LWT - Food Science and Technology 94 (2018) 50–56

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Influence of protein source on the characteristics of gluten-free layer cakes

Marta Sahagún*, Ángela Bravo-Núñez, Guillermo Báscones, Manuel Gómez

Food Technology Area, College of Agricultural Engineering, University of Valladolid, 34071, Palencia, Spain

ARTICLE INFO

Keywords:
Protein enrichment
Batter
Texture
Volume
Acceptability

ABSTRACT

The aim of this study was to examine the effect of four commercial proteins (pea, rice, egg white and whey) on the characteristics of gluten-free layer cakes. Rice flour was partially substituted with 15, 30 and 45% protein. Hydration properties, batter density and viscosity, cake characteristics (weight loss, specific volume, texture and colour) and consumer acceptability were analysed. In general, the addition of protein increased the viscosity of the batters, with higher protein contents exhibiting greater effects and with pea protein presenting the highest effect overall. The addition of egg white protein led to the hardest cakes ($p < 0.05$) and whey protein, which also increased the cake hardness ($p < 0.05$), gave rise to cakes with the highest specific volume. Both animal proteins increased the cake cohesiveness and springiness ($p < 0.05$). On the contrary, pea and rice protein hardly modified hardness, colour and specific volume of cakes overall, but reduced their cohesiveness ($p < 0.05$). Regarding sensory evaluation, all protein-enriched cakes presented lower acceptability with respect to control cake ($p < 0.05$), but this effect was more pronounced when rice and egg white protein were added due to their taste, odour and texture. Whey protein cakes were, among the enriched samples, the ones with the highest acceptability.

1. Introduction

Over recent years, the market demand for gluten-free products has increased significantly. One of the reasons for this increasing trend is the rise in diagnosed cases of celiac disease (Gallagher, Gormley, & Arendt, 2004). Although the prevalence of celiac disease is approximately 1% of the general population in Europe and the United States, the sole treatment is a unique gluten-free diet (Niewinski, 2008). However, there are also people who follow a gluten-free diet without suffering any celiac pathology, as they believe in its benefits for health or weight loss. (Staudacher & Gibson, 2015).

Currently, gluten-free products have lower protein content than their equivalent products with gluten (Miranda, Lasa, Bustamante, Churruca, & Simon, 2014; Wu et al., 2015). This lack should be compensated, as proteins are one of the basic nutrients necessary for various anabolic processes in the body (Hoffman & Falvo, 2004). In addition, some authors reported that a greater protein intake could have beneficial health effects for athletes (Phillips, 2014) and elderly people (Nowson & O'Connell, 2015). Due to this, the addition of different proteins to gluten-free bakery products could be a way to address the potential consequences of the current market demand.

Cakes are an interesting matrix in which proteins can be incorporated due to their high acceptability. Furthermore, their worldwide market is currently growing at a rate of about 1.5% per year (Wilderjans, Luyts, Brijs, & Delcour, 2013). Cake batter could be considered as a complex oil-in-water emulsion with a continuous aqueous phase containing dissolved or suspended dry ingredients (Ronda, Oliete, Gómez, Caballero, & Pando, 2011). The correct formation of the emulsion depends on both the aeration of the aqueous phase (Brooker, 1993) and the retention of this air incorporated. The efficacy of air retention in the batter is inversely proportional to batter viscosity (Sahi & Alava, 2003) and it is known that flour characteristics affect it (Gómez, Ruiz-París, & Oliete, 2010). If the batter viscosity is too low, the air bubbles escape of the batter to the surface during baking, as the batter can not retain them. On the other hand, if the batter viscosity is too high, the air bubbles can not extend in the oven and the cake volume is low. Therefore, the study of the effect of substituting the flour by different proteins on batter viscosity and cake volume would be needed. Regarding cakes elaborated with wheat flour, studies can be found about substituting flour with whey protein (Jyotsna, Manohar, Indrani, & Rao, 2007), gluten protein (Wilderjans, Pareyt, Goesaert, Brijs, & Delcour, 2008) or soy protein (Majzoobi, Ghiasi, Habibi, Hedayati, & Farahnaky, 2014; Sung, Park, & Chang, 2006). As for gluten-free cakes, there are few authors who have studied the influence of protein on product characteristics (Matos, Sanz, & Rosell, 2014; Ronda et al., 2011; Shevkani & Singh, 2014; Shevkani, Kaur, Kumar, & Singh, 2015). However, none of these studies included protein levels exceeding 15%, except that of Ronda et al. (2011) who added 20% of

