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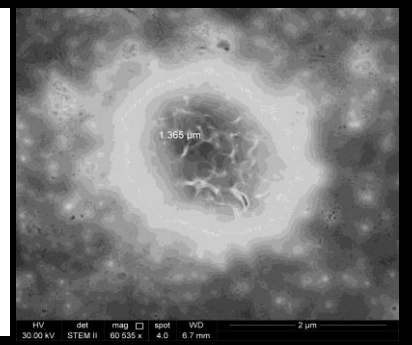

Nano-vehicles in Nutraceutical Delivery

Rahau Shirazi, Stephen Bloor, Kevin Mitchell

2016 Lipids and Nutraceuticals Conference
Nelson November 2016

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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

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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.

The global dietary supplements market expected growth by 2025 - US$252 billion – from US$131 billion by 2016.

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

Source: Future Market Insights, 2016

Vitamin D Market

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

Lipophilic Vitamins – Encapsulated or Exposed?

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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

Sensitivity of Vitamins

	Light	Oxidizing agents	Reducing agents	Heat	Humidity	Acids	Alkalis
Vitamin A	+++	+++	+	++	+	++	+
Vitamin D	+++	+++	+	++	+	++	++
Vitamin E	++	++	+	++	+	+	++
Vitamin K	+++	++	+	+	+	+	+++
Vitamin C	+	+++	+	++	++	++	+++
Thiamin	++	+	+	+++	++	+	+++
Riboflavin	+++	+	++	+	+	+	+++
Niacin	+	+	++	+	+	+	+
Vitamin B6	++	+	+	+	+	++	++
Vitamin B12	++	+	+++	+	++	+++	+++
Pantothenic Acid	+	+	+	++	++	+++	+++
Folic Acid	++	+++	+++	+	+	++	++
Biotin	+	+	+	+	+	++	++

+ Hardly or not sensitive ++ Sensitive +++ Highly sensitive

Source: F. Hoffmann - La Roche. Basel.

Food grade Nano-vehicles

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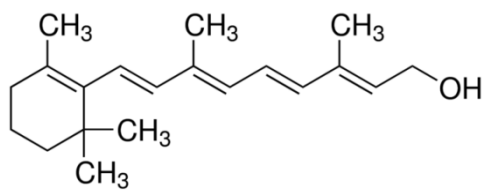
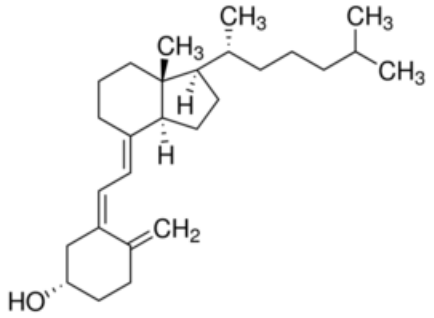
Key Characteristics: Food-grade protein-based and lipid-based materials, biodegradable, able to encapsulate lipophilic molecules (e.g. Retinol), easy to handle



Retinol (Vitamin A_1)



Cholecalciferol (Vitamin D_3)

- **ZSC-Formula**
- **C-Formula**
- **SSC-Formula**

+ Vitamin D_3

- **SS-Formula + Vitamin A_1**

Encapsulated vitamin in powder form

SBS-Formula
+ Vitamin A_1

SSC-Formula
Vitamin D_3

C-Formula
Vitamin D_3

ZSC-Formula
Vitamin D_3

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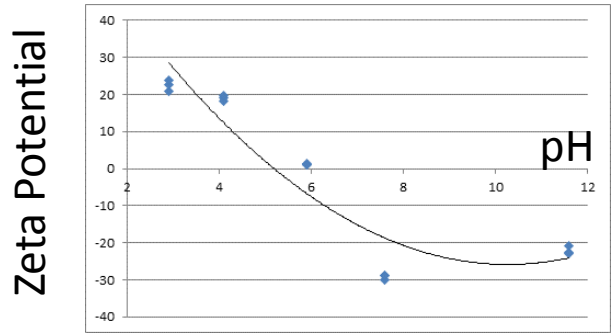
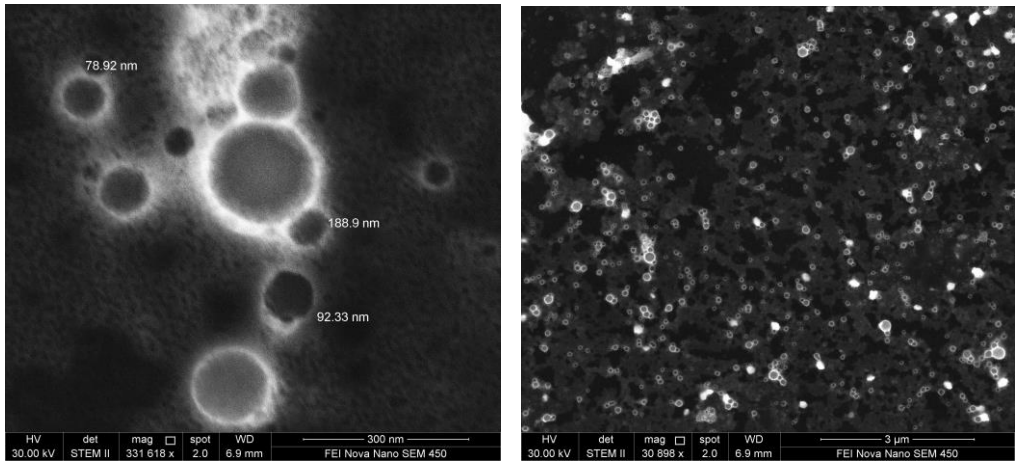
SEM – ZetaSizer Nano

