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ScienceDirect
Food Hydrocolloids 21 (2007) 1223–1228
FOOD HYDROCOLLOIDS
www.elsevier.com/locate/foodhyd

Short communication

Sugar beet pectin: A novel emulsifying wall component for microencapsulation of lipophilic food ingredients by spray-drying

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Received 22 June 2006; accepted 4 August 2006

Abstract

Fish oil rich in long-chain polyunsaturated fatty acids was microencapsulated in a matrix of sugar beet pectin and glucose syrup. In two emulsification experiments, composition and homogenisation conditions were optimised for preparation of a stable feed emulsion for spray-drying. The median of the oil droplet size was significantly influenced by the composition of the emulsion as well as homogenisation pressure, but not by the number of passes. With a median of the oil droplet size below 2 μm and a maximum viscosity of 179 mPa s, suitable emulsions could be produced with up to 50% oil and 2.2% sugar beet pectin. Physicochemical parameters like particle morphology, particle size and extractable fat generally reflect a good microencapsulation efficiency and therefore indicate a good oxidative stability. However, the proportion of non-encapsulated fat was higher in samples with 50% oil compared to samples with 20% oil and may limit the maximum oil load of the microcapsules.

Keywords: Microencapsulation; Fish oil; Composition; Homogenisation; Particle properties

1. Introduction

Among the different techniques for microencapsulation of functional food ingredients, spray-drying is the most common technique applied in the food industry as it is rather inexpensive and straightforward (Gouin, 2004). For microencapsulation of lipophilic food ingredients, the wall material usually consists of an emulsifying agent and a low-molecular weight carbohydrate compound as a bulk agent. One limitation of the spray-drying technique is the limited number of wall materials available (Desai & Park, 2005). The authors furthermore emphasise that the development of alternative and inexpensive polymers that may be considered natural, like gum Arabic, and that could encapsulate e.g. flavours with the same efficiency than gum Arabic are an area of research of increasing interest. Gum Arabic has been described as the standard of excellence for microencapsulation (Buffo & Reineccius, 2000; Finney, Buffo, & Reineccius, 2002), however, due to its rather low protein content high concentrations of about 15–25% are generally used for emulsification (Leroux, Langendorff, Schick, Vaishnav, & Mazoyer, 2003). E.g. the authors required 15% of gum Arabic for emulsification of 20% rapeseed or orange oil.

In this context sugar beet pectin must be regarded as a promising alternative as emulsifying wall material for microencapsulation. The high content of acetyl groups in sugar beet pectin is responsible for its poor gelling properties (Michel, Thibault, Mercier, Heitz, & Pouillaude, 1985), but acetyl groups support emulsion stability by reducing calcium bridging flocculation (Leroux et al., 2003). The protein associated with the pectin amounts up to 10.6% and plays a key role in emulsion stabilisation (Leroux et al., 2003). Williams, Sayers, Viebke, and Senan (2005) showed that not only protein content, but also accessibility to the protein and ferulic acid groups, the proportion of ester groups and the molecular mass influence the emulsification properties of sugar beet pectin. Aim of the present study was to investigate the physico-chemical characteristics of fish oil microencapsulated in a matrix of sugar beet pectin and glucose syrup to provide an

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doi:10.1016/j.foodhyd.2006.08.007

alternative encapsulating agent to milk proteins or gum Arabic for microencapsulation of functional food ingredients.

2. Materials and methods

Sugar beet pectin was provided by CPKelco, Großenbrode, Germany. According to the manufacturers specification, degree of acetylation was min. 18%, degree of esterification approximately 58% and protein content approximately 5%. As bulk agent, glucose syrup with a dextrose equivalent of 38 (C*Dry GL 01934, Cargill Deutschland GmbH, Krefeld Germany) was used. Cold-pressed refined fish oil containing approximately 33% *n*-3 fatty acids was supplied by Henry Lamotte GmbH, Bremen, Germany. The concentration of the long-chain polyunsaturated fatty acids eicosapentanoic acid and docosahexanoic acid was 18% and 12.3%, respectively.

