[0004] These high fortification rates may lead to increased production costs and potential complications in formulating the final product without providing additional consumer benefits. Furthermore, the over fortified formulations may overwhelm the digestive tract with non-soluble lipophilic compounds leading to indigestion.

[0005] Accordingly, there is a need for nutritional compositions for infants, toddlers, children and adults that provide necessary lipophilic compounds in a more stable soluble form.

SUMMARY OF THE INVENTION

[0006] In one aspect, the disclosure may be directed to a nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising: an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein at least 1% of the total MDG in the nutritional composition remains in an aqueous phase after centrifugation at 100,000 x g for 1 hour at 20 °C.

[0007] In another aspect, the disclosure may be directed to a nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising: an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein at least 1% of the total MDG in the nutritional composition remains in the aqueous phase after centrifugation at 100,000 x g for 1 hour at 20 °C, wherein the assembly is (i) water soluble; and (ii) has a size of 100 kD to 1000 kD.

[0008] In another aspect, the disclosure may be directed to a nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising: an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein at least 1% of the total MDG in the nutritional composition remains in the aqueous phase after centrifugation at 100,000 x g for 1 hour at 20 °C, wherein the assembly is (i) water soluble; and (ii) has a size of 100 kD to 1000 kD, wherein MDG increases the concentration of protein of the assembly by at least 2% compared to a nutritional composition without MDG.

[0009] In another aspect, the disclosure may be directed to a nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the

wherein the nutritional composition comprises: an activated assembly comprising a combination of monoglycerides and diglycerides ("MDG"), at least one hydrophobic protein, and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject.

[0042] In another aspect, the disclosure may be directed to a nutritional composition comprising at least one protein and vitamin D, having improved bioavailability of vitamin D, wherein the nutritional composition comprises: an assembly comprising a combination of monoglycerides and diglycerides ("MDG") and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject, comprising about 0.1 mg/kg to about 20 mg/kg of MDG based on total weight of the composition.

[0043] In another aspect, the disclosure may be directed to a nutritional composition comprising at least one protein and vitamin D, having improved bioavailability of vitamin D, wherein the nutritional composition comprises: an assembly comprising a combination of monoglycerides and diglycerides ("MDG") and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject, comprising about 0.1 mg/kg to about 20 mg/kg of MDG based on total weight of the composition, comprising about 0.1 mg/kg to about 10 mg/kg of MDG based on total weight of the composition.

[0044] In another aspect, the disclosure may be directed to a nutritional composition comprising at least one protein and vitamin D, having improved bioavailability of vitamin D, wherein the nutritional composition comprises: an assembly comprising a combination of monoglycerides and diglycerides ("MDG") and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject, comprising about 0.1 mg/kg to about 20 mg/kg of MDG based on total weight of the composition, comprising about 0.1 mg/kg to about 10 mg/kg of MDG based on total weight of the composition, comprising about 10 μg/kg to about 30 μg/kg of vitamin D based on total weight of the composition.

[0045] In another aspect, the disclosure may be directed to a nutritional composition comprising at least one protein and vitamin D, having improved bioavailability of vitamin D, wherein the nutritional composition comprises: an assembly comprising a combination of monoglycerides and diglycerides ("MDG") and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject, comprising about 0.1 mg/kg to about 20 mg/kg of MDG based on total weight of the composition, comprising about 0.1 mg/kg to about 10 mg/kg of MDG based on total weight of the composition, comprising about 10 μg/kg to about 30 μg/kg of vitamin D based on total weight of the composition, comprising about 0.1 mg/kg to about 10 mg/kg of MDG and about 20 μg/kg of vitamin D based on total weight of the composition.

[0046] In one aspect, the disclosure may be directed to a nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising: an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein at least 15% of the total lipophilic compound in the nutritional composition remains in an aqueous phase after centrifugation at 1,000 x g for 1 hour at 20 °C.

[0047] In one aspect, the disclosure may be directed to a method of preparing a nutritional composition having at least one lipophilic compound having improved bioavailability, the method comprising the steps of: providing a premix comprising an assembly that comprises at least one hydrophobic protein, combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein the assembly is (i) water soluble; and (ii) has a size of 100 kD to 1000 kD; adding the premix to an aqueous solution to form an activated premix; and adding the activated premix to the nutritional composition.