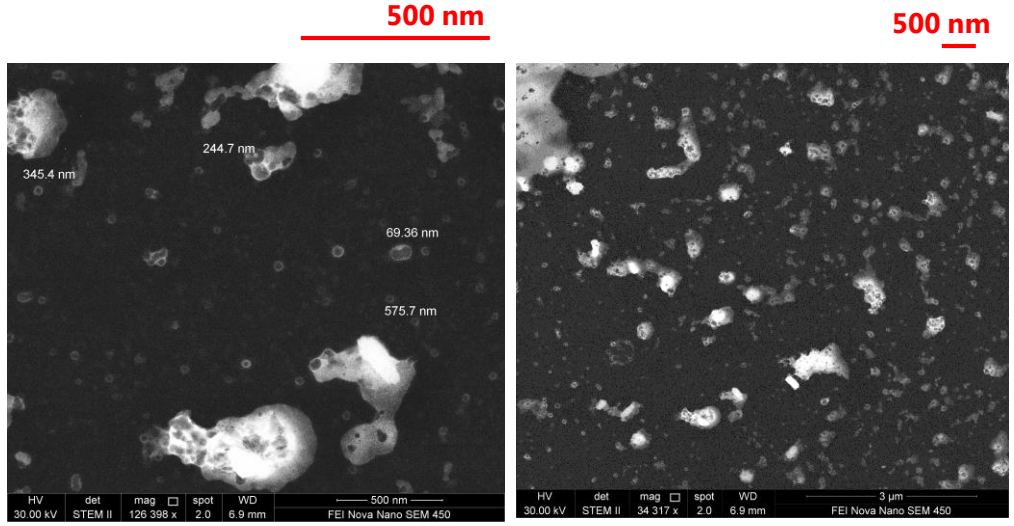
ZSC-Formula : Vitamin D_3



ZSC-Formula: Vitamin D_3



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 D_3: 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

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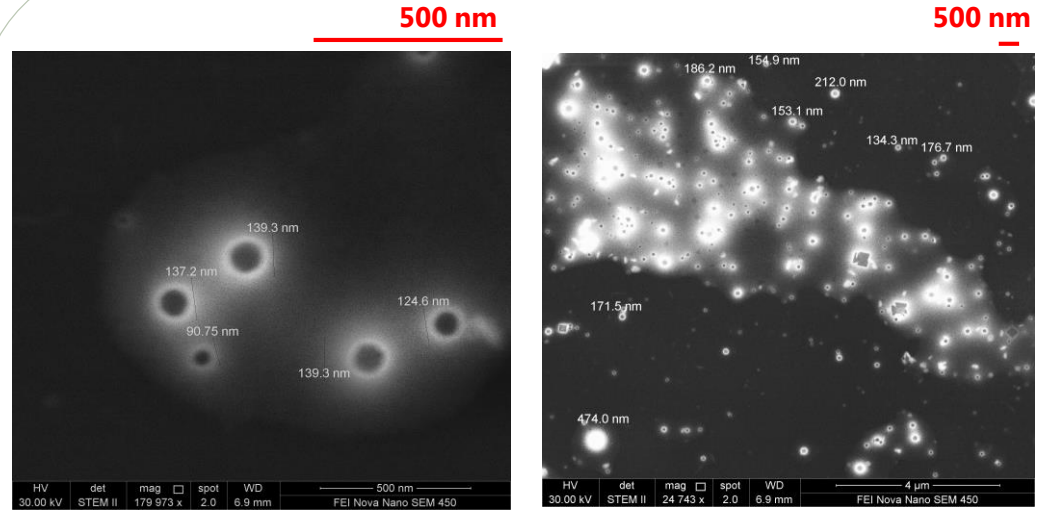
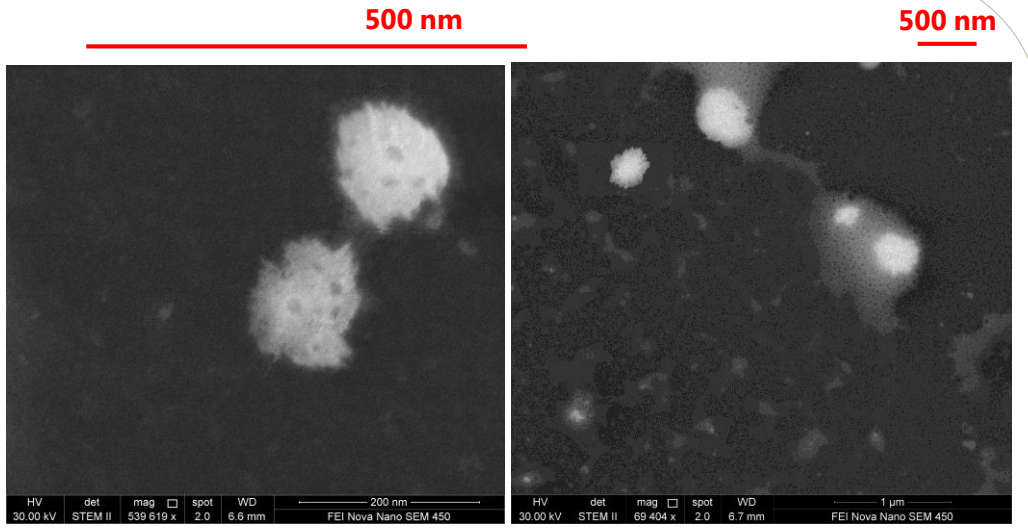
SEM – ZetaSizer Nano

