquid condensed milk; skim

milk; skim milk powder; condensed skim milk; whole milk; whole milk powder; or a combination of any two or more thereof.

[0035] In one example, the whey protein is provided by an ingredient that comprises a protein content of 35% to 95% by weight of the dry matter of the ingredient.

[0036] In certain examples, the whey protein ingredient comprises at least about 35%, 50%, 65%, 70%, 75%, or at least about 80% by weight protein. In certain examples, higher protein content compositions are utilised, for example the whey protein ingredient comprises at least about 85%, 90%, or at least about 95% by weight protein.

[0037] In various examples the composition comprises a whey protein ingredient, for example, a WPC or WPI, that has been treated to reduce lactose concentration. In various examples the whey protein ingredient comprises less than about 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0.5 or less than about 0.1% lactose.

[0038] In various examples the composition comprises at least about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or at least about 20 g whey protein per 100 mL of the composition, and various ranges may be selected from between any of these values, for example, from about 2 to about 20, 4 to about 20, about 5 to about 20, about 6 to about 20, about 7 to about 20, about 2 to about 15, about 4 to about 15, about 5 to about 15, about 6 to about 15 or about 7 to about 15 g whey protein per 100 mL of the composition.

[0039] In various examples whey protein comprises at least about 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 or at least about 95% by weight of the total protein in the composition, and various ranges may be selected from between any of these values, for example, from about 1% to about 99%, 10% to about 95%, about 20 to about 80%, about 35 to about 80%, about 40% to about 95% or from about 40% to about 80% by weight of the total protein in the composition.

[0040] In one example the casein comprises or is provided by an ingredient that comprises soluble casein. In various examples the casein is micellar casein, non-micellar casein, or micellar and non-micellar casein.

[0041] In various examples the casein comprises or is provided by an ingredient comprising milk protein isolate (MPI); milk protein concentrate (MPC); micellar casein isolate (MCI); micellar casein concentrate (MCC); proteins of liquid condensed milk; skim milk; skim milk powder, condensed skim milk; whole milk; whole milk powder; a caseinate; total milk protein (TMP); milk co-precipitates; an MPC or MPI that has been modified to

dissociate casein micelles; calcium-chelated casein micelles; a charge-modified casein; a casein ingredient, such as an MPC or MPI, where at least a portion of the calcium or phosphate or both the calcium and phosphate has been replaced with sodium, potassium, zinc, magnesium, or a combination of any two or more thereof; a glycosylated casein or a combination of any two or more thereof.

[0042] In various examples the casein may comprise or be provided by a casein ingredient such as an MPC or MPI, where at least a portion of the calcium or phosphate or both the calcium and phosphate has been replaced with sodium, potassium, zinc, magnesium, or a combination of any two or more thereof.

[0043] In various examples the caseinate comprises sodium caseinate, calcium caseinate, magnesium caseinate, potassium caseinate or a combination of any two or more thereof.

[0044] In various examples the composition comprises a casein ingredient, for example, a MPC or MPI, that has been treated to reduce lactose concentration. In various examples the casein ingredient comprises less than about 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0.5 or less than about 0.1% lactose.

[0045] In various examples casein comprises at least about 1%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70% or at least about 75% by weight of the total protein in the composition and various ranges can be selected from between these values, for example, from about 1% to about 75%, about 5% to about 75%, about 1% to about 65%, 5% to about 65%, about 10% to about 65%, about 20% to about 65%, about 30% to about 65%, or about 40% to about 65%.

[0046] In various examples the composition comprises at least about 0, 0.01, 0.1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or at least about 20 g casein per 100 mL of the composition, and various ranges may be selected from between any of these values, for example, from about 0 to about 20, about 0.01 to about 20, 4 to about 20, about 5 to about 20, about 6 to about 20, about 7 to about 20, about 0 to about 15, about 0.01 to about 15 about 4 to about 15, about 5 to about 15, about 6 to about 15 or about 7 to about 15 g casein per 100 mL of the composition.

[0047] In one example the casein is non-hydrolysed. In another example the casein is at least partially hydrolysed.

[0048] In one example the composition comprises one or more non-dairy proteins. In various examples the non-dairy protein comprises algal protein, hydrolysed algal

protein, plant protein, hydrolysed plant protein, animal protein, or hydrolysed animal protein, or any combination of any two or more thereof.

