LWT - Food Science and Technology 63 (2015) 1049–1055

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Use of chia (*Salvia hispanica* L.) mucilage gel to reduce fat in pound cakes

Mária Herminia Ferrari Felisberto [a], Adriana Lucia Wahanik [a], Cristiane Rodrigues Gomes-Ruffi [b], Maria Teresa Pedrosa Silva Clerici [a], Yoon Kil Chang [a], Caroline Joy Steel [a, *]

[a] *Department of Food Technology, School of Food Engineering, University of Campinas (UNICAMP), Cidade Universitária Zeferino Vaz, CEP 13083-862, Campinas, São Paulo, Brazil*

[b] *Food Technology Institute (ITAL), Av. Brasil, 2880, CEP 13070-178, Campinas, São Paulo, Brazil*

ARTICLE INFO

Article history:
Received 5 December 2014
Received in revised form
17 March 2015
Accepted 31 March 2015
Available online 11 April 2015

Keywords:
Chia seeds
Fat replacement
Mucilage gel
Pound cake
Salvia hispanica

ABSTRACT

Overweight indices have increased in the recent years, and thus the occurrence of non-communicable diseases related to them. The recommendation of fat reduction in food may contribute to reduce the risk of these diseases. Attention has focused on bakery products, such as pound cake, which contains up to 17 g fat/100 g product. A novel ingredient, chia seed (*Salvia hispanica* L.), has been studied for its high water-absorbing and viscous mucilaginous external layer, in order to evaluate its potential as fat substitute in bakery products. We investigated the effects of the replacement of 25, 50, 75 and 100 g/100 g of vegetable fat by chia mucilage gel (CMG) on the technological properties of pound cakes. CMG was produced by rehydration with water of lyophilized chia mucilage (LCM). Replacement of vegetable fat by CMG did not significantly alter the specific volume, symmetry, uniformity, moisture and water activity (a_w) of the cakes. Color parameters, as well as crumb firmness of cakes, were influenced by higher levels of fat replacement with CMG. We concluded that the replacement of up to 25 g/100 g of fat by CMG is technologically feasible in pound cakes, with no significant alterations on their quality characteristics.

1. Introduction

Fat reduction in food is a major concern in our days, as market demands increase for lower fat products. This is related to indices showing a duplication of the population with overweight and obesity in the last 30 years, accounting in 2008 more than 1400 million adults (WHO, 2014). Obesity may be related to other non-communicable diseases (Grundy, 2004). Fat substitution by other ingredients is a great challenge, with special focus in bakery products, as they can contain elevated levels of fat.

Pound cakes are consumed everywhere, and can contain up to 17 g/100 g fat in the product. Fat provides several advantages to pound cakes, such as higher volume and softness in the final product, due to a higher air incorporation during batter preparation and inhibition of gas-bubble coalescence, leading to a finer and softer crumb structure (Bennion & Bamford, 1997; Bobbio & Bobbio, 2003). In addition, fats and emulsifiers delay starch gelatinization by retarding water transfer into the starch granule, by the formation of complexes between polar lipids and amylose during baking, thus improving the tenderness, moisture content and flavor of the cakes, extending shelf-life (Bennion & Bamford, 1997; Luna Pizarro, Almeida, Sammán, & Chang, 2013). Thus, several problems appear when fat content is reduced in pound cakes, such as lower volume, denser crumb, firmer eating qualities, and loss of flavor, compared to conventional cakes (Cauvain & Young, 2006). It is a current challenge to provide palatable and marketable products, while reducing fat in pound cakes.