C-Formula : Vitamin D_3



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 D_3 : 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.

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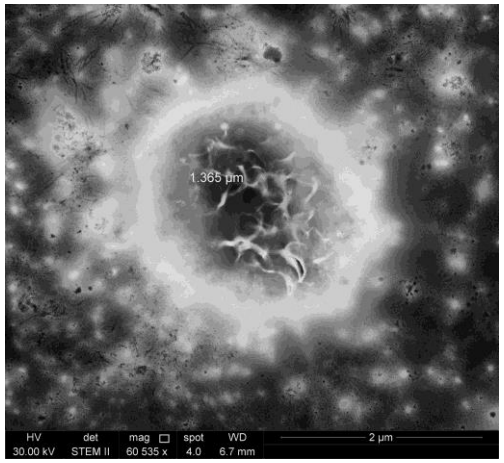
SEM

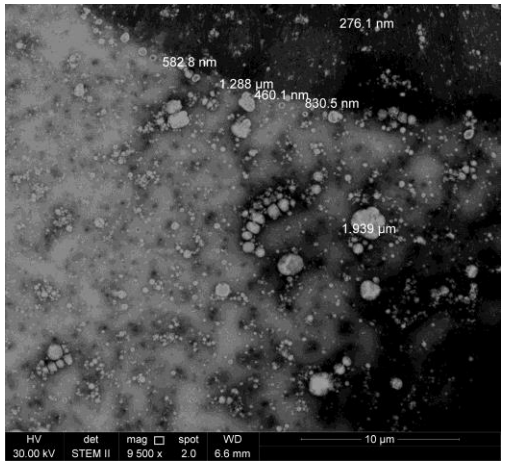
SSC : Vitamin D_3

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

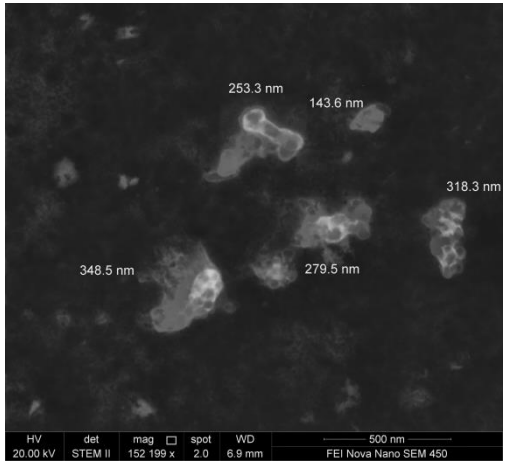
500 nm



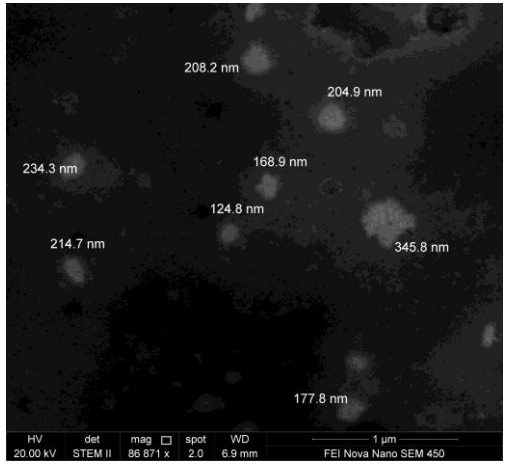
500 nm



500 nm



500 nm



Encapsulated vitamin D_3 in SSC: 4°C to 37°C size 200-300 nm. Zeta potential: -17 mv at lower temperatures and -22 mv at 37°C.