[0049] In various examples the plant protein comprises canola (rapeseed), legume, cereal, nut, or seed protein or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is a hydrolysed plant protein. In various examples the legume protein comprises pea, chickpea, bean, lupin, lentil or soy protein, or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is a hydrolysed plant protein. In various examples the cereal protein comprises rice, wheat, sorghum, maize, corn, or barley protein, or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is hydrolysed plant protein. In various examples the nut protein comprises almond, or cashew protein, or any combination thereof, optionally wherein any one or more of the plant proteins is a hydrolysed plant protein. In various examples the seed protein comprises chia, hemp or flax (linseed) protein, or any combination of any two or more thereof, optionally wherein any one or more of the plant proteins is hydrolysed plant protein.

[0050] In various examples the animal protein may comprise collagen, hydrolysed collagen, recombinant collagen, hydrolysed recombinant collagen, or any combination of any two or more thereof.

[0051] In various examples the non-dairy protein has a pI of about 3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9 or about 6, and various ranges can be selected from between these values, for example, from about 3 to about 6, about 3.5 to about 6, about 4 to about 6, about 3 to about 5.5, about 3.5 to about 5.5, about 4 to about 5.5, about 3 to about 5, about 3.5 to about 5 or about 4 to about 5.

[0052] In various examples, the composition comprises at least about 0, 0.01, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25 or at least about 30 g non-dairy protein per 100 mL of the composition, and various ranges can be selected from between these values, for example, from about 0 to about 30, about 0.01 to about 30, about 1 to about 30, about 0 to about 20, 0.01 to about 20, about 0.1 to about 20, about 0.5 to about 20, about 0.1 to about 15, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 5 to about 20, about 0 to about 10, about 0.01 to about 10, about 1 to about 10 g non-dairy protein per 100 mL of the composition.

[0053] In various examples, the composition comprises at least about 0.01, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25 or at least about 30 g lipid per 100 mL of the composition, and various ranges can be selected from between these values, for example,

from about 0.01 to about 30, about 0.1 to about 30, about 1 to about 30, about 0.01 to about 25, about 0.1 to about 25, about 1 to about 25, about 0.01 to about 20, about 0.1 to about 20, about 0.5 to about 20, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 5 to about 20 g about 0.01 to about 15, about 0.1 to about 15, about 1 to about 15, about 2 to about 15, about 5 to about 15, about 0.01 to about 10, about 0.1 to about 10, about 1 to about 10, or about 2 to about 10 g lipid per 100 mL of the composition.

[0054] In various examples, the composition comprises at least about 0.01, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 40 or at least about 45 g carbohydrate per 100 mL of the composition, and various ranges can be selected from between these values, for example, from about 0.01 to about 4, about 0.01 to about 45, about 0.1 to about 45, about 1 to about 45, about 4 to about 45, about 5 to about 45, about 0.01 to about 40, about 0.1 to about 40, about 1 to about 40, about 4 to about 40, about 5 to about 40, about 0.01 to about 30, about 1 to about 30, about 1 to about 30, about 4 to about 30, about 5 to about 30, 0.01 to about 20, about 0.1 to about 20, about 0.5 to about 20, about 0.1 to about 15, about 1 to about 20, about 2 to about 20, about 3 to about 20, about 4 to about 20, or about 5 to about 20 g carbohydrate per 100 mL of the composition.

[0055] In various examples the carbohydrate comprises digestible carbohydrate, non-digestible carbohydrate or a combination thereof.

[0056] In various examples the composition has an energy density of at least about 25, 50, 75, 100, 125, 150, 200, 250, 300, 350 or at least about 400 kcal per 100 mL, and various ranges can be selected from between these values, for example, from about 25 to about 400, 50 to about 400, about 100 to about 400, about 150 to about 400, about 175 to about 400, about 50 to about 350, about 50 to about 300, about 100 to about 300, about 25 to about 300, about 50 to about 300, about 100 to about 300, about 25 to about 250, about 50 to about 250, about 100 to about 250, about 25 to about 200, about 50 to about 200, or about 100 to about 200 kcal per 100 mL of the composition. In various preferred examples the composition has an energy density of at least about 200 kcal per 100 mL of the composition.

[0057] In various examples, the composition comprises, consists essentially of, or consists of 0 g or about or less than about 0.5, 1, 2, 3, 4, or 5 g per 100 mL of the composition of di-, oligo-, and/or poly-saccharides that comprise one glucose unit or no glucose units. Various ranges can be selected from between these values, for example, from about 0 to about 5, about 0 to about 4, or about 0.01 to about 4 g per 100 mL of the composition.