* Corresponding author.
E-mail address: msahaguncs@gmail.com (M. Sahagún).

https://doi.org/10.1016/j.lwt.2018.04.014
Received 11 January 2018; Received in revised form 6 March 2018; Accepted 6 April 2018
Available online 12 April 2018

protein, although starch was used instead of flour. On the other hand, only Matos et al. (2014) compared vegetal and animal proteins. To cover the existing gaps, the aim of this study was to study how three percentages (15, 30 and 45%) of different vegetal (pea and rice) and animal (egg white and whey) commercial proteins affected batter (density and viscosity), physical characteristics (specific volume, weight loss, texture and colour) and acceptability of gluten-free layer cakes.

2. Materials and methods

2.1. Materials

Rice flour (12.83% moisture, 8% protein and 85.4 µm particle size) was supplied by Harinera la Castellana S.A (Medina de Campo, Valladolid, Spain), Nutralys BF pea protein (78.13% protein and 134.0 µm particle size) by Roquette (Leutrem, France), Remypro N80 + G rice protein (79% protein and 95.2 µm particle size) by Beneo (Mannheim, Germany), egg white powder (81.66% protein and 30.7 µm particle size) by EPS S.P.A (Occhiobello, Italy) and Provon 295 IP whey protein (92% protein and 39.7 µm particle size) by Glanbia (Kilkenny, Ireland). Particle size was measured with a laser diffraction particle size analyser (Mastersizer 3000, Malvern Instruments, Ltd., Worcestershire, UK) and it was expressed as D(4;3), which reflects the size of those particles which constitute the bulk of the sample volume. Other ingredients were white sugar (AB Azucarera Iberica, Valladolid, Spain), UHT whole milk (President, Lactalis Food Service Iberia, S.L.U., Madrid, Spain), liquid pasteurized egg (Ovopack, Álvarez Camacho, S.L., Sevilla, Spain), refined sunflower oil (Langosta, F. Faiges, S.L., Daimiel, Ciudad Real, Spain) and baking powder "25 × 1" (Puratos, Gerona, Spain).

2.2. Methods

2.2.1. Cake elaboration

The layer cake was elaborated using the following formulation: 350 g rice flour, 315 g sugar, 210 g milk, 175 g liquid pasteurized egg, 105 g sunflower oil and 10.5 g baking powder. In the protein-enriched formulations, the rice flour was replaced by 15, 30 or 45% of each commercial protein (rice, pea, egg white and whey). The moisture of flour and flour-protein blends was adjusted to 13%. All ingredients were mixed using a KitchenAid Professional mixer (Kitchen Aid, St. Joseph, Michigan, USA) for 10 min: 1 min at speed 4 and 9 min at speed 6. The cake batter (185 g) was placed into oil-coated aluminium pans (159 × 119 × 35 mm) and baked at 190 °C for 25 min. After baking, the cakes were removed from the pan, left to cool for 1 h at room temperature and packaged in polyethylene bags to be stored at 24 °C. All the cake elaborations were performed twice.

2.2.2. Batter measurements

Batter density (at 20 °C) was determined by an Elcometer 1800 pycnometer (Manchester, UK) with a known volume (100 cm^3). The density value was calculated as the relation of the weight (g) of batter placed in the filled pycnometer and the volume capacity of the container.

