Nano-vehicles in Nutraceutical Delivery
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- Global Nutraceuticals Market
- Lipophilic Vitamins – Encapsulated or Exposed?
- Food grade Nano-vehicles
- Encapsulated Vitamins – Preparation to Characterization
- Conclusion and Future direction
Global Nutraceuticals Market

Market Reports World
October 28th, 2016

Analysts forecast the global Functional Food and Nutraceuticals market to grow at a CAGR (compound annual growth rate) of 7.39% during the period 2016-2020.


Global Infant Formula Market Revenue
By Region, 2015 (US$ Mn)

2016 – 2026 at a CAGR of 10.1%

Vitamin D Market

$2.5 billion by 2020 – increases with growing awareness of deficiency links to health problems (e.g. osteoporosis, osteomalacia, and rickets).

Source: Future Market Insights, 2016
Goal: Improve stability during processing and storage of fortified products.

Physical and chemical factors: light (UV), heat, moisture, exposure to air, acid or alkaline environments.

The biological effects of UV light:

- Degradation
- Safety, ex. formation of reactive species (singlet oxygen and superoxide radical anion) in case of vitamin A → Damage lipids and DNA
Food grade Nano-vehicles

**Key Characteristics:** Food-grade protein-based and lipid-based materials, biodegradable, able to encapsulate lipophilic molecules (e.g. Retinol), easy to handle

- ZSC-Formula
- C-Formula
- SSC-Formula
- SS-Formula + Vitamin $A_1$

Encapsulated vitamin in powder form
Encapsulated vitamins – Preparation to Characterization

SEM – ZetaSizer Nano
ZSC-Formula : Vitamin D₃

**ZSC-Formula**: 4°C to 37°C size increases from 180-200 nm and zeta potential changes -24 to -19 mv with increase in temperature

**ZSC-Formula** + Vitamin D₃: 4°C to 37°C size increases from 180-200 nm with 4.5 microm particles (3%) and zeta potential: -13 at 4°C, -20 mv at 25°C, -11 mv at 37°C
Encapsulated vitamins – Preparation to Characterization

**SEM – ZetaSizer Nano**

**C-Formula : Vitamin D₃**

C-Formula : 4°C to 37°C size increases from 160-860 nm and zeta potential from -10 to -13 mv with increase of temperature.

C-Formula+Vitamin D₃ : 4°C to 37°C size slightly increases from 380-530 nm with microparticles showing(3%) at 25°C, and 80 nm particles (6%) at 37°C and zeta potential is -25 mv at lower temperatures and -23 mv at 37°C.
Encapsulated vitamins – Preparation to Characterization

**SEM**

**SSC : Vitamin D₃**

Preparation:
Ethanol-water, Sonication, Shear mixer, Freeze Dried

Encapsulated vitamin D₃ in SSC: 4°C to 37°C size 200-300 nm. Zeta potential: -17 mv at lower temperatures and -22 mv at 37°C.
Encapsulated vitamins – Preparation to Characterization

SEM

**SS : Vitamin A**

Preparation:
Ethanol-water, Ultra-sonication, Freeze Dried

![Encapsulated Nanoliposome bilayer](Image)

**Plant Sterols:**
European Food Safety Authority (EFSA) authorised claim that allows food manufacturers to state that “plant sterols contribute to the maintenance of normal blood cholesterol levels” with a “daily intake of at least 0.8g of plant sterols”.

*Ref: Lecithin and Plant Sterols Nutrigold Update Service*
Encapsulated vitamins – Preparation to Characterization

Infant Formula

Infant Formula
UV Exposure
Vitamin D₃ Measurements

Infant Formula + UV Exposure
Vitamin A₁ Measurements

Infant Formula + UV Exposure
Vitamin D₃ Measurements

Infant Formula Label Vitamin A 65 μg/100 mL, Vitamin D₃ 0.95 μg/100 mL
Stability of Fortified Milk: Sun Exposure - LCMS Measurements

Fortified Milk contains vitamin D₃

Conditions: Mixing & Cooling in Quartz Chamber in a sunny day

Encapsulated vitamins – Preparation to Characterization
Encapsulated vitamins – Preparation to Characterization

Vitamin D₃ in Fortified Milk, UV - LCMS

Conditions: varied Volumes no mixing – cooling in UV chamber

Callaghan Innovation

![Graph](image)

Olive-based: Vitamin D₃ In Fortified Milk

<table>
<thead>
<tr>
<th>Condition</th>
<th>D₃ μg/mL (18 hours)</th>
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</thead>
<tbody>
<tr>
<td>No UV</td>
<td>2500</td>
</tr>
<tr>
<td>Olive Based Formula D₃ UV</td>
<td>2000</td>
</tr>
<tr>
<td>Olive Based Formula D₃ UV</td>
<td>1000</td>
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</table>

ZSC-Formula : Vitamin D₃ In Fortified Milk

<table>
<thead>
<tr>
<th>Condition</th>
<th>D₃ μg/mL (18 hours)</th>
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</thead>
<tbody>
<tr>
<td>No UV</td>
<td>400</td>
</tr>
<tr>
<td>ZSC-Formula + D₃ UV</td>
<td>350</td>
</tr>
<tr>
<td>ZSC-Formula + D₃ UV</td>
<td>300</td>
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</tbody>
</table>

Fortified Milk

<table>
<thead>
<tr>
<th>Condition</th>
<th>D₃ μg/mL (18 hours)</th>
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<tbody>
<tr>
<td>No UV</td>
<td>0.25</td>
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<tr>
<td>Fortified Milk UV+</td>
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<tr>
<td>Fortified Milk UV</td>
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</table>

(18 hours)
Encapsulated vitamins – Preparation to Characterization

SSC : Vitamin D$_3$ in Fortified Milk

Sample Condition: Mixing & Cooling in UV Chamber

SSC:D3 in Fortified Milk - UV Exposure
Encapsulated vitamins – Preparation to Characterization

Encapsulated Vitamin D$_3$ in Fortified Milk
UV exposure – LCMS

UV

Conditions: No Mixing - Cooling in UV Chamber

Fortified Milk + ZSC-Formula Vitamin D$_3$

Fortified Milk + C-Formula Vitamin D$_3$

Fortified Milk + SSC-Formula Vitamin D$_3$

Graph showing UV exposure over time for different fortified milk formulas with encapsulated vitamin D$_3$. The y-axis represents D$_3$ concentration in μg/mL, and the x-axis represents time in hours.
Conclusion and Future Direction

- Stability of bioactive molecules such as vitamins matters at delivery environment, storage, processing conditions.

- Next we will assess effect of heat, air, acid or alkaline environments current formulas.

- Future: other vitamins and bioactives in current and other encapsulation materials
Other Presentations by Lipids Team

Andrew McKenzie/Dawn Scott
*Talk: Natural Sources of Plasmalogens*
10th on 11:45am

Kirill Lagutin
*Poster: The use of NMR in the characterization of edible fats and oils.*

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