[0048] In another aspect, the disclosure may be directed to a method of preparing a nutritional composition having at least one lipophilic compound having improved bioavailability, the method comprising the steps of: providing a premix comprising an assembly that comprises at least one hydrophobic protein, combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein the assembly is (i) water soluble; and (ii) has a size of 100 kD to 1000 kD; adding the premix to an aqueous solution to form an activated premix; and adding the activated premix to the nutritional composition, wherein the assembly has a size of 60 kD to 400 kD.

[0049] In another aspect, the disclosure may be directed to a method of preparing a nutritional composition having at least one lipophilic compound having improved bioavailability, the method comprising the steps of: providing a premix comprising an assembly that comprises at least one hydrophobic protein, combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound, wherein the assembly is (i) water soluble; and (ii) has a size of 100 kD to 1000 kD; adding the premix to an aqueous solution to form an activated premix; and adding the activated premix to the nutritional composition, wherein the assembly has a size of 60 kD to 400 kD, wherein the lipophilic compound is a carotenoid, a lipid soluble vitamin, a lipophilic antioxidant or combinations thereof.

[0050] In another aspect, the disclosure may be directed to a method of preparing a nutritional composition having at least one lipophilic compound having improved

[00138] MDG may be in the aqueous phase at about 0.001% to about 50% of the total MDG in the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 0.5% to about 40% of the total MDG in the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 5% to about 30% of the total MDG in the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 15% to about 25% of the total MDG in the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. For example, MDG may be in the aqueous phase at about 0.001%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 0.55%, 0.6%, 0.65%, 0.7%, 0.75%, 0.8%, 0.85%, 0.9%, 0.95%, 1%, 1.25%, 1.5%, 1.75%, 2%, 2.25%, 2.5%, 2.75%, 3%, 3.25%, 3.5%, 3.75%, 4%, 4.25%, 4.5%, 4.75%, 5%, 5.25%, 5.5%, 5.75%, 6%, 6.25%, 6.5%, 6.75%, 7%, 7.25%, 7.5%, 7.75%, 8%, 8.25%, 8.5%, 8.75%, 9%, 9.25%, 9.5%, 9.75%, 10%, 10.25%, 10.5%, 10.75%, 11%, 11.25%, 11.5%, 11.75%, 12%, 12.25%, 12.5%, 12.75%, 13%, 13.25%, 13.5%, 13.75%, 14%, 14.25%, 14.5%, 14.75%, 15%, 15.25%, 15.5%, 15.75%, 16%, 16.25%, 16.5%, 16.75%, 17%, 17.25%, 17.5%, 17.75%, 18%, 18.25%, 18.5%, 18.75%, 19%, 19.25%, 19.5%, 19.75%, 20%, 20.25%, 20.5%, 20.75%, 21%, 21.25%, 21.5%, 21.75%, 22%, 22.25%, 22.5%, 22.75%, 23%, 23.25%, 23.5%, 23.75%, 24%, 24.25%, 24.5%, 24.75%, 25%, 25.25%, 25.5%, 25.75%, 26%, 26.25%, 26.5%, 26.75%, 27%, 27.25%, 27.5%, 27.75%, 28%, 28.25%, 28.5%, 28.75%, 29%, 29.25%, 29.5%, 29.75%, 30%, 30.25%, 30.5%, 30.75%, 31%, 31.25%, 31.5%, 31.75%, 32%, 32.25%, 32.5%, 32.75%, 33%, 33.25%, 33.5%, 33.75%, 34%, 34.25%, 34.5%, 34.75%, 35%, 35.25%, 35.5%, 35.75%, 36%, 36.25%, 36.5%, 36.75%, 37%, 37.25%, 37.5%, 37.75%, 38%, 38.25%, 38.5%, 38.75%, 39%, 39.25%, 39.5%, 39.75%, 40%, 40.25%, 40.5%, 40.75%, 41%, 41.25%, 41.5%, 41.75%, 42%, 42.25%, 42.5%, 42.75%, 43%, 43.25%, 43.5%, 43.75%, 44%, 44.25%, 44.5%, 44.75%, 45%, 45.25%, 45.5%, 45.75%, 46%, 46.25%, 46.5%, 46.75%, 47%, 47.25%, 47.5%, 47.75%, 48%, 48.25%, 48.5%, 48.75%, 49%, 49.25%, 49.5%, 49.75%, or 50% of the total MDG in the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C.

