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Chickpea and tiger nut flours as alternatives to emulsifier and shortening in gluten-free bread

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A B S T R A C T

Chickpea protein has good emulsifying properties, which improve gluten-free bread volume. Tiger nut is a tuber with high lipid content of healthy fatty acid profile. Taking into account these characteristics, the effect of chickpea and tiger nut flours addition to gluten-free batters and breads in order to partially or totally replace emulsifier and/or shortening in gluten-free formulations has been studied. Four formulations were compared: corn starch; 7.8 g/100 g chickpea flour and corn starch; 8.6 g/100 g tiger nut flour and corn starch; 7.8 g/100 g chickpea flour + 8.6 g/100 g tiger nut flour and corn starch. The combination of three levels of shortening (5, 2.5 and 0 g/100 g) and three levels of emulsifier (2, 1 and 0 g/100 g) was evaluated in each basic formulation. Chickpea flour increased bread specific volume but tiger nut flour reduced it. When chickpea protein and emulsifier were added in the formulation, shortening increased G′and specific volume, and reduced initial crumb firmness. Bread elaborated with both chickpea and tiger nut flour maintained its baking characteristics (bake loss, specific volume, crust and crumb color and, crumb hardness) even when shortening and/or emulsifier were reduced or eliminated.

1. Introduction

Gluten-free products demand, especially bread, is increasing as a result of the increase of celiac disease diagnosis (Cureton & Fasano, 2009). Nevertheless, production of high quality gluten-free bread is a big challenge due to the absence of gluten, which confers unique viscoelastic properties to dough. To overcome this challenge, gluten-free bread formulations incorporate a range of flours from cereals (rice, sorghum, millet), pseudocereals (quinoa, amaranth, buckwheat) or legume flours (soya, chickpea, carob, pea); starches from corn, potato or cassava; and ingredients such as proteins, hydrocolloids, emulsifiers and shortenings that improve their sensory properties and shelf-life, but also lead to an increase of final price (Miñarro, Albanell, Aguilar, Guamis, & Capellas, 2012; Moroni, Dal Bello, & Arendt, 2009; Zannini, Jones, Renzetti, & Arendt, 2012).

Chickpea (*Cicer arietinum* L.) is a legume rich in protein, dietary fiber, carbohydrates, folate and trace minerals (Fe, Mo, Mn) (Meng, Threinen, Hansen, & Driedger, 2010). Some authors have studied functional properties of chickpea proteins, reporting good emulsifying and foaming characteristics (Boye et al., 2010; Karaca, Low, & Nickerson, 2011) as well as high oil absorption capacity (Aydemir & Yemenicioglu, 2013). The functional properties of chickpea protein provide good baking characteristics in gluten-free and wheat breads elaborated with chickpea flour (Miñarro et al., 2012; Mohammed, Ahmed, & Senge, 2012).

Tiger nut (*Cyperus esculentus* L.) is an important crop in Spain that is used to produce a milky beverage called “horchata de chufa”, although it is underutilized in many countries in the world. It is a tuber rich in carbohydrates, lipids, fiber, some minerals (K, P, Ca), and vitamin E and C (Sánchez-Zapata, Fernández-López, Sendra, & Pérez-Álvarez, 2012). This tuber has 23–31 g/100 g of lipid content with a fatty acid profile similar to olive and hazelnut oil, which confers healthy properties to tiger nut tuber, together with its high fiber content (8–15 g/100 g) (Alegría-Torán & Farré-Rovira, 2003; Sánchez-Zapata et al., 2012). Tiger nut flour could be used in bakery products (Chinma, Avu, & Abubakar, 2010) as well as to formulate gluten-free bread with good baking and nutritional characteristics (Aguilar, Albanell, Miñarro, Guamis, & Capellas, 2015; Demirkesen, Sumnu, & Sahin, 2011).

