JRIFST

www.journals.rifst.ac.ir
Journal of Research and Innovation
in Food Science and Technology

Research Institute of Food Science and Technology

Volume 8, Issue 1, Spring 2019, Pages 53-66
Document Type: Extended Abstract
DOI: 10.22101/JRIFST.2019.04.30.815

Extended Abstract

Integrated Encapsulation of Fish Oil and Vitamin E with Complex Coaservation Technique and its Efficiency Optimization by Response Surface Method (RSM)

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Received: 2018.01.20; **Accepted**: 2018.06.17

Abstract
In this study, fish oil and vitamin E were nanoencapsulated using polymeric materials of gelatin and Arabic gum as wall materials applyingcomplex coaservation technique and optimization process with the aid of the response surface method (RSM) in form of central composite design (CCD). The effects of the three independent variables including fish oil amount (1, 3 and 5%), biopolymer amount (1, 3 and 5%) and homogenizer speed (7000, 9000 and 11000 rpm) on dependent variables such as surface oil, encapsulated oil, encapsulation efficiency and particle size were investigated. The results showed that homogenization speed of 7000 rpm is not suitable for producing nanocapsules below 100 nm. In addition, the percentage of fish oil and the speed of homogenizer are effective on the size of the produced nanocapsules. Also, produced nanocapsules in treatments in which a higher percentage of oil was used compared to treatments with lower oil percentages, showed higher surface oil. The encapsulation efficiency was measured between 56.29% and 98.76%. In this research, optimum treatment was introduced as the one with 1% fish oil, 1% total biopolymer and 7000 rpm homogenizer speed in which its encapsulation efficiency was recorded as 97.97%.

Keywords: Complex Coaservation, Encapsulation, Fish Oil, Gelatin, Vitamin E

Introduction
Microencapsulation technology is a process in which active substances are placed in an inactive coating. Coated materials are often referred to as core, and the protective outer layer is called core shell, cover, wall, membrane or shell (Garg, Wood, Singh, & Moughan, 2006). Complex cocervation is one of the physicochemical methods of microencapsulation. It is used in the co-exposition of a combination of opposing polymer, which is one of the most commonly used technologies to stabilize omega-3 oil through micro-coating (Kaushik, Dowling, Barrow, & Adhikari, 2015). The aim of the present study was to simultaneously encapsulate the fish oil containing omega-3 and vitamin E using modern technology in order to stabilize them against oxidation and enhance the shelf life of microencapsulated bioactive compounds.

Material and methods

Preparation of emulsions and microencapsulated powder

Gelatin and Arabic gum aqueous solutions were prepared with a concentration of 6% w/w separately. In order to immerse the wall materials completely, gelatin and gum combinations were mixed at 50 and 25 °C for 12-18 h in water bath, respectively. Fish oil at levels (1.3 and 5%), Biopolymer at levels (1.3 and 5%) at different rates of homogenizer (mechanical) (Ultra-Turrax, Wise-15D, South Korea) (7000, 9000 and 1100 rpm) were considered as independent variables for the preparation of emulsion. Initially, vitamin E was added to fish oil at a dose of 3000 ppm. Then the gelatin solution was completely homogenized into fish oil containing vitamin E. Subsequently, distilled water was added and homogenized for 8 minutes, depending on the treatment at different speeds (7000, 9000 and 11000 rpm), then the Arabic gum solution was added and again homogeneous for 8 minutes. A multiple emulsion Oil was prepared in water and some physiochemical indices such as emulsion particle size, surface oil, encapsulated oil, total oil, zeta potential and encapsulation efficiency were measured.

Results and discussion

The results showed that the mean particle size range was 59.5 to 514 nm. In treatment 11 (Optimum or best encapsulation efficiency) (514 nm), the 7000 rpm homogenizer might increase particle size and was not suitable for producing nanoparticles below 100 nm. Zeta potential values were measured in 3 treatments in the range of -2.26 to -1.49. Data shows a three-dimensional graph showing the effect of fish oil percentage and biopolymer percentage on encapsulation efficiency response, so that the percentage of encapsulating yield decreased significantly with increasing fish oil percentage rather than biopolymer percentage.

The results of the analysis of variance of the efficiency response showed that the two parameters of fish oil percentage ($P<0.01$) and biopolymer percent ($P<0.05$) are linearly effective on the amount of encapsulation efficiency. According to F-values the percentage of fish oil had the greatest effect on encapsulation yield changes. In the present study, the encapsulation efficiency was measured in different treatments varied from 56.29 to 98.76%. According to statistical analysis, the percentage of fish oil proved most effect on the variation of this response level, so that by increasing the percentage of fish oil and reducing the biopolymer percentage, the encapsulation efficiency decreased. According to Zhang, Pan, & Chung (2011) study on olive oil encapsulation and optimization using RSM response method, the authors stated that the percent of total biopolymer and the concentration of oil were linearly effective on encapsulation efficiency at 99% probability level, and when the total biopolymer ranged from 5 to 5.5% was used the rate of yield increased with increasing oil content, but at a concentration of 7% biopolymer, the rate of yield decreased, which was probably due to the self-coagulation phenomenon of the combined complex coacervation in the presence of high bipolar mass.

Conclusion

The results of this study showed that the rate of homogenizer and fish oil percentage were effective in particle size. Microencapsulation of fish oil and vitamin E can be used to produce Nano-sized particles using a complex coacervation in polymer matrix of gelatin and Arabic gum. Also, statistical analysis of the results showed that by using optimal values of experimental variables, 1% fish oil, 1% biopolymer and homogenizer speed of 7000 rpm can produce optimal Nano-particles with the lowest surface oil and the highest encapsulation efficiency.

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