[00139] MDG may be in the aqueous phase at about 0.001% to about 30% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 0.1% to about 20% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 1% to about 5% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. For example, MDG may be in the aqueous phase at about 0.001%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 0.55%, 0.6%, 0.65%, 0.7%,

0.75%, 0.8%, 0.85%, 0.9%, 0.95%, 1%, 1.25%, 1.5%, 1.75%, 2%, 2.25%, 2.5%, 2.75%, 3%, 3.25%, 3.5%, 3.75%, 4%, 4.25%, 4.5%, 4.75%, 5%, 5.25%, 5.5%, 5.75%, 6%, 6.25%, 6.5%, 6.75%, 7%, 7.25%, 7.5%, 7.75%, 8%, 8.25%, 8.5%, 8.75%, 9%, 9.25%, 9.5%, 9.75%, 10%, 10.25%, 10.5%, 10.75%, 11%, 11.25%, 11.5%, 11.75%, 12%, 12.25%, 12.5%, 12.75%, 13%, 13.25%, 13.5%, 13.75%, 14%, 14.25%, 14.5%, 14.75%, 15%, 15.25%, 15.5%, 15.75%, 16%, 16.25%, 16.5%, 16.75%, 17%, 17.25%, 17.5%, 17.75%, 18%, 18.25%, 18.5%, 18.75%, 19%, 19.25%, 19.5%, 19.75%, 20%, 20.25%, 20.5%, 20.75%, 21%, 21.25%, 21.5%, 21.75%, 22%, 22.25%, 22.5%, 22.75%, 23%, 23.25%, 23.5%, 23.75%, 24%, 24.25%, 24.5%, 24.75%, 25%, 25.25%, 25.5%, 25.75%, 26%, 26.25%, 26.5%, 26.75%, 27%, 27.25%, 27.5%, 27.75%, 28%, 28.25%, 28.5%, 28.75%, 29%, 29.25%, 29.5%, 29.75%, or 30% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C.

[00140] MDG may be in the aqueous phase at about 0.001% to about 20% of the total MDG in the nutritional composition, following centrifugation at 100,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 0.01% to about 15% of the total MDG in the nutritional composition, following centrifugation at 100,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 0.1% to about 10% of the total MDG in the nutritional composition, following centrifugation at 100,000 x g for 1 hour at 20 °C. MDG may be in the aqueous phase at about 1% to about 5% of the total MDG in the nutritional composition, following centrifugation at 100,000 x g for 1 hour at 20 °C. For example, MDG may be in the aqueous phase at about 0.001%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 0.55%, 0.6%, 0.65%, 0.7%, 0.75%, 0.8%, 0.85%, 0.9%, 0.95%, 1%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, 2%, 2.1%, 2.2%, 2.3%, 2.4%, 2.5%, 2.6%, 2.7%, 2.8%, 2.9%, 3%, 3.1%, 3.2%, 3.3%, 3.4%, 3.5%, 3.6%, 3.7%, 3.8%, 3.9%, 4%, 4.1%, 4.2%, 4.3%, 4.4%, 4.5%, 4.6%, 4.7%, 4.8%, 4.9%, 5%, 5.1%, 5.2%, 5.3%, 5.4%, 5.5%, 5.6%, 5.7%, 5.8%, 5.9%, 6%, 6.1%, 6.2%, 6.3%, 6.4%, 6.5%, 6.6%, 6.7%, 6.8%, 6.9%, 7%, 7.1%, 7.2%, 7.3%, 7.4%, 7.5%, 7.6%, 7.7%, 7.8%, 7.9%, 8%, 8.1%, 8.2%, 8.3%, 8.4%, 8.5%, 8.6%, 8.7%, 8.8%, 8.9%, 9%, 9.1%, 9.2%, 9.3%, 9.4%, 9.5%, 9.6%, 9.7%, 9.8%, 9.9%, 10%, 10.1%, 10.2%, 10.3%, 10.4%, 10.5%, 10.6%, 10.7%, 10.8%, 10.9%, 11%, 11.1%, 11.2%, 11.3%, 11.4%, 11.5%, 11.6%, 11.7%, 11.8%, 11.9%, 12%, 12.1%, 12.2%, 12.3%, 12.4%, 12.5%, 12.6%, 12.7%, 12.8%, 12.9%, 13%, 13.1%, 13.2%, 13.3%, 13.4%, 13.5%, 13.6%, 13.7%, 13.8%, 13.9%, 14%, 14.1%, 14.2%, 14.3%, 14.4%, 14.5%, 14.6%, 14.7%, 14.8%, 14.9%, 15%, 15.1%, 15.2%, 15.3%, 15.4%, 15.5%, 15.6%, 15.7%, 15.8%, 15.9%, 16%, 16.1%, 16.2%, 16.3%, 16.4%, 16.5%, 16.6%, 16.7%, 16.8%, 16.9%, 17%, 17.1%, 17.2%, 17.3%, 17.4%, 17.5%, 17.6%, 17.7%, 17.8%, 17.9%, 18%, 18.1%, 18.2%, 18.3%, 18.4%, 18.5%, 18.6%, 18.7%, 18.8%, 18.9%, 19%, 19.1%,