[0058] In various examples, the composition comprises at least about 0, 0.01, 0.025, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, or 0.5 g emulsifier and/or surfactant per 100 mL of the composition, and various ranges can be selected from between these values, for example, from about 0 to about 0.5, about 0.01 to about 3, or about 0.01 to about 0.2 g per 100 mL of the composition.

[0059] In various examples, the composition comprises at least about 0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009, 0.01, 0.015, 0.02, 0.025, 0.03, 0.035, 0.04, 0.045, 0.05, 0.055, 0.06, 0.065, 0.07, 0.075, 0.08, 0.085, 0.09, 0.095, or 0.1 g of emulsifier per g of lipid, and various ranges can be selected from between these values, for example, about 0.001 to about 0.1, about 0.002 to about 0.08, or about 0.003 to about 0.06 g per g of lipid.

[0060] In various examples the composition has a viscosity of less than about 500, 450, 400, 300, 200, 150, 100, 80, 60, 50, 40, 30, or less than about 20 mPa.s when measured at a temperature of 20°C and a shear rate of 100 s^{-1}.

[0061] In one example the composition exhibits essentially no gelation or aggregation.

[0062] In various examples the composition has an average particle size of less than about 20, 18, 15, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2.5, 2, 1.5, 1, 0.9, 0.8, 0.7 0.6, 0.5, 0.4, 0.3 or 0.25 μm as categorised by the surface weighted average particle size parameter d[3,2] and/or the volume weighted mean diameter D[4,3], and useful ranges may be selected between any of these values, for example about 0.25 to about 20, about 0.25 to about 15, about 0.25 to about 10, about 0.25 to about 8, about 0.25 to about 6, or about 0.25 to about 4 μm.

[0063] In various examples the composition may comprise, consist essentially of, or consist of a total amount of monovalent metal ions of at least about5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, or 50 mg/g of protein, and useful ranges may be selected between these values, for example, about 8 to about 20, about 8 to about 30, about 8 to about 40, about 8 to about 50, about 10 to about 50, about 15 to about 50, about 20 to about 50 and about 50 to about 50 mg/g of protein. In various examples the monovalent metal ions may comprise sodium ions, potassium ions, or both.

[0064] In various examples the composition may comprise, consist essentially of, or consist of an amount of monovalent metal ions of at least about 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 225, 250, 275, 300, 325, 350, 375,

400, 425, 450, 475, or 500 mg/100ml of the composition, and useful ranges may be selected between any of these values, for example, from about 50 to about 500, about 100 to about 400, about 150 to about 350, or about 100 to about 500 mg/100 ml.

[0065] In various examples the composition may comprise, consist essentially of, or consist of an amount of calcium of at least about 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, or 500 mg calcium/100ml of the composition, and useful ranges may be selected between any of these values, for example, from about 50 to about 500, about 100 to about 400, about 150 to about 350, or about 100 to about 500 mg/100 ml.

[0066] In various examples the protein in the composition remains soluble in the upper gastrointestinal tract, remains soluble in upper gastrointestinal fluid, does not form a coagulum in the upper gastrointestinal tract or does not form a coagulum in upper gastrointestinal fluid.

[0067] In various examples the protein in the composition remains soluble or does not form a coagulum at a pH of about 1, 2, 3, 4 or about pH 5. In one example the protein in the composition remains soluble or does not form a coagulum when simulated gastric fluid is added to the composition, for example, simulated gastric fluid prepared as described herein in the Examples (comprising hydrochloric acid, a protease, and a lipase, preferably comprising hydrochloric acid, pepsin, and lipase A, more preferably 1 M hydrochloric acid, pepsin 16 mg/mL, and lipase A 2mg/mL). In various examples, the volume weighted mean diameter D[4,3] and/or the surface weighted mean diameter D[3,2] of protein microparticles in the composition remains less than about 10 μm, or less than about 5 μm, or less than about 3 μm, or less than about 2 μm over a 220 minute period at a pH less than about 4, preferably in the presence of the simulated gastric fluid.

[0068] In various examples the composition has a viscosity of less than about 500, 450, 400, 300, 200, 150, 100, 80, 60, 50, 40, 30 or less than about 20 mPa.s when measured at a temperature of 20°C and a shear rate of 100 s^{-1} after storage for at least 2 months, 3 months, 6 months or at least 12 months storage at a temperature of 20, 22 or 25°C.

