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Addition of pin-milled pea flour and air-classified fractions in layer and sponge cakes

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A B S T R A C T

Legumes have interesting nutritional properties and many organizations, such as the World Health Organization, encourage their inclusion in the diet; their incorporation into bakery products could be a good method for increasing consumption. The aim of this study was to examine the addition of different percentages of pin-milled pea flour or its air-classified protein and starch fractions to sponge and layer cakes. Specific volume, pH and viscosity were measured in batters and specific volume, shape and texture in cakes. Evaluation through sensory analysis in a consumer test was performed after exclusion of the poorest cakes. Pin-milled pea-flour and starch-fraction cakes had similar specific volumes and firmness to wheat-flour cakes with substitution of up to 50% of the wheat flour in sponge cakes and up to 25% in layer cakes. In contrast, protein produced a lower cake specific volume and increased firmness at lower substitution percentages. Sensory acceptability decreased with increasing substitution percentages, and this was more pronounced in layer cakes. In sponge cakes, evaluations were similar to controls after substitution of 25% of the wheat flour by starch concentrate.

1. Introduction

Legumes have been identified as low-glycaemic-index foods (Bornet, Billaux, & Messing, 1997). Selecting foods with a low glycaemic index is very important in the dietary treatment of diabetes mellitus. In healthy subjects, these foods increase satiety, facilitate the control of food intake and have other health benefits in terms of postprandial glucose and lipid metabolism (Rizkalla, Bellisle, & Slama, 2002). Most health organizations encourage frequent consumption of legumes (Leterme, 2002), and this could be facilitated if the food industry and professional organizations take up the challenge to incorporate grain legumes in novel, convenient and healthy food products (Schneider, 2002). The addition of legumes into cereal-based products could be a good alternative for increasing their intake.

Pin-milled and air-classified peas yield protein and starch concentrates containing 34 g/100 g–60 g/100 g and 4 g/100 g–11 g/100 g protein, respectively (Reichert, 1982). The protein concentrate or thin fraction is also richer in lipids, fibre and ash than the starch concentrate or thick fraction (Sosulski, Walker, Fedec, & Tyler, 1987). It is also richer in oligosaccharides such as α-galactosides, responsible for flatulence (Sosulski, Elkowicz, & Reichert, 1982). Apart from the differences in composition, the fractions also differ in their nutritional properties, such as water-holding capacity, emulsifier properties, oil-holding capacity and pasting properties (Han & Khan, 1990; Horvath, Ormai-Cserhalmi, & Czukor, 1989; Sosulski, Hoover, Tyler, & Murray, 1985). These differences mean that the two fractions have different applications. Research into the addition of air-classified legume flour into bakery and cereal products has focused on pasta (Nielsen, Sumner, & Whalley, 1980), bread (Silaula, Lorimer, Zabik, & Uebersax, 1989) and doughnuts (Spink, Zabik, & Uebersax, 1984) and has only employed the protein concentrate.

Wheat-flours used in cake elaboration have lower protein content, and it is known that one of the most important characteristics of cake elaboration flours is particle size (Gaines, 1985; Gomez, Ruiz-Paris, & Oliete, 2010b; Yamazaki & Donelson, 1972). Gluten does not play an important role in this kind of product, which means that flours from other cereals (Oliete et al., 2010; Ronda, Gomez, Caballero, Oliete, & Blanco, 2009; Turabi, Sumnu, & Sahin, 2008) or even from pulses, such as chickpeas (Gomez, Oliete, Rosell, Pando, & Fernandez, 2008) can be used. Fractions achieved in the pin-milling of peas could be an alternative to wheat flours in cake making, particularly the starch concentrate, due to its low protein content and small particle size.

The aim of this study was to investigate the suitability of pin-milled pea flour, particularly the starch fraction, as an alternative to wheat flour in cake making (layer and sponge cakes).

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2. Materials and methods

2.1. Materials

Wheat flour (10.9 g/100 g moisture; 8.98 g/100 g protein; 63.12 μm mean particle size) was supplied by Harinera Castellana S.A. (Medina del Campo, Valladolid, Spain). Pin-milled pea flour (10.9 g/100 g moisture; 22.23 g/100 g protein; 17.42 μm mean particle size) was supplied by Esteve Santiago S.A. (Cabezón de Pisuerga, Valladolid, Spain) and included two air-classified fractions: thick fraction, starch concentrate (11.5 g/100 g moisture; 10.19 g/100 g protein; 24.08 μm mean particle size) and thin fraction, protein concentrate (10.8 g/100 g moisture; 51.52 g/100 g protein; 9.58 μm mean particle size). The pasting properties of the different flours are shown in Fig. 1. Sugar, sunflower oil, milk and liquid pasteurized egg were purchased from the local market. Baking powder was 25 × 1, and whipping aid agent was SuperMixo T500, both supplied by Puratos (Gerona, Spain).

2.2. Methods

AACC methods (2010) were used to analyse the wheat and pea flours for moisture (method 44-15A) and protein (method 46-30); the protein analysis was carried out with a Leco TruSpec®N elemental determinator (St. Joseph, Michigan).

Particle size was analysed with the HELOS & RODOS laser diffraction spectrometer (Sympatec Inc. Clausthal-Zellerfeld, Germany) running *Windox 5* software.

Pasting properties of flours were analysed using the standard method with a Rapid Visco® Analyser (RVA-4) (Newport Scientific Pty Ltd., Warriewood, Australia) (method 61-02, AACC, 2010), controlled by *Thermocline for Windows* software (Newport Scientific Pty. Limited, Warriewood, Australia).