19.2%, 19.3%, 19.4%, 19.5%, 19.6%, 19.7%, 19.8%, 19.9%, or 20% of the total MDG in the nutritional composition, following centrifugation at 100,000 x g for 1 hour at 20 °C.

[00141] MDG may be in the assembly at about 0.001% to about 20% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. MDG may be in the assembly at about 0.01% to about 15% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. MDG may be in the assembly at about 0.1% to about 10% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. MDG may be in the assembly at about 1% to about 5% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C. For example, MDG may be in the assembly at about 0.001%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 0.55%, 0.6%, 0.65%, 0.7%, 0.75%, 0.8%, 0.85%, 0.9%, 0.95%, 1%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, 2%, 2.1%, 2.2%, 2.3%, 2.4%, 2.5%, 2.6%, 2.7%, 2.8%, 2.9%, 3%, 3.1%, 3.2%, 3.3%, 3.4%, 3.5%, 3.6%, 3.7%, 3.8%, 3.9%, 4%, 4.1%, 4.2%, 4.3%, 4.4%, 4.5%, 4.6%, 4.7%, 4.8%, 4.9%, 5%, 5.1%, 5.2%, 5.3%, 5.4%, 5.5%, 5.6%, 5.7%, 5.8%, 5.9%, 6%, 6.1%, 6.2%, 6.3%, 6.4%, 6.5%, 6.6%, 6.7%, 6.8%, 6.9%, 7%, 7.1%, 7.2%, 7.3%, 7.4%, 7.5%, 7.6%, 7.7%, 7.8%, 7.9%, 8%, 8.1%, 8.2%, 8.3%, 8.4%, 8.5%, 8.6%, 8.7%, 8.8%, 8.9%, 9%, 9.1%, 9.2%, 9.3%, 9.4%, 9.5%, 9.6%, 9.7%, 9.8%, 9.9%, 10%, 10.1%, 10.2%, 10.3%, 10.4%, 10.5%, 10.6%, 10.7%, 10.8%, 10.9%, 11%, 11.1%, 11.2%, 11.3%, 11.4%, 11.5%, 11.6%, 11.7%, 11.8%, 11.9%, 12%, 12.1%, 12.2%, 12.3%, 12.4%, 12.5%, 12.6%, 12.7%, 12.8%, 12.9%, 13%, 13.1%, 13.2%, 13.3%, 13.4%, 13.5%, 13.6%, 13.7%, 13.8%, 13.9%, 14%, 14.1%, 14.2%, 14.3%, 14.4%, 14.5%, 14.6%, 14.7%, 14.8%, 14.9%, 15%, 15.1%, 15.2%, 15.3%, 15.4%, 15.5%, 15.6%, 15.7%, 15.8%, 15.9%, 16%, 16.1%, 16.2%, 16.3%, 16.4%, 16.5%, 16.6%, 16.7%, 16.8%, 16.9%, 17%, 17.1%, 17.2%, 17.3%, 17.4%, 17.5%, 17.6%, 17.7%, 17.8%, 17.9%, 18%, 18.1%, 18.2%, 18.3%, 18.4%, 18.5%, 18.6%, 18.7%, 18.8%, 18.9%, 19%, 19.1%, 19.2%, 19.3%, 19.4%, 19.5%, 19.6%, 19.7%, 19.8%, 19.9%, or 20% of the total MDG in the nutritional composition, following centrifugation at 31,000 x g for 1 hour at 20 °C.

