as karanjin and pongamol. These intrinsic active compounds must be removed or significantly reduced, in order to produce edible pongamia protein products.

**[0007]** Currently, there are no commercially viable processing methods available to extract and produce edible clean tasting concentrated pongamia protein products from pongamia beans. Hence, there is a need for commercially viable methods to extract and remove intrinsic active chemical components, such as karanjin and pongamol, from pongamia beans and produce value added edible protein compositions.

## BRIEF SUMMARY

**[0007a]** In an aspect of the present disclosure, there is provided a protein-enriched pongamia ingredient or composition, comprising at least 40% of pongamia proteins on a dry weight basis,
wherein the ingredient or composition has: (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined; and
wherein the ingredient or composition has less than or equal to 40% of carbohydrates on a dry weight basis.

**[0007b]** In another aspect of the present disclosure, there is provided a method of producing a protein-enriched pongamia composition disclosed herein, comprising:

preparing an aqueous slurry of pongamia meal, wherein the pongamia meal is defatted and debittered and has (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined;

adjusting the pH of the aqueous slurry to a pH between 6 and 10;

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

neutralizing, concentrating and/or pasteurizing the protein liquid fraction; and

drying the protein liquid fraction to provide a protein-enriched pongamia composition, optionally wherein the protein-enriched pongamia composition comprises at least 50% of pongamia proteins on a dry weight basis.

**[0007c]** In a further aspect of the present disclosure, there is provided a method of producing a protein-enriched pongamia ingredient disclosed herein, comprising:

preparing an aqueous slurry of pongamia meal, wherein the pongamia meal is defatted and debittered and has (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined;

adjusting the pH of the aqueous slurry to a pH between 6 and 10,

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

precipitating at least a portion of pongamia protein from the protein liquid fraction to obtain purified pongamia protein solids, optionally wherein the precipitation step is performed by isoelectric precipitation;

neutralizing and pasteurizing the purified pongamia protein solids; and

drying the purified pongamia protein solids to provide a protein-enriched pongamia ingredient, optionally further comprising washing the pongamia protein solids prior to drying, optionally wherein the protein-enriched pongamia ingredient comprises at least 70% of pongamia proteins on a dry weight basis.

**[0007d]** In another aspect of the present disclosure, there is provided a method of producing a protein-enriched pongamia ingredient disclosed herein, comprising:

preparing an aqueous slurry of pongamia meal;

adjusting the pH of the aqueous slurry to a pH between 6 and 10,

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

passing the protein liquid fraction through a membrane system to obtain a retentate comprising pongamia protein;

optionally washing, neutralizing and/or pasteurizing the retentate; and

drying the retentate to provide a protein-enriched pongamia ingredient, optionally wherein the protein-enriched pongamia ingredient comprises at least 70% of pongamia proteins on a dry weight basis.

**[0007e]** In a further aspect of the present disclosure, there is provided a method of producing a protein-enriched pongamia composition disclosed herein, comprising:

preparing an aqueous slurry of pongamia meal;

adjusting the pH of the aqueous slurry to a pH between 4 and 5 to obtain pongamia protein solids;

washing, neutralizing, and pasteurizing purified protein solids; and

drying the purified pongamia protein solids to provide a protein-enriched pongamia composition.

**[0007f]** In another aspect of the present disclosure, there is provided a food product, a beverage product, a dietary supplement product or other product, comprising: the protein-enriched pongamia ingredient or composition disclosed herein, optionally wherein the beverage product comprises at least 20 g of protein-enriched pongamia ingredient or composition per serving.

## CLAIMS

What is claimed is:

1. A protein-enriched pongamia ingredient or composition, comprising at least 40% of pongamia proteins on a dry weight basis,

wherein the ingredient or composition has: (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined; and

wherein the ingredient or composition has less than or equal to 40% of carbohydrates on a dry weight basis.