Batter viscosity was measured using a Rapid Viscoanalyser (RVA-4) (Newport Scientific model 4-SA, Warriewood, Australia). A batter sample (28 g) were placed in an RVA aluminum canister with a plastic paddle and submitted to a viscosity analysis (160 rpm at 30 °C).

For batter microstructure, a drop of the batter was placed on a microscope slide and covered with a coverslip. The slides were compressed under a constant weight (1 kg) to achieve a layer of batter of uniform thickness, removing the highest amount of air bubbles as possible. The batter samples were examined using a DM750 microscope (Leica Microsystems, Wetzlar, Germany). The microscope was equipped with a Leica EC3 video camera, and images were captured using LAS-EZ V1.7.0 for Windows software (Leica Microsystems, Heerbrugg, Switzerland).

2.2.3. Cake characteristics

Cake volume was obtained from two pieces of each elaboration using a laser sensor with the BVM-L 370 vol analyser (TexVol Instruments, Viken, Sweden). Specific volume and weight loss were calculated according to de la Hera, Martinez, Oliete, and Gómez (2013).

Crumb texture was determined using a TA-XT2 texture analyser (Stable Microsystems, Surrey, UK) with the "Texture Profile Analysis (TPA)" test. A 25-mm-diameter cylindrical aluminium probe was used in a double compression test, penetrating to 50% of the initial height at a speed of 2 mm/s, with a 30-s delay between the first and second compression and the measurements were realized on the centre of cake slices. From each cake batch, two cakes were sliced into slices of 20 mm in thickness and the three central ones of each cake were analysed. Hardness (N), cohesiveness and springiness were calculated from the TPA graphic.

Colour was measured using a Minolta CM-508i spectrophotometer (Minolta Co., Ltd, Japan) with the D65 standard illuminant and the 2° standard observer. Crust colour was measured at five points of the surface of two cakes from each elaboration. Crumb colour was obtained from the measurements of two slices of two cakes from each preparation. Both results were expressed in the CIELAB colour space with the lightness coordinate L^*, a green-red-oriented coordinate a^* ($-a^*$: greenness, + a^*: redness) and a blue-yellow-oriented coordinate b^* ($-b^*$: blueness, + b^*: yellowness) (Witt, 2007).

The measurement of cake characteristics was carried out 24 h after baking.

2.2.4. Consumer test

Sensorial evaluation of cakes was completed by 100 volunteers, who were from 16 to 65 years of age and usual consumers of cakes. Cakes were divided into pieces of 2 cm wide and presented on white plastic plates coded with four-digit numbers and served in random order. One entire cake was presented on the principal table for its appearance to be evaluated. The cakes were evaluated based on consumer acceptance of their appearance, odour, texture, taste and overall acceptability. This evaluation was completed by using a hedonic scale of 9 points. This scale ranged from "I like very much" (9 score) and "I dislike very much" (1 score).

2.2.5. Statistical analysis

The results obtained were assessed by an analysis of variance (one-way ANOVA) with the Fisher's least significant differences (LSD) test and with significance level of 95% ($p < 0.05$). Statistical analysis was completed using Statgraphics Centurion XVI software (StatPoint Technologies Inc, Warrenton, EEUU).

3. Results and discussion

3.1. Batter characteristics

Batter characteristics are shown in Table 1. In general, the incorporation of rice and egg white proteins reduced the density of the batters. Considering batter microstructure (Fig. 1), the incorporation of rice protein increased the size of bubbles due to evident coalescence phenomena, above all with 45% incorporation of protein. In the case of batters with egg white protein, the addition of this protein gave rise to the highest amount of bubbles with the lowest size because of its very good foaming properties (Richert, 1979). In both cases, these different phenomena could explain the lower density of the batter. On the other hand, pea protein had no effect on batter density. The batters with pea protein presented a greater number of bubbles, although they were smaller than the control sample. This outcome was more pronounced with higher percentage of protein. The compensation between the