2.2.1. Cake making

Layer cakes were elaborated using the following the formula based on flour weight: 350 g flour, 315 g sugar, 210 g milk, 175 g liquid pasteurized egg, 105 g sunflower oil, and 10,5 g baking powder. A single-bowl mixing procedure was used to prepare the batter. All ingredients were mixed for 10 min (speed 4 for 1 min and speed 6 for 9 min) using a Kitchen-Aid Professional mixer (Kitchen Aid, St. Joseph, Michigan). Cake batter (185 g) was placed into disposable oil-coated aluminium pans (109 × 159 × 38 mm) and the cakes were baked in an electric oven for 25 min at 185 °C.

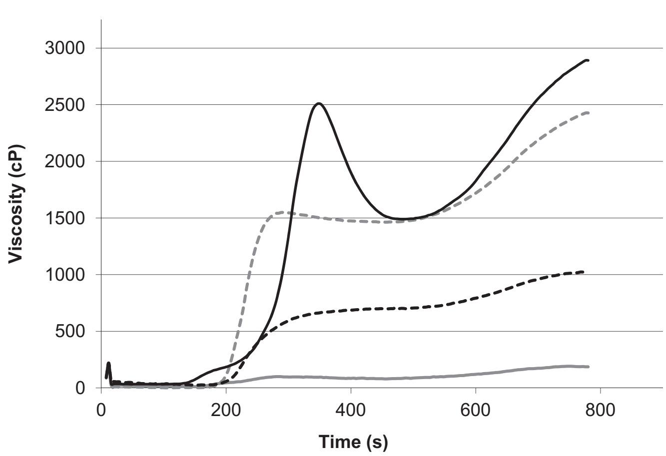

Fig. 1. Rapid Visco™ Analyser pasting curves of wheat and pea flour and its fractions. Legend: (– – ·) Starch Fraction; (——) Protein Fraction; (**– –** ·) Pin-milled pea-flour; (**——**) Wheat control.

The sponge cake formula was also based on flour weight: 245 g flour, 240,5 g sugar, 344 g liquid pasteurized egg, 55 g water, 14 g whipping aid agent, and 25 g powdered milk. A creaming-mixing procedure was used. All ingredients, except for the flour and milk were mixed for 2 min at speed 6 using a Kitchen-Aid Professional mixer (Kitchen Aid, St. Joseph, Michigan). After addition of the milk and flour, the mixing process was continued for 3 min at speed 8. Cake batter (140 g) was placed into oil-coated aluminium pans (109 × 159 × 38 mm) and baked as described above.

After baking, cakes were removed from the pans and left to cool for 50 min before being placed in coded plastic bags that were sealed to prevent drying.

Wheat flour was substituted by pea flour in accordance with the experimental design, giving 18 formulations for each type of cake: control (wheat flour), substitution by pin-milled pea flour (25%, 50% and 100%); substitution by the thick fraction (25%, 50% and 100%); and substitution by the thin fraction (25% and 50%). A 100% substitution by the thin fraction was not investigated due to the poor quality of the resulting cakes. Each formulation was prepared and measured in duplicate.

2.2.2. Batter measurements

Batter density was determined with a standard container (100 cc) of known weight filled with batter. Batter viscosity was measured with a Rapid Visco® Analyser (Newport Scientific Pty Ltd., Warriewood, Australia). A batter sample (25 g for layer-cake batter and 20 g for sponge batter) was submitted to viscosity analysis over a 5-min period using a constant speed of 160 rpm and temperature of 30 °C. The specific volume and viscosity analyses were carried out in duplicate 15 min after mixing the batters. Batter pH was determined twice with a pH-meter (pH Tester 30, Eutech Instruments, Oakton, USA).

To visualise bubbles, a drop of approximately 2 g of batter was placed on a microscope slide. The sample was covered with another microscope slide, taking care to avoid the inclusion of exogenous air bubbles. The slides were compressed under a 1 kg weight to create a layer of batter of uniform thickness. Batter samples were examined at 40-times or 100-times magnification using a DM750 microscope (Leica Microsystems, Wetzlar, Germany) fitted with an EC3 video camera (Leica Microsystems, Wetzlar, Germany), images were captured using *LAS EZ software* (Leica Microsystems, Wetzlar, Germany).

2.2.3. Cake characteristics

Collapse was measured by the difference in height between the time of withdrawal from the oven and after 50 min of cooling at room temperature. Collapse measurements were performed in duplicate.

Cake quality evaluation was performed 24 h after baking. Cake volume was determined using a laser sensor with the BVM-L 370 volume analyser (TexVol Instruments, Sweden). Cake specific volume was determined by the ratio between the cake volume and its weight. Symmetry and volume index were measured in accordance with AACC method 10-91 (AACC, 2010). A digital calliper was used to measure cake height. The symmetry index was measured on two cakes and the volume index on two slices from different cakes.

Crumb texture was determined by a TA-XT2 texture analyser (Stable Microsystems, Surrey, UK) running the *Texture Expert* software. The Texture Profile Analysis (TPA) double compression test was performed using a cylindrical aluminium probe of 25 mm in diameter. The probe was programmed to penetrate to a depth of 50% at a speed of 2 mm/s, with a 30 s delay between first and second compressions. Firmness (*N*), cohesiveness and springiness were calculated from the TPA graph (Gomez, Ronda, Caballero,