Food Bioscience 8 (2014) 33–36

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/fbio

Processing and bread-making potential of proteins isolated from malted and non-malted pea seeds by ultrafiltration/diafiltration

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ARTICLE INFO

Article history:
Received 4 June 2014
Received in revised form
9 October 2014
Accepted 20 October 2014

Keywords:
Yellow peas
Protein isolate
Germination
Malting
Ultrafiltration/diafiltration
Bread

ABSTRACT

The bread-making potential of a pea protein isolate produced by an ultrafiltration/diafiltration (UF/DF) process applied to malted seed has not been studied, to date. Thus, the objective of this work was to study the impact of supplementing breads, at a 10% level, with malted pea protein isolate produced by an UF/DF processes with a 50 kDa hollow fibers membrane. Malted pea protein isolate with approximately 90% of protein (dry basis) was obtained. Flour substituted with this isolate showed good bread-making potential allowing the production of bread with protein content over 20%, which was comparable to the protein content obtained for bread produced from non-malted pea protein isolate. The bread produced from malted pea protein isolate had a specific volume of 3.9 ± 0.1 cm^3 g^{-1} which was slightly lower than for the one produced from non-malted pea protein isolate (4.4 ± 0.1 cm^3 g^{-1}) but comparable to the control bread produced from 100% refined bread flour (4.2 ± 0.1 cm^3 g^{-1}). Color (L^*,a^*,b^*) of the crust and of the crumb of breads produced from UF/DF isolates was barely affected by the malting process but slightly differed from the color of bread produced from 100% refined bread flour.

1. Introduction

Fortifying wheat breads with pea flours or isolates to improve their nutritional value has received considerable interest (Morad, Leung, Hsu, & Finney, 1980; Hsu, Leung, Finney, & Morad, 1980; Hsu, Leung, Morad, Finney, & Leung, 1982; Sadowska, Blaszczak, Fornal, Vidal-Valverde, & Frias, 2003; Des Marchais, Foisy, Mercier, Villeneuve, & Mondor, 2011; Mondor, Guévremont, & Villeneuve, 2014). The impact of fortification is dependent on the pea processing and on the level of substitution. Generally, the substitution of wheat flour with pea-based ingredients at a level of more than 10% is harmful to the processing of bread (Sadowska et al., 2003).

A process that has been investigated in past studies is the germination (or malting) of peas prior to the preparation of pea flours (Sadowska et al., 2003; Mondor et al., 2014) or pea isolates (Hsu et al., 1982). It has long been recognized that germination generally enhances the nutritive value of seeds (Hübner and Arendt, 2013) and would thus result in flours/isolates with improved nutritional value. It was also

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http://dx.doi.org/10.1016/j.fbio.2014.10.004
2212-4292/

demonstrated that germinated or malted pea flours can be successfully incorporated into breads, at a level of 10%, without major defects to the bread structure (Sadowska et al., 2003; Mondor et al., 2014). However, in the two aforementioned studies, the improvement of the breads in terms of protein content remained limited. On the other hand, the incorporation of pea protein isolate produced from germinated pea (and from non-germinated pea) into breads, at a level of 8%, had negative effects on bread volume (Hsu et al., 1982). However, no significant difference was observed in terms of loaf volume between the bread substituted with germinated pea protein isolate and the one substituted with non-germinated pea protein isolate, indicating that the detrimental effect of substitution is not attributable to the germination process but to the processing of peas into protein isolates (Hsu et al., 1982).

It is well known that the production of plant protein isolates at industrial scale by isoelectric precipitation, and as it was the case in the study of Hsu et al. (1982), results in protein denaturation due to the use of acids during the precipitation step. This will in turn negatively impact the functional properties of the protein isolate (Petruccelli & Anon, 1994; Wagner, Sorgentini, & Anon 2000; Taherian et al., 2011). One possible explanation for the detrimental effect observed by Hsu et al. (1982), on the loaf volume, when substituting breads at 8% level with pea protein isolates is that the denatured proteins would be less prone to take part in the formation of bread structure, which would negatively impact its specific volume.

