improved liquid nutritional compositions have at least one water-insoluble plant flavonoid dispersed therein.

[0008] Therefore, in one example, the invention is directed to a method of forming a heat-treated liquid nutritional composition having a neutral pH, i.e., a pH of from about 6 to about 7.5, and comprising a water-insoluble plant flavonoid. The method comprises providing an aqueous liquid nutritional composition having a pH of from about 6 to about 7.5 and comprising protein, fat, carbohydrate, and water-insoluble plant flavonoid, homogenizing the liquid nutritional composition at a pressure of at least 2000 psi, and heat treating the liquid nutritional composition.

[0008a] In one aspect, the present disclosure refers to a method of forming a heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, and comprising a water-insoluble plant flavonoid, the method comprising providing an aqueous liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, and comprising protein, fat, carbohydrate, and water-insoluble plant flavonoid, homogenizing the liquid nutritional composition at a pressure of at least 2000 psi, or more specifically, from 2000 to 5000 psi, and heat treating the liquid nutritional composition, wherein the liquid nutritional composition comprises effective amounts of water-insoluble plant flavonoid and protein to maintain the water-insoluble plant flavonoid in suspension during heat treatment and storage of the liquid nutritional composition.

[0008b] In another aspect, the present disclosure refers to a heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, comprising a water-insoluble plant flavonoid, protein, fat and carbohydrate, wherein at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the water-insoluble plant flavonoid remains suspended throughout the liquid nutritional composition after two months, or more specifically, after eight months, of storage at room temperature; and wherein

upon centrifugation at 30,000 x g, 3 hours, the water-insoluble plant flavonoid and protein in each resulting fraction are in a molar ratio of at least 1.4:1, at least 1.5:1, at least 1.6:1, or at least 1.7:1.

[0008c] In another aspect, the present disclosure refers to a heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, comprising a water-insoluble plant flavonoid, protein, fat and carbohydrate; wherein the nutritional composition comprises effective amounts of water-insoluble plant flavonoid and protein such that at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the water-insoluble plant flavonoid remains suspended throughout the liquid nutritional composition after two months, or more specifically, after eight months, of storage at room temperature.

[0009] In another example, the disclosure is directed to a heat-treated liquid nutritional composition having a pH of from about 6 to about 7.5 and comprising a water-insoluble plant flavonoid and protein. At least about 75 wt % of the water-insoluble plant flavonoid remains suspended throughout the liquid nutritional composition after two months of storage at room temperature.

[00010] The methods and liquid nutritional compositions of the disclosure are advantageous in allowing the incorporation of water-insoluble plant flavonoids in storage stable liquid nutritional compositions which are acceptable for routine consumption, including daily consumption, and which allow predictable dosing of the water-insoluble plant flavonoids. These and additional examples and advantages of the disclosure will be more fully described in the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[00011] The drawings may facilitate understanding of certain aspects or embodiments of the invention, wherein

[00012] Fig. 1 shows a relationship of the water-insoluble flavonoid hesperidin and protein, on a weight basis, in, respectively, a conventional liquid nutritional composition and a liquid nutritional composition prepared according to the method of the invention; and

Claims

What is claimed is:

1. A method of forming a heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, and comprising a water-insoluble plant flavonoid, the method comprising

providing an aqueous liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, and comprising protein, fat, carbohydrate, and water-insoluble plant flavonoid,

homogenizing the liquid nutritional composition at a pressure of at least 2000 psi, or more specifically, from 2000 to 5000 psi, and

heat treating the liquid nutritional composition,

wherein the liquid nutritional composition comprises effective amounts of water-insoluble plant flavonoid and protein to maintain the water-insoluble plant flavonoid in suspension during heat treatment and storage of the liquid nutritional composition.

2. The method of claim 1, wherein the liquid nutritional composition comprises from 50 to 800 mg, from 50 to 600 mg, or from 50 to 300 mg water-insoluble plant flavonoid per 237 ml of the liquid nutritional composition.

3. The method of claim 2, wherein the liquid nutritional composition comprises from 2 to 20 g, or from 2 to 15 g, or from 2 to 10 g protein per 100 ml of the liquid nutritional composition.

4. The method of any one of claims 1-3, wherein the liquid nutritional composition comprises a weight ratio of protein to flavonoid of from 5 to 100, from 10 to 50, or from 15 to 25.