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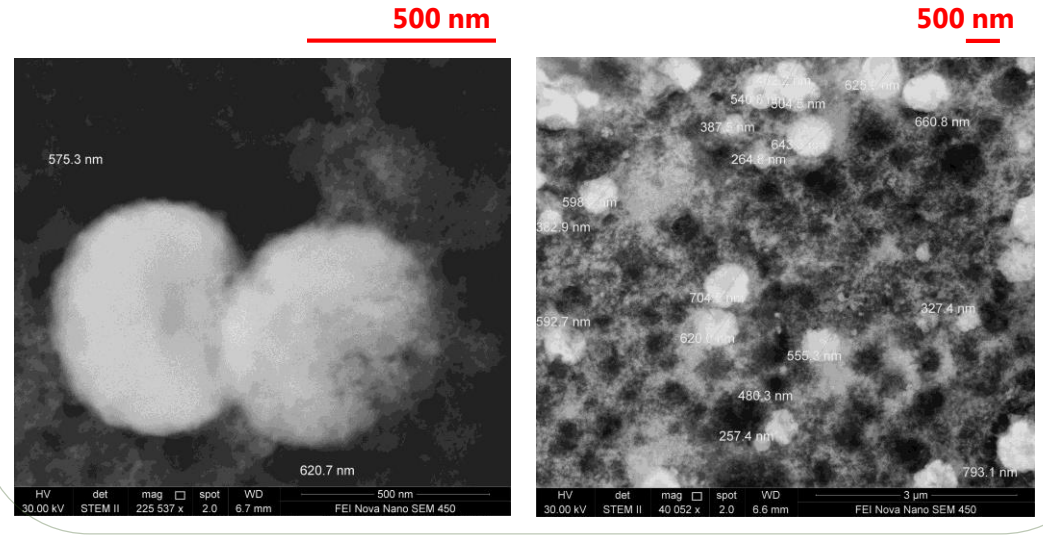
SEM

SS : Vitamin A

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

Encapsulated



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

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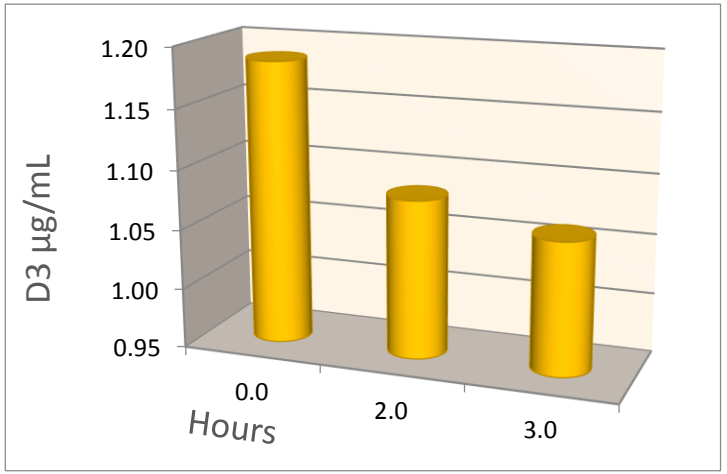
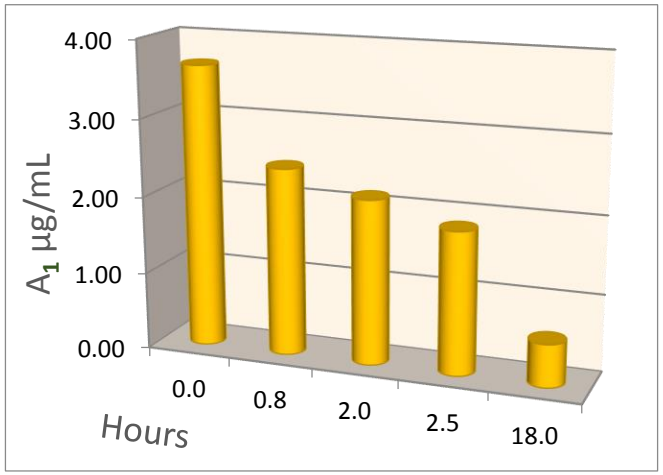
Infant Formula