2. The ingredient or composition of claim 1, wherein the ingredient or composition has between 40% and 70% of pongamia proteins on a dry weight basis, optionally wherein the ingredient or composition is a pongamia protein concentrate;

or

the ingredient or composition comprises at least 70% of pongamia proteins on a dry weight basis,

wherein the ingredient or composition has: (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined; and

wherein the ingredient or composition has less than or equal to 20% of carbohydrates on a dry weight basis;

or

the ingredient or composition has between 70% and 90% of pongamia proteins on a dry weight basis, optionally wherein the ingredient or composition is a pongamia protein isolate.

3. The ingredient or composition of claim 1 or claim 2, wherein the ingredient or composition is derived from pongamia meal, wherein the protein-enriched pongamia ingredient or composition has at least 1.25 times greater pongamia protein content than the pongamia meal.

4. The ingredient or composition of any one of claims 1 to 3, wherein the ingredient or composition has less than 5% of fat on a dry weight basis, optionally wherein the ingredient or composition has less than 2% of fat on a dry weight basis.

5. The ingredient or composition of any one of claims 1 to 4, wherein the ingredient or composition has a relative amino acid profile that includes at least 15% glutamic acid, at least 12% aspartic acid, at least 9% leucine, at least 8% lysine, at least 6% phenylalanine, or any combination thereof, optionally wherein the ingredient or composition has a protein digestibility-corrected amino acid score of at least 0.7.

6. The ingredient or composition of any one of claims 1 to 5, wherein at least 35% of the proteins present in the ingredient or composition are soluble in water at a pH of at least pH 6;
and/or

wherein the ingredient or composition has a viscosity of at least 2 mPa*s at a shear rate of 100 $s^{-1}$;
and/or

wherein the ingredient or composition, when emulsified, produces an emulsion having an average droplet size of at least 1 μm.

7. The ingredient or composition of any one of claims 1 to 6, wherein the ingredient or composition has an average molecular weight of protein between 10,000 Daltons and 250,000 Daltons; and/or

wherein the ingredient or composition comprises seed storage proteins, and wherein 30-40% of the proteins present are proteins having a molecular weight of between 45 kDa and 70 kDa, as determined by SDS-PAGE, optionally wherein the ingredient or composition further comprises seed storage proteins having molecular weight of 170-250 kDa, 115-160 kDa, 45-70 kDa, 19-25 kDa, 14-17 kDa, or 10-13 kDa, or any combinations thereof.

8. The ingredient or composition of any one of claims 1 to 7, wherein the ingredient or composition has:

(i) a viscosity of between 2 mPa*s and 100 mPa*s at a shear rate of 100 $s^{-1}$;

(ii) a foaming capacity of between 100% and 200% of volume of 0.1% protein solution;

(iii) a bulk density of at least 0.2 $g/cm^3$;

(iv) a protein solubility of at least 35% at pH 7;

(v) a median emulsion droplet size of less than or equal to 5 μm;

(vi) a median emulsion droplet size of less than or equal to 5 μm after 7 days of storage;

(vi) a water-holding capacity of at least 1.5 g water per gram of protein-enriched pongamia ingredient or composition;

(vii) an oil-holding capacity of at least 1.5 g oil per gram of protein-enriched pongamia ingredient or composition;

(viii) a minimum gelling concentration of at least 10 g protein-enriched pongamia ingredient or composition per 100 grams;

(ix) a powder dispersibility of at least 10%; or

(x) a neutral, non-bitter taste;

or any combinations of (i)- (x) thereof.

9. A method of producing a protein-enriched pongamia composition of any one of claims 1 to 8, comprising:

preparing an aqueous slurry of pongamia meal, wherein the pongamia meal is defatted and debittered and has (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined;

adjusting the pH of the aqueous slurry to a pH between 6 and 10;

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

neutralizing, concentrating and/or pasteurizing the protein liquid fraction; and

drying the protein liquid fraction to provide a protein-enriched pongamia composition, optionally wherein the protein-enriched pongamia composition comprises at least 50% of pongamia proteins on a dry weight basis.