Over the years, different ingredients have been used for replacement of fat in foods, such as gums, fibers or mucilage. Chia mucilage has been recently studied as a possible fat replacer. Chia seed (*Salvia hispanica* L.) was an important staple food for Mesoamerican cultures in pre-Columbian times, surpassed only by corn and beans in significance (Luna Pizarro et al., 2013; Reyes-Caudillo, Tecante, & Valdivia-López, 2008). It was initially cultivated in Mexico, being now spread to other regions. The evaluation of its properties and possible uses has shown a high nutritional value,

* Corresponding author. Tel.: +55 19 3521 3999.
E-mail address: steel@unicamp.br (C.J. Steel).

http://dx.doi.org/10.1016/j.lwt.2015.03.114

especially due to its fiber content (Bushway, Belyea, & Bushway, 1981; Ixtaina, Nolasco, & Tomás, 2008; Reyes-Caudillo et al., 2008).

Special interest has been awakened by chia mucilage, which is composed of neutral sugars, indicating the presence of diverse carbohydrates on its structure. Lin, Daniel, and Whistler (1994) proposed a structure of a tetrasaccharide with 4-*O*-methyl-α-D-glucoronopyranosyl residues occurring as branches of β-D-xylopyranosyl on the main chain. Due to its structure, chia mucilage acts like soluble fiber and it is known to have excellent water holding properties. Thus, chia mucilage might provide hydration, viscosity development and conservation of freshness, especially for baked goods, therefore, presenting a potential as fat substitute (Vázquez-Ovando, Rosado-Rubio, Chel-Guerrero, & Betancur-Ancona, 2009).

In this study our purpose was to extract and characterize chia mucilage, prepare chia mucilage gel (CMG), and evaluate the effects of its incorporation on the technological quality of pound cakes with the reduction of 25, 50, 75 and 100 g/100 g of fat.

2. Material and methods

2.1. Material

The wheat flour used was type 1 (Nita, Santos, Brazil), blended with corn starch (16 g/100 g), in order to reduce flour strength (Amidex 3001–Corn Products, Mogi Guaçu, Brazil). This blend contained 11.03 g/100 g moisture, 11.84 g/100 g protein, 0.89 g/100 g lipids, 0.53 g/100 g ash, 1.87 g/100 g dietary fiber and 75.71 g/100 g carbohydrates. Farinograhic water absorption, stability and mixing tolerance index of the blend were 55.87 g/100 g, 15.8 min and 38.33 Brabender Unit (BU), respectively, determined through AACC method 54-21.01 (AACC, 2010); alveographic resistance to extension (P), extensibility (L) and the dough deformation energy (W) of the blend were 82.97 mm, 36.67 mm and 135.03 10^{-4} J, respectively, determined through AACC method 54-30.02 (AACC, 2010).

The chia seeds were kindly donated by R & S Blumos (Campinas, Brazil). The vegetable fat used was Pan Advance S550 (Cargill Agrícola S/A, Itumbiara, Brazil). Additional ingredients were obtained at the local market: sugar (Guarani, Olímpia, Brazil), baking powder and emulsifier (Emulzint, Jundiaí, Brazil), whole milk powder (Piracanjuba, Bela Vista de Goiás, Brazil) and whole liquid pasteurized eggs (Fleischmann, Sorocaba, Brazil).

2.2. Methods

2.2.1. Chia mucilage extraction

The chia mucilage was obtained according to Muñoz, Cobos, Diaz, and Aguilera (2012), with modifications at the end of the process. The optimum extraction process was performed at a temperature of 80 °C with a seed: water ratio of 1:40. The mixtures were stirred and hydrated for 2 h. Then, the aqueous suspension was separated from the chia seed with an M6 227/3498 brush depulper (Sterling Electric Motors, California, USA). Finally, the aqueous suspension was filtered (Tyler 20 mesh, 0.85 mm screen), concentrated in a vacuum jacketed kettle (Groen MFG, Illinois, USA), freeze-dried in an LP 820 lyophilizer (São Paulo, Brazil) and stored in hermetically sealed plastic packaging. The yield was 7.86 g of lyophilized chia mucilage/100 g of chia seeds.

