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Enhancing the Stability and Bioaccessibility of β-Carotene through Emulsion-Filled Gel Encapsulation: A Promising Delivery System

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Introduction

β-Carotene, the most essential carotenoid widely found in fruits and plants, plays a crucial role in human visual health and cancer prevention as a precursor to vitamin A. However, its poor water solubility and vulnerability to oxygen, light and heat make it highly susceptible to degradation during application, limiting its potential applications due to poor bioaccessibility in gastrointestinal digestion. To overcome these limitations, there is growing interest in developing various delivery systems to improve β-carotene's stability and bioaccessibility. One promising approach is encapsulating oil in a gel with a three-dimensional network structure. Emulsion gels, which can be prepared through two methods, emulsion-filled gels and emulsion-particle gels, offer a solution to improve β-carotene delivery. Compared to particle gels, emulsion-filled gels have the added benefit of adjustability of particle composition, structure and size.

Description

β-Carotene is a type of carotenoid, which is a pigment found in fruits and plants. It is a precursor to vitamin A and plays an essential role in human visual health and cancer prevention. β-Carotene is poorly water soluble and vulnerable to degradation by oxygen, light and heat, limiting its potential applications. Encapsulation of β-carotene in emulsion-filled gels is a promising delivery system that enhances its stability and bioaccessibility. This approach offers several advantages over other delivery systems, including adjustability of particle composition, structure and size and controlled release of β-carotene. Emulsion-filled gel encapsulation has various potential applications, including in food and beverage industries, cosmetics and pharmaceuticals. Further research is needed to optimize the preparation methods and formulation of emulsion-filled gels for specific applications.

Current research suggests that a diet rich in carotenoids can provide significant health benefits to humans, including the preservation of major bodily functions and prevention of inflammatory diseases such as cardiovascular, ophthalmological, pulmonary, neurodegenerative complications and various types of cancer. Studies indicate that the health benefits of carotenoids are largely due to their ability to affect cellular signaling pathways, including various transcription factors, which regulate the expression of genes related to antioxidant defense, anti-inflammatory and anti-cancer properties.

Food records were collected from each subject for 24 hours on days 0, 3, 6, 9, 12, 15, 21 and 27 to determine their average energy and vitamin A intakes, as well as the percentage of energy obtained from fat, carbohydrates and protein in their diet. The records were analyzed using NUTRITIONIST IV software (N-Squared Computing, Salem, OR). Additionally, the records were evaluated using the US Department of Agriculture's carotenoid database for fruits, vegetables and multicomponent foods (2) to determine the intake levels of α-carotene, β-carotene, lycopene and lutein.

β-Carotene, a carotenoid found in fruits and plants, is essential for human health, particularly for visual health and cancer prevention. However, its poor water solubility and vulnerability to degradation by oxygen, light and heat limit its potential applications. One solution to these issues is to encapsulate β-carotene in emulsion-filled gels, a promising delivery system that enhances its stability and bioaccessibility. Emulsion-filled gel encapsulation involves the encapsulation of oil droplets in a three-dimensional gel network, which protects β-carotene from degradation by oxygen, light and heat. The emulsion gel matrix also improves β-carotene bioaccessibility during gastrointestinal digestion, leading to better absorption and utilization by the body.

Blood samples of 15 mL each were collected from each subject via venipuncture on days 0 and 28 to conduct biochemical and immunologic assays. The blood was collected into vacuum tubes coated with EDTA for HPLC determination of carotenoids and hematologic indexes. The plasma was obtained through refrigerated centrifugation (680 × g for 12 min at 4°C) and stored at –80°C until analysis. An internal standard (β-apo-8-carotenal in ethanol containing 1 g butylated hydroxytoluene/L) was added to each plasma sample in measured amounts. The samples were then extracted three times with hexane and the combined hexane extracts were filtered and dried under nitrogen. The samples were reconstituted with 500 μL of mobile phase (65% acetonitrile, 25% methylene chloride and 10% methanol) and analyzed with a 1050 series HPLC instrument (Hewlett-Packard, Palo Alto, CA) equipped with a diode array detector.

To validate the accuracy of the calibration curves, standard reference materials (SRM 968B, human serum) from the National Institute of Standards and Technology in Gaithersburg, MD were analyzed. The plasma concentrations of individual carotenoids (α-carotene, β-carotene, lutein and lycopene), retinol and α-tocopherol were adjusted based on the recovery of the internal standard. Compliance with the supplementation protocol was determined through HPLC analysis of plasma β-carotene concentrations. Furthermore, the carotenoid contents of the β-carotene and placebo capsules were confirmed through assay analysis.

Conclusion

Emulsion-filled gels can be prepared using various methods, including electrostatic extrusion, homogenization and phase inversion. The method used depends on the desired size, structure and composition of the oil droplets in the emulsion gel matrix. Compared to other delivery systems, emulsion-filled gels offer several advantages. They allow for the adjustability of particle composition, structure and size, making them suitable for various applications. Furthermore, they can be formulated to release β-carotene in a controlled manner, ensuring optimal bioavailability and utilization. Emulsion-filled gel encapsulation has several potential applications, including food and beverage industries, cosmetics and pharmaceuticals. In food and beverage industries,

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emulsion-filled gels can be used to fortify products with β-carotene, providing a stable and bioavailable source of the nutrient. In cosmetics, they can be used as a delivery system for β-carotene, offering protection from degradation and improving its efficacy. In pharmaceuticals, emulsion-filled gels can be used to enhance the delivery of β-carotene in drug formulations. Emulsion-filled gel encapsulation is a promising delivery system for enhancing the stability and bioaccessibility of β-carotene. Its ability to protect β-carotene from degradation and improve its bioavailability makes it a suitable candidate for various applications, including food and beverage industries, cosmetics and pharmaceuticals. Further research is needed to optimize the preparation methods and formulation of emulsion-filled gels for specific applications [1-5].

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