In a recent work, it was demonstrated that pea protein isolates produced by an ultrafiltration/diafiltration (UF/DF) process have significantly better functional properties than commercial pea protein isolates produced by isoelectric precipitation (Taherian et al., 2011). The good bread-making potential of this isolate, at a level of 10%, was also confirmed (Des Marchais et al., 2011). To our knowledge, the bread-making potential of pea protein isolates produced by an UF/DF processes applied to malted seed has not been studied to date. Nevertheless, even at a substitution level of 10%, it would allow the production of breads with improved nutritional value and with protein content significantly higher than when flours are used for substitution. Thus, the objective of this work was to study the impact of supplementing breads, at a 10% level, with pea protein isolate produced by an UF/DF processes from malted yellow peas.

2. Materials and methods

2.1. Raw materials

Refined bread flour (Robin Hood KEYNOTE 80 Bleached Enriched Flour; Horizon Milling, Montreal, Quebec, Canada) was used. Certified #1 Eclipse yellow peas were purchased from Wagon Wheel Seed Corporation (Churchbridge, SK, Canada). Commercial pea protein isolate was obtained from Nutri-pea Limited (Portage La Prairie, MB, Canada) and used as control.

2.2. Malting process and production of pea protein isolates by UF/DF

The malting procedure previously described in Mondor et al. (2014) was used in this study. The brittle acrospires of dry peas were removed by sieving and the peas were processed into flours as previously described (Mondor et al., 2014). Then, isolates were produced by extracting pea flours produced from non-malted and malted yellow peas, in water with 1:15 w/w solid/liquid ratio at room temperature and pH 7.5 for 1.25 h. Extracts were purified by UF/DF processes performed with a 50 kDa hollow fibers membrane, by applying a volume concentration ratio of 5, in order to obtain protein isolates, as previously described by Taherian et al. (2011). A 50 kDa membrane was selected based on the work of Fuhrmeister and Meuser (2003) who demonstrated that the most favourable combination of permeate flux and pea protein yield in economic terms is achieved at that cut-off. A 50 kDa membrane was also used by Frederickson, Biot, Alminger, Carlsson, and Sendberg (2001) for the production of high quality pea protein isolate. The resulting pea protein isolates were lyophilized and placed in aluminium pouches which were hermetically sealed and stored at 4 °C until used. Ash and protein contents of the flours and isolates were measured based on the methods provided by Taherian et al. (2011).

2.3. Bread preparation

Bread was prepared according to AACC International Method 10–10.03 applying the 100 g-flour procedure. Water absorption of 62.5% and mixing time of 7 min were applied. Three different breads, such as bread made using pea protein isolates produced by UF/DF from non-malted peas (NMPB), bread made using pea protein isolates produced by UF/DF from malted peas (MPB) and bread made using commercial pea protein isolates (CPB), were prepared in duplicate with refined bread flour substituted at a 10% level (dry basis) with the pea protein isolates. Control bread was also made using 100% refined bread flour. After the cooling period (1 h after removal from the oven), the breads were weighed and their volume was determined by rapeseed displacement (National Mfg, Co., Lincoln, Nebraska, U.S.A.). The specific volume was then calculated by dividing the volume of the bread by its mass. Color measurements of crust and crumb were performed using a Minolta colorimeter model CR-300 (Konica Minolta Sensing Americas, Ramsey, NJ, U.S.A.). Measurements were done in a light testing box (Macbeth, The Judge II, Grand Rapids, MI, USA) under "day" light intensity. Results are expressed in terms of the Hunter colour system L^* (blackness to whiteness), a^* (greenness to redness) and b^* (blueness to yellowness). Bread crumb was dried in a vacuum oven at 92 °C for 16 h and protein content was determined using a Kjeldahl digestion system (Tecator, Höganäs, Sweden) and a conversion factor of $N \times 6.25$ for peas and $N \times 5.7$ for refined wheat flour.

2.4. Statistical analysis

Analysis of variance was performed *a priori* on each parameter using SAS software (version 8.2, SAS Institute Inc. Cary, NC, USA). Multiple comparison procedure (Least Significant