Res., 26(5): 1217–1225 (2009)), D-glucose to form α-glycosyl hesperidin (JP 3549436 B2 and JP 2007308414 A), and various polymers (Cao et al, *J Sci Food Agric*, 98: 2422–2427 (2018)). However, such complexes can change the biological properties of the flavonoid and/or affect its chemical characteristics, and many of these complexed structures may not be suitable for use in beverages intended for daily or otherwise regular consumption.

[0004] Another method for improving the solubility/dispersibility of the citrus flavonoid hesperidin comprises dissolving hesperidin in a strong alkali solution, and then adding a polysaccharide thickener to adjust the pH of the solution (JP 4202439 B2). However, it is known that hesperidin is extremely unstable, especially against light and oxygen, in the alkali pH range, and decomposition occurs during storage.

[0005] Another attempt to stabilize hesperidin involves combining it with a specific dihydric alcohol, and a sugar alcohol, wherein the decomposition of hesperidin is suppressed and enables hesperidin dissolution/dispersion without the use of a strong alkali solution (US 8,507,452 B2). However, the specific dihydric alcohols and sugar alcohols which are employed are not typically used or acceptable in beverages intended for daily consumption.

[0006] Thus, there is a need for a method to stabilize and uniformly disperse water-insoluble bioactive flavonoids such as the citrus flavonoid hesperidin in a beverage for daily consumption, such as in a liquid nutritional product, that exhibits storage stability, and, specifically, that can survive heat processing and remain in suspension over time.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the disclosure to provide a method for improving the suspension stability of water-insoluble plant flavonoids in beverages, and, more specifically, in liquid nutritional compositions, including liquid nutritional compositions which have a neutral pH of from about 6 to about 7.5 and which have been heat treated. A related object is to provide

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.

[008a] In one example, the present disclosure refers to a method of forming a heat-treated liquid nutritional composition having a pH of from about 6 to about 7.5, or from about 6.5 to about 7.2, and comprising a water-insoluble plant flavonoid, the method comprising providing an aqueous liquid nutritional composition having a pH of from about 6 to about 7.5, or from about 6.5 to about 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 about 5000 psi, and heat treating the liquid nutritional composition.

[008b] In another example, the present disclosure refers to a heat-treated liquid nutritional composition having a pH of from about 6 to about 7.5, or from about 6.5 to about 7.2, comprising a water-insoluble plant flavonoid, protein, fat and carbohydrate, wherein at least about 75 wt %, at least about 80 wt %, at least about 85 wt %, or at least about 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