soluble nutrients, such as, vitamin E (tocotrienols and tocopherols), CoQ10 (ubiquinol and ubiquinone), curcuma terpenoids (xanthorrhizol, tumerones, curcumenes, and curcumins), symmetrical carotenoids (astaxanthin, zeaxanthin, lycopene, and beta-carotene), omega-3s (DHA and EPA), phenolics (policosanols, resveratrol, EGCG, and quercetin), and other lipid-soluble vitamins (A, D, K).

In one aspect, the present invention provides a method of making a lipid-soluble ingredient nanoemulsion comprising the steps of: a) mixing an active lipid-soluble ingredient and a lipid-soluble natural product co-solvent to produce a lipid solution, b) mixing an emulsifier, consisting of a botanical, and an aqueous co-solvent to produce an aqueous solution, c) mixing the lipid solution and the aqueous solution together and homogenizing the two solutions under high pressure, without heat to generate emulsified particles of a lipid-soluble ingredient nanoemulsion; wherein the botanical is a saponin derived from quillaja, yucca, and soy; and wherein the ration of the emulsifier to the aqueous solution is from 1 : 5 to 1 : 200.

Also described herein is a method of making a lipid-soluble ingredient nanoemulsion comprising the steps of: a) mixing an active lipid-soluble ingredient and a lipid-soluble natural product co-solvent to produce a lipid solution, b) mixing an emulsifier, consisting of a botanical, and an aqueous co-solvent to produce an aqueous solution, c) mixing the lipid solution and the aqueous solution together and homogenizing the two solutions without heat to generate emulsified particles of a lipid-soluble ingredient nanoemulsion.

Brief Description of the Figures

Figure 1 shows the zeta potential required to yield a stable emulsion.

Figure 2 shows the stability of botanically-derived tocotrienol nanoemulsions in lemonade at different times and storage temperature.

Figure 3 shows the stability of botanically-derived tocotrienol nanoemulsions in chocolate (C) and milk (M) beverages. "+" means "with added nanoemulsion".

Figure 4 shows the stability of botanically-derived tocotrienol nanoemulsions in apple juice (A) and lemonade (L). "+" means "with added nanoemulsion".

Figure 5 shows the stability of botanically-derived tocotrienol nanoemulsions in water (W) and orange juice (O). "+" means "with added nanoemulsion".

Detailed Description of the Invention

Emulsification is an important process because oil and water do not mix. One way to mix oil and water is to make finely dispersed oil particles in water, which is referred to as an oil-in-water emulsion. For a long time, low-energy blenders/mixers have been used to produce these oil-in-water emulsions, typically resulting in 1 μm to 10 μm particle sizes. Such emulsions are blended into many food applications. These oil-in-water emulsions are suitable for many *macro*-nutrient (e.g., fat, protein, carbohydrate) delivery applications, such as, vegetable oils and fats that may or may not include flavored ingredients, such as, vanilla or chocolate.

If there is a need to add an oil-soluble substance of importance (e.g., a nutrient or drug) into a food application, an oil-in-water emulsion is a strategic route to do so effectively, provided the conditions for delivery are optimal. Typically, only a small amount of a nutrient or drug is added into the oil carrier before the oil-in-water emulsion is made. This may be referred to as *micro*-nutrient (e.g., vitamins, carotenoids, omega-3s, antioxidants, polyphenols) delivery.

In summary, to deliver a macro-nutrient oil or fat via the oil-in-water emulsion route, use of a low-energy mixer to produce particle sizes of 1 μm to 10 μm is suitable. However,

Claims

Claim 1. A method of making a lipid-soluble ingredient nanoemulsion comprising the steps of: a) mixing an active lipid-soluble ingredient and a lipid-soluble natural product co-solvent to produce a lipid solution, b) mixing an emulsifier, consisting of a botanical, and an aqueous co-solvent to produce an aqueous solution, c) mixing the lipid solution and the aqueous solution together and homogenizing the two solutions under high pressure, without heat to generate emulsified particles of a lipid-soluble ingredient nanoemulsion; wherein the botanical is a saponin derived from quillaja, yucca, and soy; and wherein the ratio of the emulsifier to the aqueous solution is from 1 : 5 to 1 : 200.

Claim 2. The method of Claim 1, wherein the emulsified particle is from 50 nm to 600 nm in diameter.

Claim 3. The method of Claim 1, wherein the emulsified particle is from 100 nm to 400 nm in diameter.

Claim 4. The method of Claim 1, wherein the emulsified particle is from 100 nm to 200 nm in diameter.

Claim 5. The method of Claim 1, wherein a zeta potential is calculated for the emulsified particle and the zeta potential is less than -30mV or more than +30mV.

Claim 6. The method of Claim 1, wherein the saponin is derived from quillaja.

Claim 7. The method of claim 1 or 6, wherein the botanical is quillaja saponins.

Claim 8. The method of Claim 1, wherein the active lipid-soluble ingredient is selected from the group consisting of vitamin E, CoQ10, curcuma terpenoid, symmetrical carotenoid, omega-3, phenolics, vitamin A, vitamin D, vitamin K, and lipid-soluble pharmaceutical drugs.

Claim 9. The method of Claim 8, wherein the vitamin E is selected from the group consisting of tocotrienol and tocopherol.

Claim 10. The method of Claim 9, wherein the tocotrienol is selected from the plant source consisting of annatto, palm, and rice.

Claim 11. The method of Claim 8, wherein the CoQ10 is selected from the group consisting of ubiquinol and ubiquinone.

Claim 12. The method of Claim 8, wherein the curcuma terpenoid is selected from the group consisting of xanthorrhizol, tumerones, curcumenes, and curcumins.

Claim 13. The method of Claim 8, wherein the symmetrical carotenoid is selected from the group consisting of astaxanthin, zeaxanthin, lycopene, and beta-carotene.

Claim 14. The method of Claim 8, wherein the omega-3 is selected from the group consisting of DHA and EPA.

Claim 15. The method of Claim 8, wherein the phenolics is selected from the group consisting of policosanol, resveratrol, EGCG, and quercetin.

Claim 16. The method of Claim 1, wherein the lipid-soluble natural product co-solvent is a natural terpenoid.

Claim 17. The method of Claim 16, wherein the natural terpenoid is selected from the group consisting of limonene, farnesol, and geranylgeraniol.

Claim 18. The method of Claim 1, wherein the aqueous co-solvent is selected from the group consisting of ethanol and glycerol.

Claim 19. The method of Claim 1, wherein the nanoemulsion is added to a beverage.

Claim 20. The method of Claim 19, wherein the beverage has a clarity selected from the group consisting of clear, semi-clear and opaque.

Claim 21. The method of Claim 19, wherein the beverage has a pH from 3.0 to 7.0.

Claim 22. The method of Claim 19, wherein the beverage has a temperature from 20° C to -20° C.

Claim 23. The method of Claim 1, wherein the nanoemulsion is a liquid-liquid formulation.

Claim 24. The method of Claim 23, wherein the liquid-liquid formulation is selected from the group consisting of a beverage, an injectable, an aerosol, an aspirator product, a douche, a softgel, an eye drop product, an oral tincture product, a skin care product, and a suppository.

Claim 25. The method of Claim 24, wherein the injectable is adapted for administration by the group consisting of subcutaneous, intramuscular and intravenous.

Claim 26. The method of Claim 1, wherein the nanoemulsion is added to a food product for mammals with a malabsorption condition.