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Obtention of dietary fibre enriched fractions from peach bagasse using ethanol pre-treatment and microwave drying

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ABSTRACT

A process involving ethanol pre-treatment and subsequent microwave drying was proposed to obtain fractions enriched in dietary fibre from peach bagasse *Prunus persica* L. The processing conditions that allow to obtain samples with optimal functional properties involved the use of 4.6 mL of ethanol (96 mL/100 mL) per gram of tissue in the extraction step performed at 20 °C for 15 min and a temperature of 55.0 °C for drying in a microwave equipment working at a maximum power of 450 W. In general, high values were observed for functional properties evaluated, fact that indicates the potential of the fractions for being used for technological as well as for nutritional purposes. Physicochemical and microstructural analysis were carried out for the product obtained with the optimal process conditions, observing that the concentration of cell wall material was 80 g/100 g dry fraction and the optimum fraction also contained phenolic compounds.

1. Introduction

In Argentina, peach production for industrial use was close to 156 Gg in 2012. The waste generated from the processing and/or non-standard quality, historically has reached 5–8% of total production, according to the Ministry of Agriculture, Livestock and Fisheries of Argentina (2012). Non-standard fruits and also wastes from processing can be used for the obtention of fractions enriched in dietary fibre (DF), contributing to diminish environmental impact and improving the economic efficiency of the production chain.

Dietary fibre (DF) consists of the plant polysaccharides and lignin which are resistant to hydrolysis by digestive enzymes of man. This definition defines a macro constituent of foods which includes cellulose, hemicellulose, lignin, gums, modified celluloses, mucilages, oligosaccharides and pectins and associated minor substances such as waxes, cutin and suberin (McCLeary et al., 2011).

The DF functional properties are related to the composition, physicochemical properties and chemical structure of the plant polysaccharides (Guillon & Champ, 2000). Processes such as drying can alter the physicochemical properties of the original products, thus modifying the functional properties of fibre fractions (Femenia, Bestard, Sanjuan, Roselló, & Mulet, 2000). De Escalada Pla et al. (2012) reported the effect of air drying and freeze drying on functional and physicochemical properties of DF obtained from peach Calred variety.

Drying is one of the most time and energy consuming processes in food industry. New techniques are permanently investigated for reducing drying time and energy consumption without affecting quality. During the past two decades, there has been an increasing interest in microwave drying because it has several advantages such as faster drying rates, shorter drying times, decreasing energy consumption and improved quality of final products (Raghavan et al., 2005). According to Murthy and Prasad (2005), the key features in the use of microwave heating is that the temperature and moisture gradients are in the same direction, being opposite to conventional heating where moisture should leave the matter against the temperature gradient. In previous works authors

Abbreviations: a_W, water activity; DF, Dietary fibre; RSM, Response surface methodology; RW, Retained water; SC, Swelling capacity; WHC, Water holding capacity; WRC, Water retention capacity; WSF, Water soluble fraction; OHC, Oil holding capacity.

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realized that an ethanol treatment step prior drying enhanced functional properties of dietary fibre (De Escalada Pla, Uribe, Fissore, Gerschenson, & Rojas, 2010; De Escalada Pla et al., 2012; De Escalada Pla, Eim, Roselló, Gerschenson, & Femenia, 2015). Moreover, preliminary studies showed that the factors that most influenced the functional properties of DF when ethanol treatment was used along with microwave drying for its obtention, were ethanol/sample ratio and drying temperature (Sette, Latorre, Soria, de Escalada Pla, & Gerschenson, 2011). Microwave drying also has been contemplated in the drying up process of carrots pomace and of oranges peel and leaves according to Bejar, Kechaou, and Mihoubi (2011) and Hernández-Ortega, Kissangou, Necoechea-Mondragón, Sánchez-Pardo, and Ortiz-Moreno (2013) respectively. In the literature there is no study, to our knowledge, analysing the effect of ethanol treatment step combined with microwave drying when they are applied for the obtention from *Prunus persica* of fractions enriched in dietary fibre.

The aim of this study was to find through the response surface methodology, the ethanol/sample ratio and the microwave drying temperature that allow obtaining fractions enriched in DF with optimal yield and properties when processing involves an ethanol treatment step previous to drying. Physicochemical and also microstructural analyses were carried out on the products obtained with the optimal process conditions in order to complete their characterization.

2. Materials and methods

2.1. Materials

2.1.1. Chemicals

Deionized water (MilliQ™, USA) was used for all assays. Ethanol used was of USP grade. Chemicals were of analytical grade and, in general, provided by MERCK Argentina (Buenos Aires, Argentina) unless stated. All reagents used as standards for calibration curves were provided by SIGMA-Aldrich (St Louis, MO).

2.2. Methods

2.2.1. DF enriched fractions preparation

The fractions were obtained from peaches (*P. persica* L.) Jungold variety, from which stone was separated and juice was extracted. Residual peel and pulp were milled and subjected to a treatment with ethanol (96 mL/100 mL) under continuous homogenization (Sorvall Omni Mixer, USA), at 20.0 °C for 15 min. Subsequently, the mixtures were filtered and the filtrate was dehydrated using an Ethos Plus microwave equipment (Milestone, Italy) operated at a maximum power of 450 W. A drying program based on a 1 min ramp was used to reach the desired temperature and it was followed by heating at a constant temperature.