In two subsequent experiments, the dependency of oil droplet size and emulsion viscosity from oil and sugar beet pectin content, dry matter content of the emulsion, homogenisation pressure and number of passes was investigated. Both emulsification experiments were planned and analysed using Design Expert, Version 6.0.10 (Stat Ease Inc, Minneapolis, USA). A two-level full-factorial design was chosen. Power at 5% alpha level for effect of twofold standard deviation was 94.9%. Constants and regression coefficients of the multiple linear regression equation in terms of coded factors and probability values are reported. Based on these data two levels of pectin and oil content were defined for spray-drying experiments and their impact on physicochemical properties of spray-dried microcapsules was determined.

For homogenisation of the emulsions, a high-pressure homogeniser (Panda 2k, Niro Soavi Deutschland, Lübeck, Germany) was used. Spray-drying was performed on a laboratory scale spray-dryer (7 kg/h water evaporative capacity, Mobile Minor, Niro A/S, Denmark) equipped with a rotating disk for atomisation. Table 1 gives an overview on the experimental conditions of the emulsification and spray-drying experiments.

Viscosity of the emulsions was determined within 2 h after preparation after cooling to room temperature using a rotational viscometer (Haake Viscotester 7L, Thermo Electron Corporation, Dreiech, Germany). Oil droplet size of the emulsions, particle size of the microcapsules and oil droplet size of the reconstituted microcapsules were determined using a laser-diffraction sensor (Helos, Sympatec GmbH, Clausthal-Zellerfeld, Germany) equipped with a cuvette. Oil droplet size of the emulsions was determined after dilution of the sample with water to an optical density of 15%. For analysis of the oil droplet size of the microcapsules, an aliquot of powder (approximately 100 mg) was reconstituted with water, again, until an optimum optical density of 15% was reached. Particle size analysis of the microcapsules was performed after dispersing an aliquot of the powder in an inert oil (Miglyol 812, Sasol Germany, Hamburg, Germany).

Table 1
Overview on the experimental conditions for the emulsification and spray-drying experiments

Experiment/factor	Unit	Low level (−1)	High level (+1)
Emulsification experiment 1[a]			
Oil content	% dry matter	20	50
Pectin content	% dry matter	1.1	2.2
Dry matter	%	30	45
Emulsification experiment 2[b]			
Oil content	% dry matter	20	50
Homogenisation pressure	bar	200/50	500/100
Number of passes		2	4
Spray drying experiment[c]			
Oil content	% dry matter	20	50
Pectin content	% dry matter	1.1	2.2

[a]Fixed parameters: homogenisation pressure (200/50 bar); number of passes (2).
[b]Fixed parameters: pectin content (1.1% dry matter); dry matter content (45%).
[c]Fixed parameters: dry matter content (45%), homogenisation pressure (200/50); number of passes (2), spray-drying temperature (170/70 °C).

A Leo S420 scanning electron microscope (Oberkochen, Germany) was used to view and describe the characteristics of the microcapsules. BET analyses was performed using a Gemini 2360 (Micromeritics, Mönchengladbach, Germany). True density of the powder particles was determined using a helium pycnometer (Pycnomatic, Thermo Electron Corporation, Dreiech, Germany). Flow cleaning time was set at 60 s, five cleaning cycles of 20 s were run and atmosphere stabilisation time was set at 30 s. Each sample was analysed three times. The result of each of the three analyses was accepted if standard deviation of five measurements was below 0.5%. Analysis of bulk density (tapped and untapped) was performed as described in the European Pharmacopoeia (European Pharmacopeia, 2002).

The amount of extractable fat in the microcapsules was determined gravimetrically after extraction of the fat from 2 g sample on a lab shaker for 15 min using petrol ether. The method is in good agreement with a reference method for determination of free fat in dried milk products including extraction of the fat in a Soxhlet apparatus. (Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten, 1985).

3. Results

In the first emulsification experiment, viscosity of the fish oil emulsion ranged from 14 to 179 mPa s for the sample