2.2.2. Physicochemical characteristics of chia seeds and mucilage

The moisture, protein, lipid, and ash contents of the chia seeds and lyophilized chia mucilage (LCM) were determined by the following AACC methods: 44-15.02, 46-13.01, 30-25.01 and 08-01.01 (AACC, 2010), respectively. Total dietary fiber was determined according to AACC method 32-07.01 (AACC, 2010), reducing sample weight to 0.1 g because of the increase in viscosity caused by mucilage in the samples, as cited by Mañas, Bravo, and Saura-Calixto (1994) and Reyes-Caudillo et al. (2008). The digestible carbohydrate content was calculated by difference.

Instrumental color analysis was performed on LCM using a CR 410 colorimeter (Konica Minolta, Tokio, Japan), with a 50 mm port size, illuminant D65, SCI and a 10° standard observer angle. The LCM color was evaluated by the tri-stimulus CIELab color space method, determining the lightness (L^*), redness (a^*) and yellowness (b^*) values.

2.2.3. Chia mucilage technological characterization

The LCM was characterized by its water holding (WHC) and oil holding capacity (OHC), according to Vázquez-Ovando et al. (2009), with modifications.

2.2.4. Cake preparation

The cake formulation showed in Table 1 was based and balanced according to Montenegro (2011), Bedoya-Perales and Steel (2014) and Bennion and Bamford (1997). Vegetable fat (in the reference formulation-RF) was replaced by CMG at different levels of substitution: 25, 50, 75 and 100 g/100 g. Before cake preparation, CMG was prepared by hydrating LCM with tap water (3 g/100 g aqueous solution), mixing with a Walita mixer (Philips–RI 1341, Varginha, Brasil) and leaving to rest for 30 min.

For cake preparation, sugar, fat and emulsifier were initially creamed by mixing for 10 min at high speed (level three speed) in a K45SS high-speed planetary mixer (Kitchenaid, St. Joseph, USA). The eggs were then added to cream phase and mixed for 5 min at high speed (level three speed) in an LA planetary mixer (Amadio, São Paulo, Brazil), with 20 L capacity.

The wheat flour, corn starch, salt, baking powder and sodium propionate were then added and mixed for 5 min at low speed (level one speed). Finally, the reconstituted whole milk, water and CMG were added and mixed for 1 min at low speed, then 1 min at high speed and 1 additional min at low speed to obtain a uniform batter. The batter density was measured at this point.

The batter (260 g), at approximately 26 °C, was then transferred to paper molds (16 × 7 × 4.5 cm) and placed in a hearth oven, with forced air circulation, Vipinho 0448 (Perfecta, Curitiba, Brazil), at 170 ± 2 °C for 25 min. After cooling to room temperature (25 °C/2 h), the cakes were sprayed with a sorbic acid alcoholic solution (preservative) and packaged in polyethylene plastic bags. Cake processing was carried out three times on different days. Cake samples were stored at room temperature for periodical evaluation.

2.2.5. Technological characteristics of the cakes

The specific volume, symmetry and uniformity indices were determined 1 day after the cakes were prepared. The cake crumb color, moisture content, water activity (a_w) and crumb firmness were evaluated after 1, 7 and 14 days of storage.

The specific volume was calculated as the ratio of apparent volume to weight. Apparent volume (mL) was measured by seed displacement, according to AACC method 10-05.01 (AACC, 2010), and weight (g) was determined using a PB 3002 semi-analytical balance (Mettler Toledo, Greifensee, Switzerland). Cake symmetry and uniformity indices were calculated according to AACC method 10-90.01 (AACC, 2010).

Instrumental color analysis was performed directly on central slices from cakes, on days 1, 7 and 14 of storage, using the same equipment and parameters as for mucilage color evaluation.

Cake moisture content was determined by AACC method 44-15.02 (AACC, 2010). Water activity (a_w) was measured directly in a CX-2T hygrometer (Decagon, Pullman, EUA), at room temperature (25 °C).