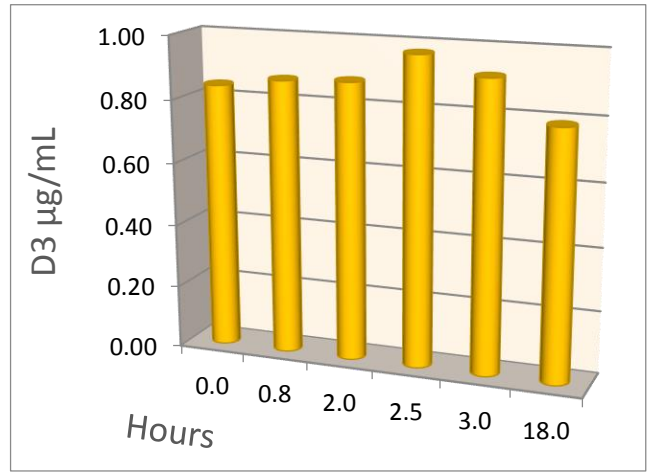


Infant Formula
UV Exposure
Vitamin D_3 Measurements

Added: SS Formula + Vitamin A_1



Infant Formula +
UV Exposure
Vitamin A_1 Measurements



Infant Formula +
UV Exposure
Vitamin D_3 Measurements

Infant Formula Label Vitamin A 65 µg/100 mL, Vitamin D_3 0.95 µg/100 mL

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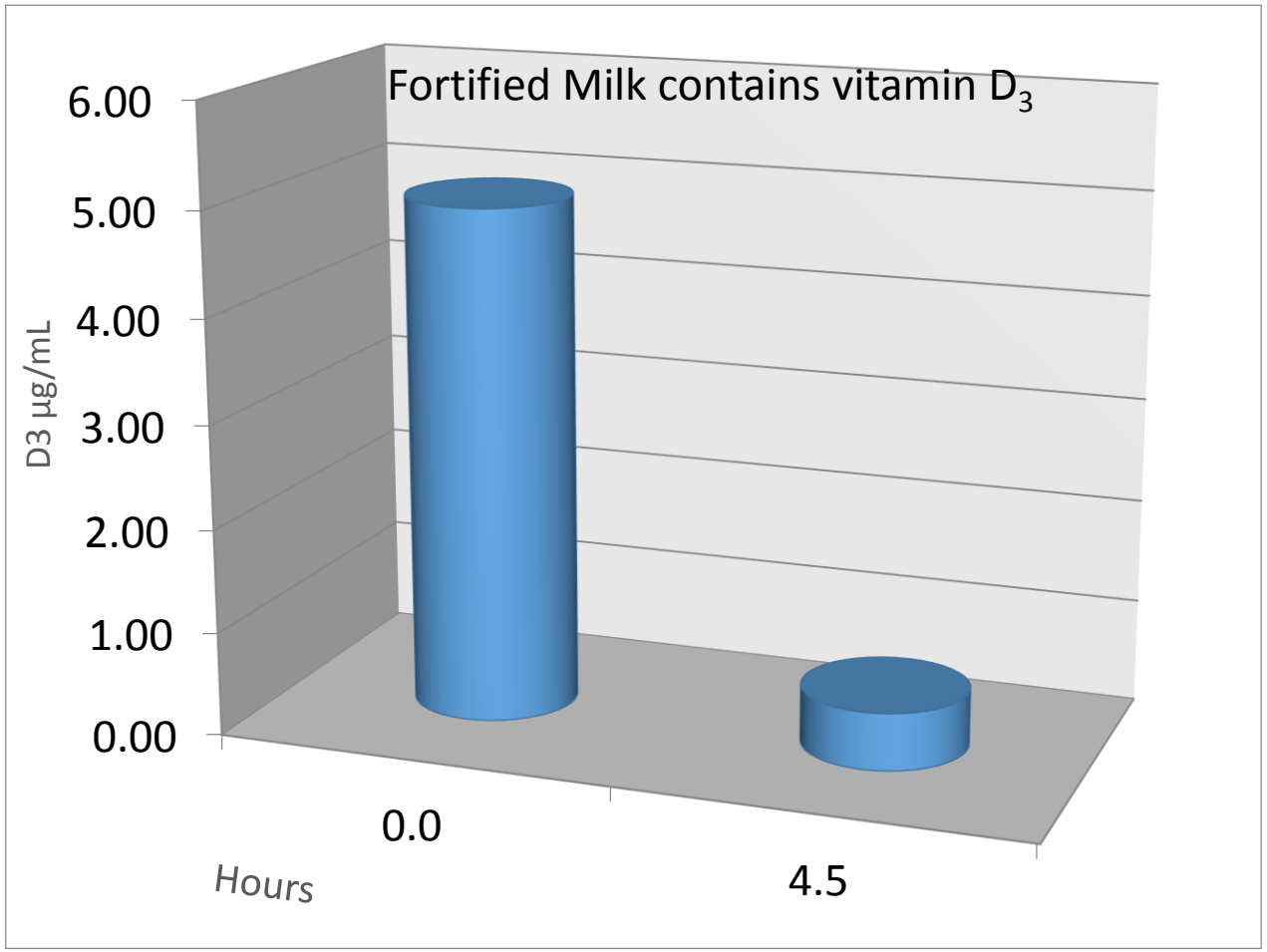
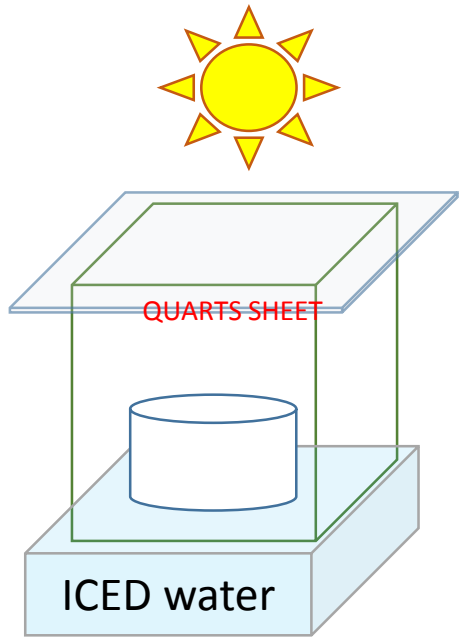
Stability of Fortified Milk: Sun Exposure - LCMS Measurements