[00142] Lutein, a lipophilic compound discussed below, may be in the aqueous phase at about 0.001% to about 50% of the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. Lutein may be in the aqueous phase at about 0.5% to about 40% of the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. Lutein may be in the aqueous phase at about 5% to about 30% of the nutritional composition, following centrifugation at 1,000 x g for 1 hour at 20 °C. Lutein may be in the aqueous phase at about 15% to about 25% of the nutritional composition, following centrifugation at 1,000 x

CLAIMS

What is claimed is:

1. A nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising:

an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound,

wherein at least 1% of the total MDG in the nutritional composition remains in an aqueous phase after centrifugation at 100,000 x g for 1 hour at 20 °C.

2. The nutritional composition of claim 1, wherein the assembly is (i) water soluble; and (ii) has a size of 60 kD to 1000 kD.

3. The nutritional composition of any of the preceding claims, wherein MDG increases the concentration of the hydrophobic protein in the assembly by at least 2% compared to a nutritional composition without MDG.

4. The nutritional composition of any of the preceding claims, wherein MDG increases the bound lipophilic compound of the assembly by at least 2% compared to a nutritional composition without MDG.

5. The nutritional composition of any of the preceding claims, wherein the lipophilic compound of the composition has at least a 15% improvement in bioavailability when administered to a subject, wherein the 15% improvement in bioavailability is measured by lymphatic absorption of the composition over a nutritional composition without MDG.

6. The nutritional composition of any of the preceding claims, wherein the assembly is still water soluble after centrifugation at about 31,000 x g for at least 1 hour at 20 °C.

7. The nutritional composition of claim 6, wherein at least 5% of the assembly remains in the aqueous phase after centrifugation.

8. The nutritional composition of any of the preceding claims wherein the protein is intact protein, hydrolyzed protein or combinations thereof.

9. The nutritional composition of any of the preceding claims, wherein the assembly is stable for at least 12 months at 23 °C.

10. The nutritional composition of any of the preceding claims, wherein the assembly is stable for at least 24 months at room temperature.

11. The nutritional composition of any of the preceding claims, wherein the assembly comprises a hydrophobic protein having a GRAVY value from about -0.5 to about 0.

12. The nutritional composition of any of the preceding claims, wherein the hydrophobic protein is β-lactoglobulin, bovine lactoferrin, γ_2-casein, β-casein, α-lactalbumin, or combinations thereof.

13. The nutritional composition of any of the preceding claims wherein the assembly has a size of 60 kD to 400 kD.

14. The nutritional composition of any the preceding claims wherein the lipophilic compound is a carotenoid, a lipid soluble vitamin, a lipophilic antioxidant or combinations thereof.

15. The nutritional composition of claim 13, wherein the lipophilic compound is lutein, vitamin A, vitamin D, vitamin E, vitamin K or combinations thereof.

16. The nutritional composition of any of the preceding claims wherein the fat is MDG, coconut oil, fractionated coconut oil, soy oil, corn oil, olive oil, safflower oil, high oleic coconut oil, fractionated coconut oil, soy oil, corn oil, olive oil, safflower oil, high oleic safflower oil, sunflower oil, high oleic sunflower oil, palm oil, palm kernel oil, palm olein, canola oil, marine oils, cottonseed oil, flax seed oil, hemp seed oil, peanut oil, borage oil, algal oils, fungal oils, MCT oil (medium chain triglycerides) and combinations thereof.

17. The nutritional composition of any of the preceding claims comprising from about 145 mg/kg to about 890 mg/kg of MDG based on total weight of the composition.

18. The nutritional composition of any of the preceding claims comprising from about 145 mg/kg to about 600 mg/kg of MDG based on total weight of the composition.

19. The nutritional composition of any of the preceding claims comprising from about 1.0 μg/kg to about 7.0 g/kg of the lipophilic compound based on total weight of the composition.