[0069] In various examples the viscosity of the composition increases by less than about 10, 20, 30, 40, 50, 60, 70, 80, 90 or less than about 100% when measured at a temperature of 20°C and a shear rate of 100 s^{-1} after storage for at least 2 months, 3 months, 6 months or 12 months at a temperature of 20, 22 or 25°C.

[0070] In various examples the composition exhibits no observable gelation, or no observable aggregation, no observable sedimentation or a combination of any two or more thereof, for at least 2 months, 3 months, 6 months or at least 12 months at a temperature of 20, 22 or 25°C.

[0071] In various examples, the composition may be subjected to a heat treatment having an F_0-value of at least 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, or 40 (and half-unit increments thereof, e.g. 19.5), and useful ranges can be selected between these values, for example, 3 to 20, 3 to 30, 3 to 40, 10 to 20, 10 to 30, or 10 to 40.

[0072] In various examples, when subjected to a heat treatment having an F_0-value of at least 3, for example , 121.1°C for 3 min, 130 °C for 25 s, 135 °C for 7.5 s, 140°C for 2.5s, 145 °C for 0.75 s, or 150 °C for 0.25 s, the composition

a) exhibits substantially no gelation, aggregation or sedimentation

b) has a viscosity of less than about 500 mPa.s when measured at a temperature of 20°C and a shear rate of 100 s^{-1},

c) has an average particle size of less than about 20, 18, 15, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2.5, 2, 1.5, 1, 0.9, 0.8, 0.7 0.6, 0.5, 0.4, 0.3 or 0.25 µm as categorised by the volume weighted mean diameter D[4,3] and/or the surface weighted average particle size parameter d[3,2], or

d) a combination of any two or more of a) to c) above.

[0073] In one example the heat-treated liquid nutritional composition

a) has a viscosity of less than about 500 mPa.s when measured at 20°C and shear rate of 100 s^{-1}, or

b) has an average particle size of less than about 20 µm as categorised by the volume weighted mean diameter D[4,3] and/or the surface weighted average particle size parameter d[3,2], or

c) exhibits essentially no observable gelation or aggregation or sedimentation, or

d) any combination of any two or more of (a) to (c) above.

[0074] In one example the heat treatment has an F_0 value of at least 3. In various examples the heat treatment has an F_0 value of at least equivalent to 121.1°C for 3

min, 130 °C for 25 s, 140°C for 2.5s or 150 °C for 0.25 s. In one example the heat treatment is sufficient to provide a shelf stable product.

[0075] In various examples the method comprises heat treating the liquid composition at a temperature of at least about 121, 125, 130, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149 or at least about 150 °C for a period of at least about 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 30, 40, 50, 60 seconds or at least about 1, 2, 3, 4, 5, 6, 7, 8, 9 or at least about 10 minutes. Various ranges can be selected from between any of these values, for example, in various examples the method comprises heat treating the liquid composition at a temperature of at least about, 121 to about 150, 125 to about 150, 130 to about 150, 135 to about 150, 138 to about 150, 121 to about 145, 125 to about 145, 130 to about 145, 135 to about 145, or about 138 to about 145 °C for at least about 0.1 s to about 10 minutes, about 0.1 s to about 1 minute, about 0.1 s to about 30 s, about 0.5 s to about 30 s, about 1 s to about 30 s, about 3 s to about 30 s about 0.1 s to about 20 s, about 0.5 to about 20 s, about 1 to about 20 s, about 3 to about 20 s, about 0.1 to about 10 s, about 1 to about 10 s, about 3 to about 10 s, about 0.1 to about 7 s, about 1 to about 7 s, about 3 to about 7 s, about 0.1 to about 5 s, about 1 to about 5 s or about 3 s to about 5s.

[0076] In one example the heat treatment is an indirect heat treatment. In another example the heat treatment is a direct heat treatment.

[0077] In one example, the liquid composition has a pH of greater than 6.0, 6.5, 7.0, or 7.5 when heat treated.

[0078] In one example the method further comprises drying the heat-treated liquid composition.

[0079] In one exemplary example, prior to packaging or consumption the heat-treated liquid composition undergoes no further heat treatment. In one exemplary example, prior to packaging or consumption the heat-treated liquid composition undergoes no further sterilisation. In one exemplary example, prior to packaging or consumption no further ingredients are added to the heat-treated liquid composition, such that its composition is unchanged.

