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Application of ultrasound for encapsulation of ω-3 fatty acids and enrichment of Doogh

Abbasi S. [1]*, Sheikhshoaei F. [1] and Sahari M.A. [1]
[1] Tarbiat Modares University, P O Box 14115-336, Tehran, Iran
* sabbasifood@modares.ac.ir

INTRODUCTION AND OBJECTIVES

Polyunsaturated fatty acids (PUFA) are a group of fatty acids that their beneficial effects on health and prevention of diseases have been demonstrated by numerous studies. Since there is a gap between the actual consumption of fish oil and the intake of omega-3 recommended by many expert committees and nutritionists, therefore it seems that a reasonable approach to achieve the needed value is to add these fatty acids into food products (Kolanowski 2006). On the other hand, milk and dairy products although are perceived as healthy foods, however its fat contains about 70% of saturated fatty acids (SFA) and their consumption may lead to increase the rate of different cardio-vascular diseases (Huertas 2010). As a result, in this research the capability of ultrasound was evaluated for encapsulation of ω-3 fatty acids in order to produce ω-3 enriched Doogh (Iranian yoghurt drink). In addition, the effects of ultrasound was determined on the peroxidation of fatty acids, rheological and sensory properties of sonicated Dooghs as well.

MATERIALS AND METHODS

In the present study, yoghurt, water, salt, water-soluble part of tragacanth gum (tragacanthin), raw rapeseed oil, raw soybean oil and fish oil have been utilized for the preparation of Omega-3 fatty acid enriched Doogh. Firstly, oil was blended with yoghurt and the mixture was homogenized by ultrasound. Afterwards, the mixture was added to water solution (salt and stabilizer) and the homogenization process was done by ultrasound again. Effects of ultrasound at different amplitudes and exposure times was determined in order to select the approporiate combination in which Doogh could be stabilized and be prepared well. For physical evaluation of enriched Doogh, phase separation level and presence or absence of oil on the surface of Dooghs was measured during storage at 5°C for 35-day at determined intervals. Furthermore, effect of various parameters such as storage temperature, thermal treatment and addition of antioxidant agent on physical stability and amount of peroxide value was evaluated in regular intervals during storage. Rheological characteristics of selected samples were studied using viscometric and oscillation tests (Azarikia and Abbasi 2010). Finally, the sensory properties of stabilized samples were evaluated using hedonic test after addition of natural essential oil.

RESULTS AND DISCUSSION

With reference to our findings, sonication at different amplitudes and exposure times was able to encapsulate as well as homogenize omega-3 fatty acids in enriched Doogh system. In addition, these samples showed excelent physical stability during storage period. It is to say that sonication energy could likely break down the oil droplets to smaller globules and the proteins which were in yoghurt could coat these globules and lead to the absence of oil on the surface of Doogh. Moreover, the presence of stabilizer possibly, due to electrostatic and steric repulsions, interacted between the oil globules encapsulated by proteins and physical stability extended.

Results from investigation of various factors on peroxide value of enriched Doogh showed that this parameter was increased for all samples during storage. Comparison of different combinations of amplitudes and sonication times showed no significant difference. The high oxidative stability of yoghurt depends on the presence of antioxidant peptides released during fermentation by lactic acid bacteria (Farvin 2010; Nielsen et al 2009).

In terms of thermal treatment (Table 1), presence of antioxidant (Table 2), and storage temperature (Table 3), our results showed that the first two parameters can not cause significant difference on peroxide value against control but there was a significant difference between the peroxide value for samples which were stored at refrigerated and ambient temperature. It should be noted that all the samples were physically stable (no phase seperation and oil drops on the surface) during storage.

Table 1: Effect of heat treatment on the peroxide value (meq/kg oil) of the omega-3 enriched Doogh

Type of heat treatment	Storage time (day)					
	0	7	14	21	28	35
Without heat treatment	0.26± 0.07 [a]	0.64± 0.07 [a]	0.61± 0.3 [a]	0.61± 0.12 [a]	0.74± 0.07 [b]	0.83± 0.35 [a]
Pasteurization	0.34± 0.02 [a]	0.4± 0.2 [a]	0.57± 0.08 [a]	0.67± 0.14 [a]	0.52± 0.05 [a]	2.00± 0.44 [b]

Table 2: Effect of antioxidant on the peroxide value (meq/kg oil) of the omega-3 enriched Doogh

