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, comprising at least 40% of pongamia proteins on a dry weight basis,
wherein the ingredient 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 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, 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, 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, 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, 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 protein-enriched pongamia ingredient produced according to the method disclosed herein.

[0007g] In a further 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 disclosed herein, optionally wherein the beverage product comprises at least 20 g of protein-enriched pongamia ingredient per serving.

[0008] In some examples, provided herein are pongamia compositions with high protein content, such as pongamia protein concentrates or isolates, that can serve as an edible protein source for animals, in particular humans. In some variations, the pongamia protein products described herein have functional properties, including for example solubility, viscosity, and emulsifying properties, that are comparable or improved as compared to other commercial plant protein ingredients, such as soy, pea, lupin, and sunflower. These pongamia protein products can serve as useful ingredients in a variety of food and beverage products, and address the substantial unmet need in the industry for emerging plant proteins that are superior in protein quality with great taste and great texture.

[0009] In some examples, provided is a protein-enriched pongamia composition, comprising at least 50% of pongamia proteins on a dry weight basis. In some examples, provided is a protein-enriched pongamia composition, comprising at least 70% of pongamia proteins on a dry weight basis. In some examples, the composition is a pongamia protein concentrate. In other examples, the composition is a pongamia protein isolate.

[0010] In certain examples, provided is method of producing a protein-enriched pongamia composition, comprising: preparing an aqueous slurry of pongamia meal; adjusting the pH of the aqueous slurry to a pH between 8 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.

[0011] In certain examples, provided is a method of producing a protein-enriched pongamia composition, comprising: preparing an aqueous slurry of pongamia meal; adjusting the pH of

the aqueous slurry to a pH between 8 and 10, separating the slurry into a protein liquid fraction and insoluble wet cake fraction; precipitating a portion of pongamia proteins from the liquid fraction by adjusting pH to between 3.5 to 4.5 to obtain purified pongamia proteins; washing, neutralizing and/or pasteurizing the purified pongamia proteins; and drying the purified pongamia proteins to provide a protein-enriched pongamia composition.

[0012] In certain examples, provided is a method of producing a protein-enriched pongamia composition, 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; washing, neutralizing and/or pasteurizing the retentate; and drying the retentate to provide a protein-enriched pongamia composition.

[0013] In one example, provided is a protein-enriched pongamia composition produced according to the methods described herein.

[0014] In certain examples, provided are also various products incorporating any of the protein-enriched pongamia compositions described herein. In some examples, the product is food product, a beverage product, or a dietary supplement product. In some variations, the product is a baked good, a protein supplement, a protein bar, or a non-dairy beverage. In yet other variations, the product is a medical food, an infant formula, a cosmetic or a pharmaceutical product.

[0015] In one example, provided is a protein-enriched pongamia ingredient, comprising at least 40% of pongamia proteins on a dry weight basis, wherein the ingredient 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 has less than or equal to 40% of carbohydrates on a dry weight basis. In some examples of the present example, the protein-enriched pongamia ingredient comprises at least 70% of pongamia proteins on a dry weight basis, wherein the ingredient 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 has less than or equal to 15% of carbohydrates on a dry weight basis.

[0016] In some examples, the ingredient has (i) a viscosity of between about 2 mPa*s and about 100 mPa*s at a shear rate of 100 s^{-1}; (ii) a foaming capacity of between about

100% and about 200% of volume of 0.1% protein solution; (iii) a bulk density of at least about 0.2 g/cm^3; (iv) a protein solubility of at least about 35% at pH 7; (v) a median emulsion droplet size of less than or equal to about 5 µm; (vi) a median emulsion droplet size of less than or equal to about 5 µm after 7 days of storage; (vi) a water-holding capacity of at least about 1.5 g water per gram of protein-enriched pongamia ingredient; (vii) an oil-holding capacity of at least about 1.5 g oil per gram of protein-enriched pongamia ingredient; (viii) a minimum gelling concentration of at least about 10 g protein-enriched pongamia ingredient per 100 grams; (ix) a powder dispersibility of at least about 10%; or (x) a neutral, non-bitter taste; or any combinations of (i)- (x) thereof.

[0017] In other examples, the ingredient has: (i) a viscosity of between about 2 mPa*s and about 100 mPa*s at a shear rate of 100 s^{-1}; (ii) a foaming capacity of between about 100% and about 200% of volume of 0.1% w/v pongamia protein solution; (iii) a bulk density of at least about 0.2 g/cm^3; (iv) a protein solubility of at least about 35% at pH 7; (v) a median emulsion droplet size of less than or equal to about 5 µm; (vi) a median emulsion droplet size of less than or equal to about 5 µm after 7 days of storage; (vii) a neutral, non-bitter taste; or any combinations of (i)-(vii) thereof.

[0018] In yet other examples, the ingredient has: (i) a viscosity of between about 2 mPa*s and about 100 mPa*s at a shear rate of 100 s^{-1}; (ii) a foaming capacity of between about 100% and about 200% of volume of 0.1% w/v protein solution; (iii) a bulk density of at least about 0.2 g/cm^3; (iv) a protein solubility of at least about 35% at pH 7; (v) a median emulsion droplet size of less than or equal to about 5 µm; (vi) a median emulsion droplet size of less than or equal to about 5 µm after 7 days of storage; (vii) a water-holding capacity of at least about 1.5 g water per gram of protein-enriched pongamia ingredient; (viii) a minimum gelling concentration of at least about 10 g protein-enriched pongamia ingredient per 100 grams; or (ix) a neutral, non-bitter taste or any combination of (i)- (ix) thereof.

[0019] In still other examples, the ingredient has (i) a bulk density of at least about 0.2 g/cm^3; (ii) a protein solubility of at least about 35% at pH 7; (iii) a water-holding capacity of at least about 1.5 g water per gram of protein-enriched pongamia ingredient;(iv) an oil-holding capacity of at least about 1.5 g oil per gram of protein-enriched pongamia ingredient; (v) a minimum gelling concentration of at least about 10 g protein-enriched pongamia ingredient per 100 grams; or (vi) a neutral, non-bitter taste; or any combination of (i)-(vi) thereof.

[0020] In some examples, the ingredient has: (i) a foaming capacity of between about 100% and about 200% of volume of 0.1% w/v protein solution; (ii) a minimum gelling concentration of at least about 7 g protein-enriched pongamia ingredient per 100 grams; or (iii) a neutral, non-bitter taste; or any combination of (i)-(iii) thereof.

[0021] In one example, provided herein is a method of producing a protein-enriched pongamia composition, 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.

[0022] In another example, provided herein is a method of producing a protein-enriched pongamia ingredient, 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; neutralizing and pasteurizing the purified pongamia protein solids; and drying the purified pongamia protein solids to provide a protein-enriched pongamia ingredient.

[0023] In another example, provided herein is a method of producing a protein-enriched pongamia ingredient, 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.

DESCRIPTION OF THE FIGURES

[0024] The present application can be understood by reference to the following description taken in conjunction with the accompanying figures.

CLAIMS

What is claimed is:

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

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

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

or

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

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

or

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

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

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

5. The ingredient of any one of claims 1 to 4, wherein the ingredient 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 has a protein digestibility-corrected amino acid score of at least 0.7.

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

and/or

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

and/or

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

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

wherein the ingredient 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 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 of any one of claims 1 to 7, wherein the ingredient 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;

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

(viii) a minimum gelling concentration of at least 10 g protein-enriched pongamia ingredient 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, 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, 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, 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, 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 protein-enriched pongamia ingredient produced according to the method of any one of claims 9 to 14.

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

17. The product of claim 16, 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.