[0080] In one example, the method further comprises aseptic handling, bottling and/or packaging the heat-treated liquid composition.

[0081] In various examples, the person in need of nutrition may be suffering from or predisposed to a disease or condition, or may be being or have been treated for a disease or condition, is an elderly person, a person that is recovering from a disease or condition, or

a person that is malnourished. In other examples, the person may also be a healthy person, such as a sportsperson or active elderly, including persons having particular nutritional requirements.

[0082] This disclosure may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this disclosure relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

[0083] It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9, and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5, and 3.1 to 4.7) and, therefore, all sub-ranges of all ranges expressly disclosed herein are hereby expressly disclosed. These are only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

[0084] In this specification, where reference has been made to external sources of information, including patent specifications and other documents, this is generally for the purpose of providing a context for discussing the features of the present disclosure. Unless stated otherwise, reference to such sources of information is not to be construed, in any jurisdiction, as an admission that such sources of information are prior art or form part of the common general knowledge in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0085] The invention will now be described by way of example only and with reference to the drawings in which:

[0086] Figure 1 is a flow chart showing an exemplary method of manufacturing the liquid nutritional compositions described herein.

[0087] Figure 2 is a graph showing the particle size of the liquid nutritional compositions prepared using native whey (formulations B1-6), using denatured whey (formulations A1-5) and after retort treatment of A5.

[0088] Figure 3 is a graph showing changes in particle size ($d_{3,2}$) during gastric digestion of different liquid nutritional compositions containing 6%, 9.6% and 14.4% protein in a human gastric simulator.

CLAIMS

1. A heat-treated, shelf-stable liquid nutritional composition having a pH of from 6.0 to 8.0, the composition comprising

a total protein content of at least 9 g per 100 mL of the composition, the total protein content comprising

a) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least 55% is present in a denatured state, and

b) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins,

wherein the whey protein has a degree of hydrolysis of less than 4%, and the whey protein and the non-whey protein are present in a weight ratio of from 35:65 to 80:20.

2. A liquid nutritional composition of claim 1, wherein the total protein content of the composition comprises at least 10 g or 12 g protein per 100 mL of the composition.

3. A liquid nutritional composition of claim 1 or 2, wherein the composition has an energy density of at least 150 kcal or 200 kcal per 100 mL of the composition.

4. A liquid nutritional composition of claim 1, wherein

a) the total protein content of the composition comprises at least 12 g protein per 100 mL of the composition, and

b) the composition has an energy density of at least 200 kcal per 100 mL of the composition.

5. A liquid nutritional composition of any one of claims 1 to 4, wherein the whey protein in a denatured state comprises microparticles having a volume weighted mean diameter D[4,3] of less than 10 μm.

6. A liquid nutritional composition of any one of claims 1 to 5, wherein

a) whey protein comprises at least 35% by weight of the total protein, and/or.

b) the composition comprises at least 5 g whey protein per 100 mL of the composition.

7. A liquid nutritional composition of any one of claims 1 to 6, wherein the liquid nutritional composition has a pH of 6.5 to 7.5.

8. A liquid nutritional composition of any one of claims 1 to 7, wherein the whey protein is non-hydrolysed.

9. A liquid nutritional composition of any one of claims 1 to 8, wherein the whey protein comprises or is provided by an ingredient that comprises heat-denaturable protein of which at least 65% is present in a denatured state.

10. A liquid nutritional composition of any one of claims 1 to 9, wherein the non-whey protein comprises or consists of casein.

11. A liquid nutritional composition of any one of claims 1 to 10, wherein the casein comprises or is provided by an ingredient comprising non-micellar casein, micellar casein or non-micellar and micellar casein.

12. A liquid nutritional composition of any one of claims 1 to 11, wherein the casein comprises or is provided by an ingredient comprising milk protein isolate (MPI), milk protein concentrate (MPC), micellar casein isolate (MCI), micellar casein concentrate (MCC), proteins of liquid condensed milk, skim milk, skim milk powder, condensed skim milk, whole milk, whole milk powder, a caseinate, total milk protein (TMP), milk co-precipitates, an MPC or MPI that has been modified to dissociate casein micelles, calcium-chelated casein micelles, a charge-modified casein, a casein ingredient, such as an MPC or MPI, where at least a portion of the calcium or phosphate or both the calcium and phosphate has been replaced with sodium, potassium, zinc, magnesium and like, or a combination of any two or more thereof; a glycosylated casein or a combination of any two or more thereof.

