Use of fibrillar β-lactoglobulin for microencapsulation of lipophilic ingredients by spray drying

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INTRODUCTION

Protein fibrils are gaining increasing attention for their use in e.g. food and/or material science (Jones & Mezzenga 2012; Kroes-Nijboer et al. 2012). The use of protein fibrils for preparation of template-induced hollow microcapsules via a layer-by-layer-approach with oppositely charged biopolymers was shown in literature (Sagis et al. 2008; Rossier-Miranda et al. 2010). Based on these studies, the present study aimed at investigating the use of fibrillar protein as a primary emulsifier for production of microencapsulated fish oil by spray drying.

MATERIALS AND METHODS

β-Lactoglobulin rich (~70%) whey protein isolate (WPI, Bipro, Davisco Foods International Inc., USA), glucose syrup solids (DE 38, C*Dry 01934; Cargill Deutschland GmbH, Germany) and fish oil (18/12 TG Gold, BASF Personal Care and Nutrition GmbH, Germany) were used.

Preparation of WPI fibrils was done according to the literature (Jung & Mezzenga 2009), but without dialysis and freeze drying. Fibrils were produced based on 2.5w% WPI solutions. After removal of denatured protein and filtration, pH was adjusted to 2.0. Solutions were heated at 90°C for 5 hours. Imaging of fibrils was done using AFM in tapping mode. Emulsions were based on 45% dry matter and contained 1% protein (native vs. fibrils) and 18% oil. Homogenization was done at 40 MPa. Emulsions were spray-dried on a lab-scale spray dryer at 180/70°C inlet/outlet temperature. Oil droplet sizes were measured by static light scattering. Micro-encapsulation efficiency was determined via solvent extractable oil content. Oxidative stability of encapsulated oil at 20°C and 33% RH (dark) was analyzed via thiocyanate hydroperoxide content after oil extraction.

RESULTS AND DISCUSSION

Preparation of fibrils and their fate during processing

In heated WPI solutions, the initial length of WPI fibrils was up to ~ 10 µm. Emulsification (dispersing and homogenizing) of fibrillar WPI solutions resulted in fibril breakdown. After homogenization, regular sized fragments of 80 – 90 nm length were observed by AFM. As recently shown by Oboroceanu et al. (2011) fibril breakdown is accompanied by a change in secondary structure.

Microencapsulation efficiency

Emulsifying activity and microencapsulation efficiency of fibrillar WPI were compared to native WPI. Fibrillar WPI had a slightly better emulsifying activity than native WPI at the pH studied. The higher interfacial activity of non-dialysed fibrils compared to native monomers were reported before (Jung et al. 2010). In the present study, microencapsulation efficiency was also higher in microcapsules based on fibrillar WPI (>95%) than based on native WPI (~90%).

Oxidative stability

The oxidative stability of fish oil was higher in microcapsules prepared with WPI fibrils than in microcapsules with native WPI (Table 1).

Table 1: Development of the hydroperoxide content during storage of microcapsules at 20°C and 33% rh

	Hydroperoxide content [mmol/kg oil]	
Storage time	*WPI native*	*WPI fibrils*
initial	5.6 ± 0.2	5.0 ± 0.3
2 weeks	25.2 ± 2.9	13.3 ± 1.7
4 weeks	86.0 ± 5.1	52.6 ± 2.4

This can be partly attributed to differences in microencapsulation efficiency. It is well established that a high amount of extractable oil favours oxidation of microencapsulated ingredients.

CONCLUSIONS

Application of mechanical stress leads to breakdown of fibrillar protein structures changing their initial physical dimensions. However, the results of the present study clearly showed that functionality (microencapsulation efficiency and oxidative stability) of spray-dried fish oil emulsions can be enhanced by use of WPI fibrils in comparison to native WPI at acidic pH conditions. Further studies should aim at interfacial engineering by using the layer-by-layer approach.

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