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

Encapsulated vitamins – Preparation to Characterization

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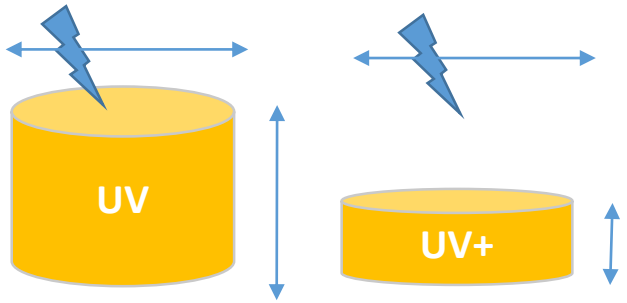
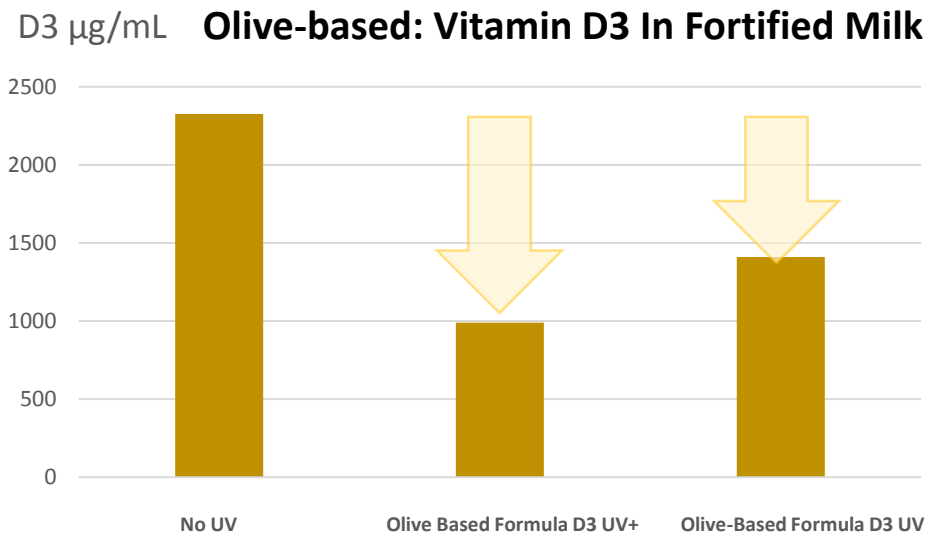
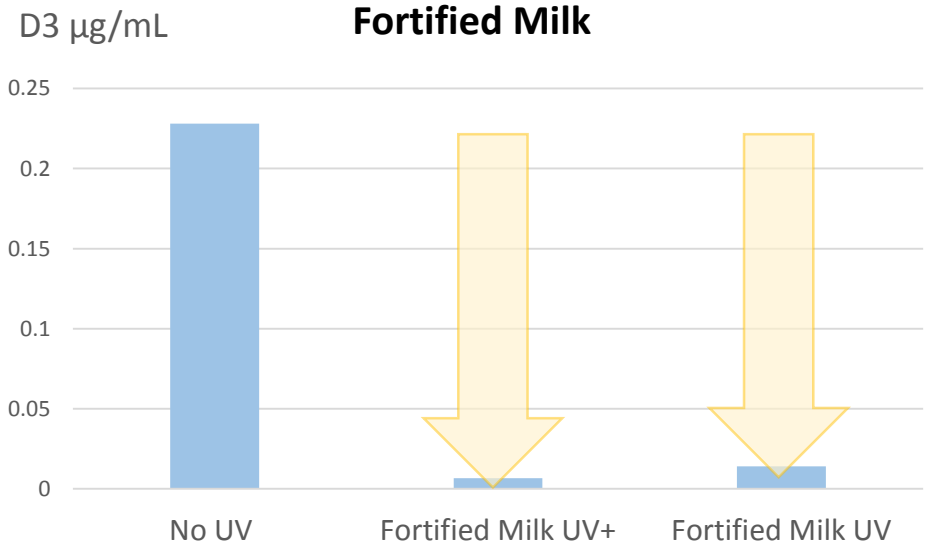
Vitamin D_3 in Fortified Milk, UV - LCMS



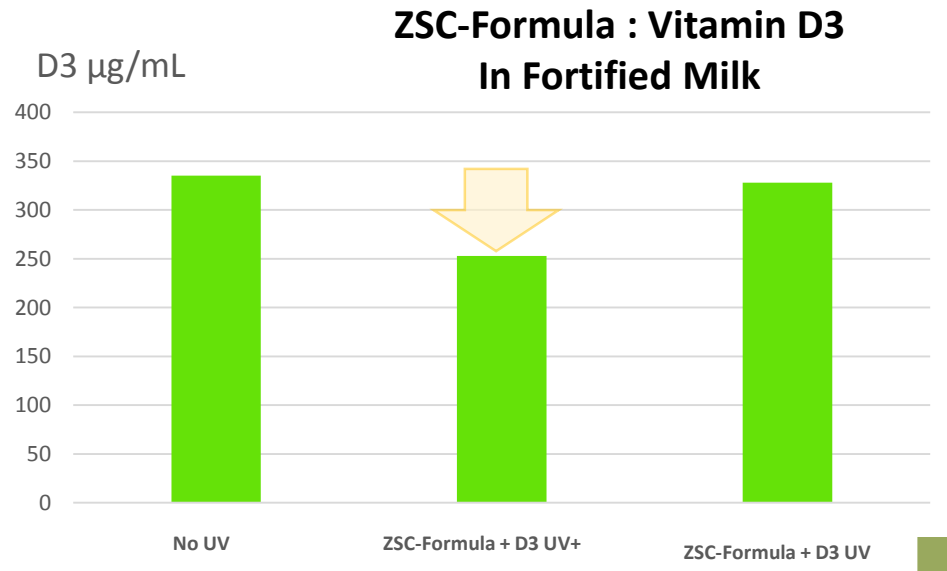
Conditions: varied Volumes no mixing – cooling in UV chamber