13. A liquid nutritional composition of claim 12, wherein the caseinate comprises sodium caseinate, calcium caseinate, magnesium caseinate, potassium caseinate or a combination of any two or more thereof.

14. A liquid nutritional composition of any one of claims 1 to 13, wherein the non-dairy protein comprises plant protein or hydrolysed plant protein.

15. A liquid nutritional composition of claim 14, wherein the plant protein or hydrolysed plant protein comprises canola (rapeseed), pea, chickpea, bean, lupin, lentil, soy, rice,

wheat, sorghum, maize, corn, barley, almond, cashew, chia, hemp or flax (linseed) protein, a hydrolysed form thereof, or a combination of any two or more thereof.

16. A liquid nutritional composition of any one of claims 1 to 15, wherein the composition

a) comprises from 0.01 to 10 g non-dairy protein per 100 mL of the composition,

b) comprises from 0.01 to 25 g lipid per 100 mL of the composition,

c) comprises from 0.01 to 45 g carbohydrate per 100 mL of the composition,

d) has an energy density of from 50 to 400 kcal per 100 mL of the composition,

e) comprises less than 4 g per 100 mL of the composition of di-, oligo-, or poly-saccharides, or a combination thereof, that comprise one glucose unit or no glucose units, or

f) any combination of any two or more of a) to e).

17. A liquid nutritional composition of any one of claims 1 to 16, wherein casein comprises from 5% to 65%, 20% to 65% or 30% to 65% by weight of the total protein.

18. A liquid nutritional composition of any one of claims 1 to 17, wherein the composition

a) exhibits substantially no gelation or aggregation when subjected to a heat treatment having an F_0-value of at least 3, or

b) has a viscosity of less than 500 mPa.s when measured at a temperature of 20°C and a shear rate of 100 s^{-1}, or

c) has an average particle size of less than 20 µm as categorised by the surface weighted average particle size parameter d[3,2] and/or the volume weighted mean diameter D[4,3], or

d) any combination of any two or more of a) to c).

19. A method of preparing a heat-treated liquid nutritional composition, the method comprising

a) providing a liquid composition having a pH of between 6.0 and 8.0, the composition comprising

a total protein content of at least 9 g per 100 mL of the composition, the total protein content comprising

i) whey protein comprising or provided by an ingredient that comprises heat-denaturable protein of which at least 55% is present in a denatured state, and

ii) non-whey protein comprising or consisting of casein, or one or more non-dairy proteins, or casein and one or more non-dairy proteins,

wherein the whey protein has a degree of hydrolysis of less than 4%, and the whey protein and the non-whey protein are present in a weight ratio of from 35:65 to 80:20,

b) subjecting the liquid composition to a heat treatment having an F_0-value of at least 3 to prepare the heat-treated liquid nutritional composition, and

c) optionally drying the heat-treated liquid nutritional composition.

20. A method of claim 19, wherein the heat-treated liquid nutritional composition

a) has a viscosity of less than 500 mPa.s when measured at 20°C and shear rate of 100 s^{-1}, or

b) has an average particle size of less than 20 µm as categorised by the surface weighted average particle size parameter d[3,2] and/or the volume weighted mean diameter D[4,3], or

c) exhibits essentially no observable gelation or aggregation, or

d) any combination of any two or more of (a) to (c) above.

21. A method of claim 19 or 20, wherein the liquid composition comprises a composition as defined in any one of claims 1 to 18.

22. A liquid nutritional composition of any one of claims 1 to 18 for use in therapy.

23. Use of a liquid nutritional composition according to any one of claims 1 to 18 in the manufacture of a composition for maintaining or increasing muscle protein synthesis, maintaining or increasing muscle mass, preventing or reducing loss of muscle mass, maintaining or increasing growth, preventing or decreasing muscle catabolism, preventing or treating cachexia, preventing or treating sarcopenia, increasing rate of glycogen

resynthesis, modulating blood sugar levels, increasing insulin response to raised blood glucose concentration, reducing satiety, reducing satiation, reducing food intake, reducing calorie intake, improving glucose metabolism, increasing rate of recovery following surgery, increasing prehabilitation efficacy prior to surgery or chemotherapy, increasing rate of recovery following injury, increasing rate of recovery following exercise, increasing sports performance, and/or providing nutrition to a subject in need thereof.