Amount of antioxidant	Storage time (day)					
	0	7	14	21	28	35
Without antioxidant	0.26± 0.07 [a]	0.64± 0.07 [a]	0.61± 0.3 [a]	0.61± 0.12 [a]	0.74± 0.07 [b]	0.83± 0.35 [a]
50 ppm EDTA	0.38± 0.13 [a]	0.78± 0.08 [a]	0.87± 0.02 [a]	0.76± 0.08 [a]	0.46± 0.05 [a]	0.72± 0.23 [a]

Table 3: Comparison of the storage temperature effect on the peroxide value (meq/kg oil) of the omega-3 enriched Doogh

Storage temperature	Storage time (day)					
	0	7	14	21	28	35
5± 1Ċ	0.26± 0.07[a]	0.64± 0.07[a]	0.61± 0.3[a]	0.61± 0.12[a]	0.74± 0.07[a]	0.83± 0.35[a]
22±2Ċ	0.26± 0.07[a]	0.89± 0.04[b]	1.22± 0.05[b]	1.21± 0.11[b]	1.34± 0.04[b]	1.78± 0.05[b]

For prediction of flow behavior of enriched Doogh, correlation level of rheological data was evaluated with six mathematical models and the most approporiate models for control and samples containing fish oil (at 0.25, 0.5 and 1% w/w and without thermal treatment), werePower law and Sisco models, respectively. All the abovementioned samples showed non-Newtonian behavior and their viscosity decreased with increase of shear rate that is the characteristics of pseudoplastic fluids (Fig. 1). In addition, thermal treatment caused a considerable increase in viscosity as well as flow behavior. The thermal treatment not only affected the tragacanth and increased the viscosity, but also more likely caused to the formation of cross-links between encapsulated oil droplets (via whey proteins and caseins micells interaction) and consequentlya considerable increase in viscosity level. Based on visco-elastic characteristics, dominant behavior in samples without thermal treatment and samples with thermal treatment was viscous and elastic behavior respectively.

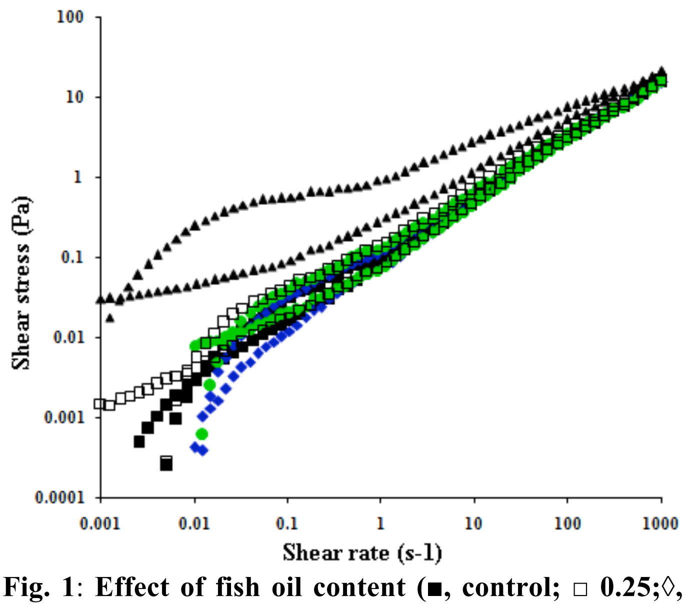

Fig. 1: Effect of fish oil content (■, control; □ 0.25;◊, 0.50; ○, 1.00w/w%) and heat treatment (▲, 1.00%) on the shear stress–shear rate curves at 10°C

Results of sensory evaluation of enriched doogh was indicative of significant difference between some samples and control for some characteristics such as taste and scent, consistency, color, smell and overall acceptence. Among samples including 0.25, 0.5% fish oil and samples including 1% mixture of fish oil with crude rapeseed oil or soy bean oil (50:50), sample with 0.25% fish oil had the highest acceptance. Noticeable point in this research was the low level of enrichement (0.25%) in this sample.

CONCLUSIONS

The results of this research showed the potential capability of ultrasound (sonication) on encapsulation and emulsification of ω-3 poly unsaturated fatty acids as well as stabilization of these nanocapsules in an acidic medium (doogh). In addition, ultrasound did not cause significant difference in peroxide value of samples at different amplitudes and exposure times. Moreover, thermal treatment and addition of antioxidant showed no significant effect on peroxide value but storage at ambient temperature considerably increased the peroxide value. According to this research, the most suitable rheological model for Dooghs including fish oil (1%w/w) with and without thermal pasteurization was power law and Scisco model, respectively. It should be noted that Dooghs enriched with 0.25% fish oil had the highest sensory acceptability.

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