Microencapsulation of pufa rich oil using pea protein and pectin

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INTRODUCTION

Oil rich in polyunsaturated fatty acids (PUFA) is functional food, which means that besides the nutritional functions, its consumption may have beneficial effects on health. On the other hand, one of the major problems associated with PUFA rich oils is their high susceptibility to oxidative deterioration and consequent production of undesirable flavor. Also, attempting to supplement foods with PUFA may lead to only limited success due to their low solubility in most food systems and excessive susceptibility to oxidation. Thus, there is a need to protect these oils in order to make them more stable during handling, processing and storage. This study aimed to evaluating the potential of pectin combination with pea protein isolate (PPI) in the microencapsulation of PUFA rich oil by spray drying, in order to maximize encapsulation efficiency and minimize lipid oxidation. The feed emulsions used for particle production were prepared consisting of PUFA rich oil droplets coated by either PPI (primary emulsion) or PPI/pectin (secondary emulsion).

MATERIALS AND METHODS

Materials

DHASCO single cell oil (40 % docosahexaenoic acid) was obtained from Martek Biosciences Corporation (Columbia, MD, USA). Powdered pea protein isolates (PPI) and maltodextrin DE 28 (MD 28) were obtained from Roquette-frères SA, (Lestrem, France). High methoxy pectin (degree of esterification ~ 60 %) was purchased from Sigma Chemical Co (Germany). All reagents were of analytical grade and used as received.

Preparation of emulsions An aqueous emulsifier solution containing 1.111 wt.% PPI was prepared by dispersing powdered pea protein isolate into imidazole/ acetate buffer (5 mM, pH 2.4 or 3). 10 wt.% of PUFA-rich oil was blended with 90 wt.% aqueous emulsifier solution at 17500 rpm . The resultant pre-emulsion was further homogenised at 500 using a high pressure homogeniser (TC5, Stanted Fluid Power LTD, UK). Imidazole/acetate buffer or pectin solution was slowly added. Finally, concentrated aqueous maltodextrin (DE 28) solution in the same buffer was, respectively, added to these emulsions to obtain primary (5 wt.% oil, 0.5 wt.% PPI, 11 wt.% maltodextrin) or secondary (5 wt.% oil, 0.5 wt.% PPI, 0.2 wt.% pectin, 11 wt.% maltodextrin) emulsions. The obtained emulsions containing were stored at room temperature overnight prior to spray-drying.

Particle size measurement and microencapsulation efficiency

Particle size distributions of parent and reconstituted primary and secondary emulsions were measured by a laser diffraction instrument (Malvern Mastersizer S, Malvern Instruments, Worcs., UK). The emulsion droplet size was expressed as d_{32}, the Sauter mean diameter. Non-encapsulated oil was determined by washing method with petroleum ether. The microencapsulation efficiency (ME) was calculated as follows:

$$\mathrm{ME} = \frac{\text{Total oil} - \text{Extractable oil}}{\text{Total oil}} \times 100$$

Oxidation tests and physical state

The chemical stability of the oil was evaluated by monitoring the formation of hydroperoxides and Thiobarbituric Acid Reactive Substances (TBARS) over the course of 8 weeks storage at 20 ± 1 °C and different relative humidities (11 %, 33 %, 57 % and 75 %). Scanning electron microscopy (Philips, FW 6800/70) was used to study the structures of the spray-dried emulsion powders. Differential scanning calorimetry (DSC, TA instruments Q1000-O506) was used to determine the glass transition temperatures (Tg) of the encapsulation matrices.

RESULTS AND DISCUSSION

The average volume-surface diameter, d_{32}, of the emulsion droplets stabilised by pea protein (1.576 ± 0.40 µm) increased in presence of pectin (2.836 ± 0.17 µm). During reconstitution, the original oil-in-water emulsion was not fully reformed and polydisperse systems were obtained for both dry primary (d_{32} = 2.373 ± 0.197 µm) and secondary (d_{32} = 3.323 ± 0.321 µm) emulsions. Flocculation occurred in the reconstituted emulsions and any changes observed in droplet size after reconstitution could be ascribed to effect of atomization, dehydratation and reconstitution (Gharsallaoui 2010).

Primary emulsion exhibited a better ME (83.34 %) than the secondary emulsion (77.52 %). Amount of extractable oil and thus ME depend on oil droplet size in liquid emulsions and the physical stability of the dispersed systems during drying and particle

formation. Soottitantawat et al. (2003) reported that the amount of surface oil increased with the increasing droplet size. The possible explanation was the breakdown of the large emulsion droplets during spray drying. The results obtained for encapsulation efficiency in the present study could therefore be related to the emulsions droplet size

Thermal analysis of dry emulsions at different RH showed glass transition temperatures from -11.8 °C to 83.5 °C for primary emulsion and from -7.6 °C to 77.5 °C for secondary emulsion (Table 1). Expectedly, glass transition temperatures decreased with increasing moisture content (Table 1). Glass transition temperatures of primary emulsion are slightly lower than those of the secondary emulsion except in the case of 75 % RH.

Table 1: *Tg* of dry primary (A) and secondary (B) emulsions at different RH

RH %	11	33	57	75
Tg °C (A)	83.49 ± 1.26	56.21 ± 0.04	22.75 ± 0.02	-11.82 ± 0.31
Tg °C (B)	77.47 ± 1.52	54.74 ± 0.954	20.76 ± 1.93	-7.62 ± 0.96

Figure 1 shows the SEM microstructures of emulsion powders. Microcapsules were spherical and smooth with some wrinkles or scars on the surface irrespective of drying conditions. The composition of the different wall materials influenced microparticles morphology. Pea protein/pectin/maltodextrins mixture resulted in microspheres with smoother surface and fewer teeth or roughness.

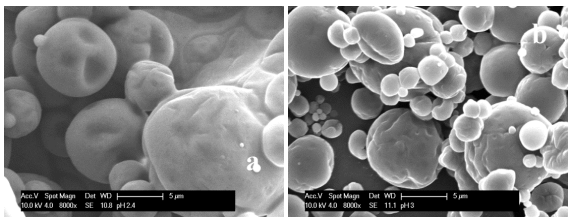

Figure 1: External microstructures of primary (a, b) and secondary (c, d) dry emulsions

The multilayer interfacial membrane on the dried emulsion droplets improved the oxidative stability of oil as indicated by both lipid hydroperoxide and TBARS formation (result not shown). A similar observation was reported by Serfert et al. (2013) for fish oil in β-lactoglobulin and β-lactoglobulin-pectin stabilized single and bilayered emulsions, respectively. Pectin may have formed with Pea protein a thick interfacial layer around the lipid droplets that sterically hindered the ability of the transition metal ions from reaching the encapsulated lipids. Powder oxidative stability was influenced by encapsulating materials. Although the pea protein/pectin mixture showed the lowest encapsulation efficiency, this combination presented at all times better oil protection against oxidation. Drusch and Berg (2008) showed that the differences in stability could only partly be explained by the varying amount of extractable oil. They concluded that the surface oil protects other fractions of the extractable oil and that the extractable oil cannot be used to predict shelf-life of microencapsulated oils.

CONCLUSION

Primary emulsion showed the best encapsulation efficiency result. On the other hand, in the oxidative stability study, the secondary emulsion performed better in protecting the active material against oxidation during storage.

According to the results, a mixture of PPI and pectin could be suggested as a better material for microencapsulation of PUFA rich oil than PPI alone. These results can have important implications for the development of new commercial products allowing to replace animal proteins and containing lipid phases susceptible to lipid oxidation.

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