(18 hours)



(18 hours)



(18 hours)

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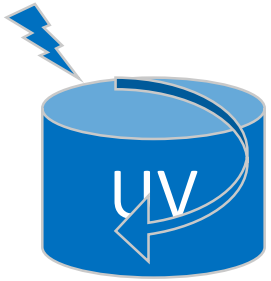
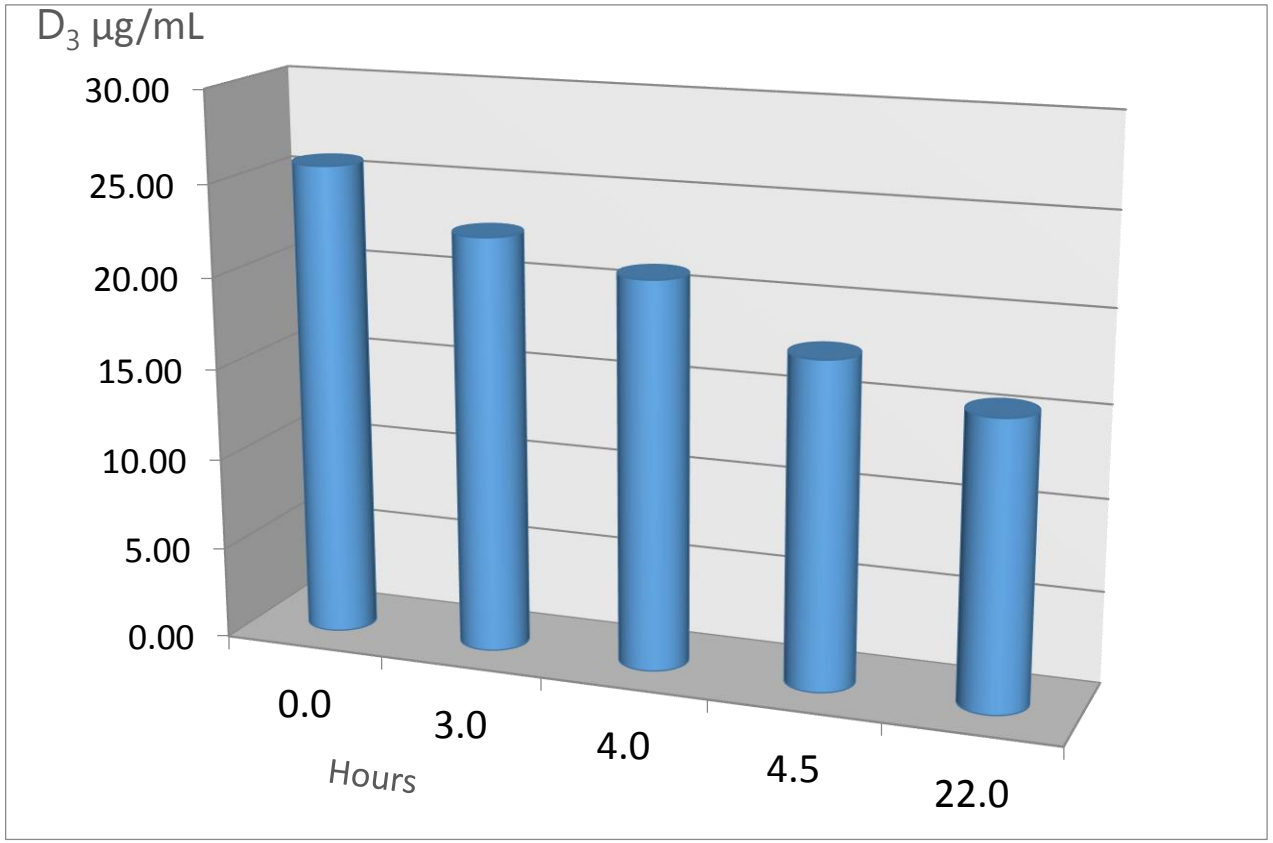
SSC : Vitamin D_3 in Fortified Milk