20. The nutritional composition of any of the preceding claims comprising from about 147.4 mg/kg to about 589.6 mg/kg of MDG and about 1.12 mg/kg of the lipophilic compound based on total weight of the composition.

21. The nutritional composition of any preceding claims, wherein the ratio of MDG to lipophilic compound are selected from the group consisting of 12000:1, 11000:1, 10000:1, 9000:1, 8000:1, 7000:1, 6000:1, 5000:1, 4000:1, 3000:1, 2000:1, 1000:1, 900:1, 800:1, 700:1, 600:1, 500:1, 400:1, 300:1, 200:1, 100:1, 75:1, 50:1, 25:1, 20:1, 15:1, 14:1, 13:1, 12:1, 11:1, 10:1, 9:1, 8:1, 7:1, 6:1, 5:1, 4:1, 3:1, 2:1 and 1:1 (w/w).

22. The nutritional composition of any preceding claims, wherein the ratio of MDG to lipophilic compound comprises a ratio of from about 12000:1 to about 1:1 (w/w).

23. The nutritional composition of claims 21 and 22, wherein the ratio of MDG to lipophilic compound is 4:1, 3:1 or 2:1.

24. The nutritional composition of any of the preceding claims comprising from about 1.0 g/L to about 100 g/L of hydrophobic protein based on total weight of the composition.

25. The nutritional composition of any of the preceding claims further comprising choline.

26. The nutritional composition of claim 25, comprising about 5 mg/kg to about 1 g/kg of choline based on total weight of the composition.

27. The nutritional composition of any of the preceding claims further comprising lecithin.

28. The nutritional composition of claim 27, comprising about 10 mg/kg to about 5 g/kg of lecithin based on total weight of the composition.

29. The nutritional composition of any of the preceding claims further comprising docosahexaenoic acid ("DHA").

30. The nutritional composition of claim 29, wherein the nutritional composition comprises about 10 mg/kg to about 10 g/kg DHA based on total weight of the composition.

31. The nutritional composition of any of the preceding claims further comprising high palmitic acid vegetable oil.

32. The nutritional composition of claim 31, wherein the nutritional composition comprises about 0.5 g/kg to about 35 g/kg of high palmitic acid vegetable oil based on total weight of the composition.

33. The nutritional composition of any of the preceding claims, wherein the nutritional composition comprises from about 0.2 g/L to about 20 g/L of β-casein based on total weight of the composition.

34. The nutritional composition of any of the preceding claims, wherein the nutritional composition comprises a carbohydrate.

35. The nutritional composition of claim 34, wherein the carbohydrate is maltodextrin, hydrolyzed or modified starch, hydrolyzed or modified cornstarch, glucose polymers, corn syrup, corn syrup solids, rice-derived carbohydrates, glucose, fructose, lactose, high fructose corn syrup, honey, sugar alcohols, maltitol, erythritol, sorbitol, or combinations thereof.

36. A nutritional composition comprising at least one protein and vitamin D, having improved bioavailability of vitamin D, wherein the nutritional composition comprises:

an activated assembly comprising a combination of monoglycerides and diglycerides ("MDG"), at least one hydrophobic protein, and vitamin D, wherein the vitamin D has improved bioavailability when administered to a subject.

37. The nutritional composition of claim 36, comprising from about 0.1 mg/kg to about 20 mg/kg of MDG based on total weight of the composition.

38. The nutritional composition of claim 37, comprising about 0.1 mg/kg to about 10 mg/kg of MDG based on total weight of the composition.

39. The nutritional composition of claims 36-38 comprising about 10 μg/kg to about 30 μg/kg of vitamin D based on total weight of the composition.

40. The nutritional composition of claims 36-39 comprising about 0.1 mg/kg to about 10 mg/kg of MDG and about 20 μg/kg of vitamin D based on total weight of the composition.

41. A nutritional composition having at least one protein, at least one fat, and at least one lipophilic compound, the composition comprising:

an activated assembly comprising at least one hydrophobic protein, at least one combination of monoglycerides and diglycerides ("MDG") and at least one lipophilic compound,

wherein at least 15% of the total lipophilic compound in the nutritional composition remains in an aqueous phase after centrifugation at 1,000 x g for 1 hour at 20 °C.