5. The method of any one of claims 1-4, wherein the water-insoluble plant flavonoid comprises a citrus flavonoid, or the water-insoluble plant flavonoid comprises at least one of hesperidin and hesperetin.

6. The method of any one of claims 1-4, wherein the water-insoluble plant flavonoid comprises resveratrol.

7. The method of any one of claims 1-6, wherein the protein comprises milk protein, plant protein, or a combination thereof.

8. The method of any one of claims 1-7, wherein the homogenizing step comprises at least one stage at a pressure of from 2500 to 5000 psi.

9. The method of claim 8, wherein the homogenizing step comprises a two-stage homogenization with a second stage at a pressure of from 250 to 1000 psi.

10. The method of any one of claims 1-9, wherein the heat treatment provides sterilization sufficient to maintain product stability of the liquid nutritional composition over a shelf-life of at least 12 months.

11. The method of any one of claims 1-9, wherein the heat treatment is a high temperature, short time heat treatment at a temperature of from 158° F to 176° F (from 70° C to 80° C) for 10 to 25 seconds, or an ultra-high temperature (UHT) heat treatment at a temperature of from 280° F to 305° F (from 138° C to 152° C) for at least 5 seconds.

12. The method of any one of claims 1-11, wherein at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the water-insoluble plant flavonoid remains suspended throughout the homogenized and heat treated liquid nutritional composition after two months, or more specifically, after eight months, of storage at room temperature.

13. A heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, comprising a water-insoluble plant flavonoid, protein, fat and carbohydrate, wherein at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the water-insoluble plant flavonoid remains suspended throughout the liquid nutritional composition after two months, or more specifically, after eight months, of storage at room temperature; and wherein upon centrifugation at 30,000 x g, 3 hours, the water-insoluble plant flavonoid and protein in each resulting fraction are in a molar ratio of at least 1.4:1, at least 1.5:1, at least 1.6:1, or at least 1.7:1.

14. The liquid nutritional composition of claim 13, comprising from 50 to 800 mg, from 50 to 600 mg, or from 50 to 300 mg water-insoluble plant flavonoid per 237 ml of the liquid nutritional composition.

15. The liquid nutritional composition of claim 13 or 14, wherein the liquid nutritional composition comprises a weight ratio of protein to flavonoid of from 5 to 100, from 10 to 50, or from 15 to 25.

16. The liquid nutritional composition of any one of claims 13-15, wherein the water-insoluble plant flavonoid comprises a citrus flavonoid, or the water-insoluble plant flavonoid comprises at least one of hesperidin and hesperetin.

17. The liquid nutritional composition of any one of claims 13-15, wherein the water-insoluble plant flavonoid comprises resveratrol.

18. The liquid nutritional composition of any one of claims 13-17, wherein the protein comprises milk protein, plant protein or a combination thereof.

19. The liquid nutritional composition of any one of claims 13-18, further comprising vitamin B12.

20. The liquid nutritional composition of claim 19, comprising from 1 to 20 µg/L vitamin B12.

21. The liquid nutritional composition of claim 19 or 20, wherein after two months of storage at room temperature, at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the vitamin B12 originally included in the liquid nutritional composition remains in the liquid nutritional composition.

22. The liquid nutritional composition of any one of claims 19-21, wherein the concentration of the water-insoluble plant flavonoid and any ascorbic acid contained in the liquid nutritional composition is not greater than 5 mM.

23. The liquid nutritional composition of any one of claims 13-22, comprising a source of protein in an amount of 2 wt % to 20 wt %, a source of carbohydrate in an amount of 5 wt % to 30 wt %, and a source of fat in an amount of 0.5 wt % to 10 wt %, based on the weight of the nutritional composition.

24. A heat-treated liquid nutritional composition having a pH of from 6 to 7.5, or from 6.5 to 7.2, comprising a water-insoluble plant flavonoid, protein, fat and carbohydrate;

wherein the nutritional composition comprises effective amounts of water-insoluble plant flavonoid and protein such that at least 75 wt %, at least 80 wt %, at least 85 wt %, or at least 90 wt % of the water-insoluble plant flavonoid remains suspended throughout the liquid nutritional composition after two months, or more specifically, after eight months, of storage at room temperature.

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