Sample Condition:
Mixing & Cooling
in UV Chamber



SSC:D3 in Fortified Milk - UV Exposure

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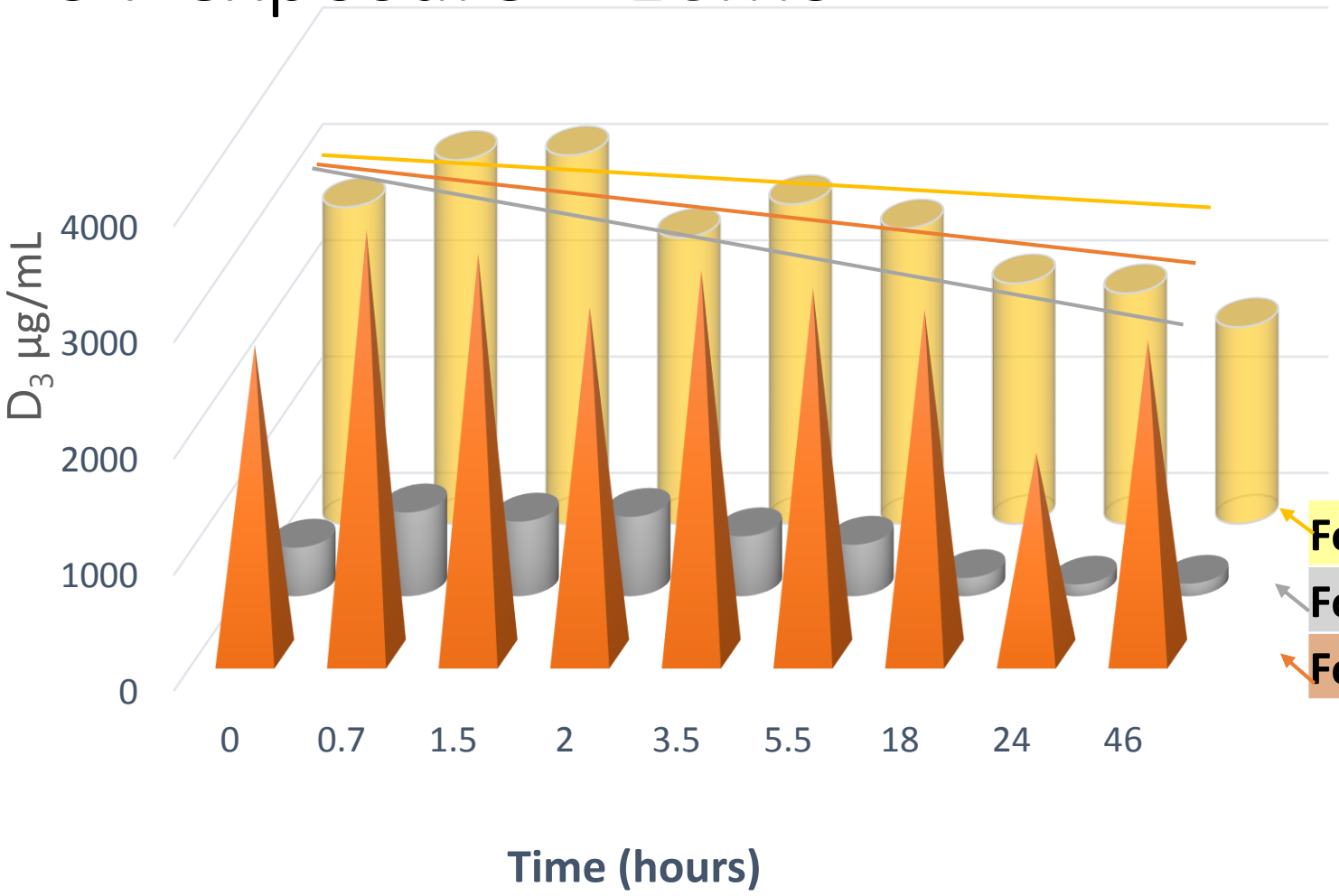
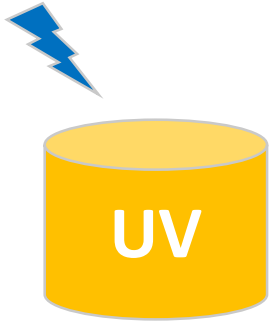
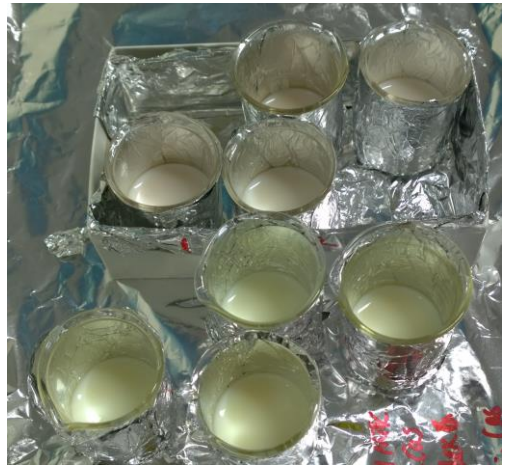
Encapsulated Vitamin D_3 in Fortified Milk UV exposure – LCMS







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

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

Thank You

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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.

Special Thanks to IBT Group Members especially to Rosemary Webby

Funded by Strategic Investment Fund – Callaghan Innovation

The Integrated Bioactive Technologies Group (IBT)
Providing high-value solutions for the industrial biotech sector

Lipid Chemistry
Create high-value nutraceuticals and cosmeceuticals using our lipid expertise

Natural Products and Plant Chemistry

Proteins and bioactive peptides

Analytical Services

Pilot Scale Facilities

Fermentation & Bioprocessing

Enzyme Technology

Supercritical Fluid Extraction

Biology and biochemistry expertise and application to industry

Process Development