10. A method of producing a protein-enriched pongamia ingredient of any one of claims 1 to 8, comprising:

preparing an aqueous slurry of pongamia meal, wherein the pongamia meal is defatted and debittered and has (i) less than 500 ppm of karanjin; or (ii) less than 500 ppm of pongamol; or (iii) less than 500 ppm of karanjin and pongamol combined;

adjusting the pH of the aqueous slurry to a pH between 6 and 10,

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

precipitating at least a portion of pongamia protein from the protein liquid fraction to obtain purified pongamia protein solids, optionally wherein the precipitation step is performed by isoelectric precipitation;

neutralizing and pasteurizing the purified pongamia protein solids; and

drying the purified pongamia protein solids to provide a protein-enriched pongamia ingredient, optionally further comprising washing the pongamia protein solids prior to drying, optionally wherein the protein-enriched pongamia ingredient comprises at least 70% of pongamia proteins on a dry weight basis.

11. The method of claim 10, further comprising:

dehulling pongamia beans to produce dehulled pongamia beans; and

pressing the dehulled pongamia beans to remove at least a portion of free oil in the pongamia beans to produce the pongamia meal, wherein the pongamia meal has a reduced fat content, optionally further comprising grinding the pongamia meal;

or

dehulling pongamia beans to produce dehulled pongamia beans;

pressing the dehulled pongamia beans to remove at least a portion of free oil in the pongamia beans to produce a reduced fat pongamia meal; and

combining the reduced fat pongamia meal with solvent to produce the pongamia meal, wherein the pongamia meal is defatted and debittered, optionally wherein the solvent comprises ethyl acetate, ethyl alcohol, or a combination thereof,

optionally further comprising grinding the reduced fat pongamia meal prior to combining with solvent.

12. A method of producing a protein-enriched pongamia ingredient of any one of claims 1 to 8, comprising:

preparing an aqueous slurry of pongamia meal;

adjusting the pH of the aqueous slurry to a pH between 6 and 10,

separating the slurry into a protein liquid fraction and an insoluble wet cake fraction;

passing the protein liquid fraction through a membrane system to obtain a retentate comprising pongamia protein;

optionally washing, neutralizing and/or pasteurizing the retentate; and

drying the retentate to provide a protein-enriched pongamia ingredient, optionally wherein the protein-enriched pongamia ingredient comprises at least 70% of pongamia proteins on a dry weight basis.

13. The method of claim 12, further comprising:

dehulling pongamia beans to produce dehulled pongamia beans; and

pressing the dehulled pongamia beans to remove at least a portion of free oil in the pongamia beans to produce the pongamia meal, wherein the pongamia meal has a reduced fat content, optionally further comprising grinding the pongamia meal;

or

dehulling pongamia beans to produce dehulled pongamia beans;

pressing the dehulled pongamia beans to remove at least a portion of free oil in the pongamia beans to produce a reduced fat pongamia meal; and

combining the reduced fat pongamia meal with solvent to produce the pongamia meal, wherein the pongamia meal is defatted and debittered, optionally further comprising grinding the reduced fat pongamia meal prior to combining with solvent.

14. A method of producing a protein-enriched pongamia composition of any one of claims 1 to 8, comprising:

preparing an aqueous slurry of pongamia meal;

adjusting the pH of the aqueous slurry to a pH between 4 and 5 to obtain pongamia protein solids;

washing, neutralizing, and pasteurizing purified protein solids; and

drying the purified pongamia protein solids to provide a protein-enriched pongamia composition.

15. A food product, a beverage product, a dietary supplement product or other product, comprising: the protein-enriched pongamia ingredient or composition of any one of claims 1 to 8, optionally wherein the beverage product comprises at least 20 g of protein-enriched pongamia ingredient or composition per serving.

16. The product of claim 15, wherein the product is a baked good, a protein supplement, a protein bar, or a non-dairy beverage; or

wherein the product is a medical food, an infant formula, a cosmetic or a pharmaceutical product; or

wherein the product is a beverage product, a dairy-product substitute, a meat substitute product, or an egg substitute,

optionally wherein the beverage product is a fruit smoothie, a meal replacement beverage, a protein drink, an instant shake,

optionally wherein the dairy-product substitute is a non-dairy milk, non-dairy cheese, non-dairy coffee whitener or creamer, non-dairy yogurt, non-dairy Greek yogurt, non-dairy drinkable yogurt.