Weight loss was recorded for drying intervals of 2.5 min plus one minute of ventilation and drying was performed till the water activity of the fractions was lower than 0.6 and constant weight was attained (Muggeridge & Clay, 2001). Sample temperatures during drying step as well as ethanol/sample ratio during treatment previous to drying varied according to an experimental design (Table 1).

The fractions obtained were milled and sieved through a mesh ASTM 40 to obtain particles of sizes below 420 μm. Samples of each system, were vacuum packed in Cryovac ™ bags (Sealed Air Corporation, Argentina) and stored at −18 °C until its characterization.

2.2.2. Evaluation of fraction functional properties

Water retention capacity (WRC), retained water (RW), water holding capacity (WHC), swelling capacity (SC) as well as oil holding capacity (OHC) were determined as previously described by De Escalada Pla et al. (2010). All determinations of the properties studied were performed in triplicate.

The water soluble fraction (WSF) of DF was determined on the supernatant of the WRC determination after its freeze drying. The WSF was calculated as:

$$WSF\ (\%) = \frac{M_1}{M_2} \times 100$$

where M_1 is the mass of solids in the freeze dried supernatant and M_2 is the mass initially weighed of DF fraction on dry basis.

2.2.3. Yield and physicochemical characterization of the fractions

The determinations were performed, at least, in duplicate.

2.2.3.1. Yield evaluation. The percent yield of DF enriched fractions was determined as the ratio between mass of DF fraction obtained after the microwave drying and mass of peach bagasse (peel and pulp) used.

2.2.3.2. Apparent density. It was determined by measuring the volume of a weighed sample (≈2.0000 g) in a 5 mL graduated and calibrated tube (Chau, Wang, & Wen, 2004).

2.2.3.3. Particle size. The size distribution of DF particles was determined using laser light scattering (Mastersizer 2000E view. 5.20, Malvern, Worcestershire, UK), according to Guillon, Auffret, Robertson, Thibault, and Barry (1998).

2.2.3.4. Moisture content and water activity. Moisture was determined on ≈0.5 g samples by using infrared heating (Ohaus MB45

Table 1
Measured responses for central composite design.

Ethanol/sample ratio (mL/g)	Drying temperature (°C)	WRC (g/g)	RW (g/100 g)	WHC (g/g)	SC (mL/g)	OHC (g/g)[1]	Specific volume (mL/g)	Yield (g/100 g)	WSF (g/100 g)
5.0	70.0	19.1 ± 0.7	46 ± 2	31 ± 2	25.4 ± 0.4	1.46 ± 0.02	2.30 ± 0.01	5.3 ± 0.2	14 ± 1
5.0	50.0	23 ± 1	58 ± 2	41 ± 2	33 ± 1	1.7 ± 0.1	2.30 ± 0.04	5.1 ± 0.2	14 ± 3
3.0	70.0	21 ± 2	49 ± 2	36.7 ± 0.2	29.35 ± 0.04	1.89 ± 0.02	2.82 ± 0.01	5.9 ± 0.2	12 ± 1
3.0	50.0	17.3 ± 0.9	44 ± 3	37.4 ± 2.2	26.4 ± 0.8	1.22 ± 0.06	2.03 ± 0.01	5.2 ± 0.2	16 ± 2
4.0	60.0	23.5 ± 0.2	53.5 ± 0.5	36.1 ± 0.8	30 ± 2	1.75 ± 0.02	2.73 ± 0.01	6.2 ± 0.2	12 ± 1
4.0	40.0	19 ± 1	49 ± 2	38 ± 1	25 ± 1	1.25 ± 0.03	2.06 ± 0.02	5.0 ± 0.2	13 ± 2
4.0	80.0	22.3 ± 0.7	56 ± 1	35.1 ± 0.4	28.6 ± 0.2	1.77 ± 0.03	2.44 ± 0.04	5.3 ± 0.2	11 ± 1
2.0	60.0	20 ± 2	44 ± 2	34 ± 1	21.6 ± 0.5	1.24 ± 0.03	2.56 ± 0.01	7.3 ± 0.2	18 ± 2
6.0	60.0	21 ± 1	51.6 ± 0.2	36 ± 1	29.2 ± 1	1.32 ± 0.08	2.02 ± 0.01	5.7 ± 0.2	14 ± 2
4.0	60.0	22.2 ± 0.5	53 ± 2	34 ± 2	31.5 ± 0.6	2.05 ± 0.03	2.85 ± 0.02	6.5 ± 0.2	12 ± 2
4.0	60.0	22.1 ± 0.7	55 ± 2	35 ± 2	32.1 ± 0.7	1.98 ± 0.09	2.85 ± 0.01	5.9 ± 0.2	10.2 ± 0.6

Responses are informed as the mean and standard deviation (n = 3).
WRC: Water retention capacity, RW: Percentage of water retained, WHC: Water holding capacity, SC: Swelling capacity, OHC: Oil holding capacity, WSF: Water soluble fraction.