Soy protein nanomaterials improve stability and bioavailability of vitamin D

Nawaf Altwalili, Emely C. Lopez, Shashank Gaur, Hao Feng, Nicki J. Engeseth, Juan E. Andrade

1Department of Food Science and Human Nutrition & 2Division of Nutritional Sciences
University of Illinois, Urbana-Champaign

Introduction

Vitamin D deficiency (VD) is a recognized public health concern throughout the Middle East, especially in Saudi Arabia [1]. VD can induce growth retardation and skeletal deformities in utero and during childhood (rickets), and could exacerbate the risk of bone fractures later in life. During adulthood, VD can provoke osteopenia and osteoporosis [1]. Recent evidence has shown the critical role that VD plays in the etiology of chronic diseases, including common cancers, diabetes, and autoimmunity, cardiovascular and infectious diseases [2]. VD is defined as serum values of circulating VD (e.g., 25(OH)-VD) at or lower than the cut-off level (normal range = 20-100 ng/mL; insufficient = <11 <20 ng/mL; severe <10 ng/mL) [1]. Due to excessive heat, cultural and religious practices, Saudi Arabians do not receive adequate sun exposure, and thus, reducing by far the largest potential source of VD [1]. In one study, the average daily sun exposure among healthy children aged 4-15 yr (n=510) was 7.63 ± 7.49 minutes per day [4]. Other causes of VD include a reduced consumption of VD-rich foods, continuous breastfeeding from mothers deficient in VD, and lack of skin exposure to UV rays in populations living at higher altitudes, and/or in individuals who use multiple sunscreens [4]. Food fortification has been present for decades; however, its stability in foods is still a major concern. Soy protein-based nanomaterials (SPN) have been used to improve the stability of VD [5]. The objective was to evaluate the stability, bioaccessibility and bioavailability of VD dispersed in SPN.

Methodology

Sample Preparation

Table 1. Description of sample treatments.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Media</th>
<th>Water</th>
<th>Vitamin D</th>
<th>US</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S-US</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>W-Oil-US</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>OIL-NL</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>OIL-SUS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>W-Oil-LS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
</tbody>
</table>

*Solubilized SPI (5) after pH shifting, ultrasound and centrifugation. Either non-sonicated (NS) or sonicated (US) for a second time. Lechitin (L), water (W), canola oil (oil).

Results

Figure 2. Particle size of different dispersions.

Figure 3. Bioaccessibility of Vitamin D after two-compartment simulated in vitro digestion.

Figure 4. Effect of UVB radiation on Vitamin D stability over time.

Figure 5. Bioaccessibility of Vitamin D after two-compartment simulated in vitro digestion.

Conclusions and Future Studies

• Combination of pH shifting (pH 12) followed by ultrasonication (20 kHz, 5 min) and centrifugation is an effective method to decrease particle size of soy protein and oil droplets, facilitating the dispersion of non-polar compounds such as vitamin D, resulting in stable nanomaterials.
• The effect of the type of oil and its concentration on particle size and stability of SPI-based nanomaterials require further evaluation.
• The efficacy of soy protein nanomaterials containing VD, alone and in fortified orange juice, to improve VD status in patients with VD insufficiency will be evaluated in a randomized clinical trial.
• In conclusion, dispersion of VD in soy protein isolate-based nanomaterials protects it from UV exposure and increases its bioaccessibility and oral bioavailability.

References

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Abstract

Deficiency and insufficiency of vitamin D (25(OH)D) persist worldwide; fortification of foods with vitamin D has been present for decades; however, its stability in foods is often compromised by its rapid degradation, low absorption and poor water solubility. In this study, soy protein based nanoparticles containing ultrasonication and centrifugation were used to improve the stability of vitamin D dispersed in soy protein based nanoparticles (SPI) (20 kHz, 5 min). Vitamin D dispersed in SPI (30 mg/mL) containing soybean oil (2%), cholecalciferol, and containing SPI (3%) in man. VD-containing SPI were compared to controls, including VD dispersed in SPI and SPI containing VD. These results showed a significant increase in the stability of VD in SPI containing VD (p < 0.05). Stability was measured using AUC (0-24 h), with SPI containing VD showing a significant increase in the AUC (p < 0.05) and reaching a Cmax at 24 hours compared to the Oil+DTD control. These results revealed that dispersion of VD in SPI nanoparticles protect VD from UV exposure and increases its bioaccessibility and oral bioavailability. Future studies will evaluate the sensory properties of SPI in food products.