Emulsifiers in wheat bread can be classified, according to its functionality, as dough strengtheners or crumb softeners (Stampfli

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& Nersten, 1994). Some authors have incorporated emulsifiers in gluten-free formulations in order to strengthen the dough and/or soften the crumb (Demirkesen, Mert, Sumnu, & Sahin, 2010; Nunes, Moore, Ryan, & Arendt, 2009; Onyango, Unbehend, & Lindhauer, 2009; Purhagen, Sjöö, & Eliasson, 2012; Sciarini, Ribotta, León, & Pérez, 2012). In 2011, Csáki reported that synthetic emulsifiers, commonly used in bakery industry, could increase intestinal permeability, favoring the incidence of allergic and autoimmune diseases. As inhibition of intestinal barrier dysfunction is recommended for celiac disease treatment (Paterson & Turner, 2008), reduction or elimination of synthetic emulsifiers from gluten-free bread could benefit the intestinal health of celiac patients.

Shortening is defined as crystalline lipids and oils from vegetable and/or animal origin with a composition of 100 g/100 g lipid approximately. Shortening plasticizes and lubricates dough, increases dough rise, oven spring and loaf volume, as well as improves crumb structure and shelf-life of wheat bread (Autio & Laurikainen, 1997; Chin, Rahman, Hashim, & Kowng, 2010; Ghotra, Dyal, & Narine, 2002; Pareyt, Finnie, Putseys, & Delcour, 2011). Shortening is usually incorporated in gluten-free bread to improve its quality (Aguilar et al., 2015; Demirkesen et al., 2010; Miñarro et al., 2012; Schober, 2009; Sciarini et al., 2012). In addition, shortening showed a crumb softening effect in sorghum gluten-free bread (Schober, 2009). Nevertheless, shortening increases the caloric intake and may imbalance the nutritional profile of gluten-free bread due to the increase of fat content with a high proportion of saturated fatty acids.

Considering the properties of chickpea proteins and tiger nut lipid content, their flours could be used to improve gluten-free formulations, providing a cleaner label and a better nutritional quality. The aim of this research was to study the effect of chickpea and tiger nut flours, separately and combined, in gluten-free batters and breads in order to partially or totally replace emulsifier and/or shortening from gluten-free formulations.

2. Materials and methods

2.1. Raw materials

Ingredients used for the elaboration of gluten-free bread and batter were: tap water, corn starch (Syral Iberia S.A.U., Zaragoza, Spain), chickpea flour (El Granero Integral S.L., Madrid, Spain), tiger nut flour (Tigernuts Traders S.L., Valencia, Spain), shortening (Puratos, Sils, Spain), white sugar (Azucarera Ebro S.L., Madrid), baking powder (Panreac Química S.L.U., Castellar del Vallès, Spain), xanthan gum (Degussa Texturant Systems, Paris, France), emulsifier (Degussa Texturant Systems), dry yeast (Lallemand Iberica S.A., Cachofarra, Portugal), and iodized refined salt (Sal Costa S.A., Barcelona, Spain).

Commercial chickpea flour nutritional composition expressed in g/100 g was: 8.2 moisture, 3.0 ash, 6.1 fat, 19.6 protein, 54.2 carbohydrates, 50.2 starch, 4.0 sugars, <0.1 soluble fiber, 8.8 insoluble fiber. Commercial tiger nut flour was sieved through a 0.5-mm sieve to avoid the incorporation of particles leading to sandy texture in bread. Nutritional composition (expressed in g/100 g) of the sieved tiger nut flour was: 6.7 moisture, 3.0 ash, 28.6 fat, 5.4 protein, 44.3 carbohydrates, 26.2 starch, 18.1 sugars, <0.1 soluble fiber, 11.9 insoluble fiber. Shortening used contained refined vegetable fats and oils, tocopherol-rich extract (E-306), ascorbyl palmitate (E-304) and beta-carotene (E-160a). Emulsifier was composed of citric acid esters of mono and diglycerides and sucrose fatty acid esters.

Four basic formulations were compared (Table 1): starch (S), chickpea (C), tiger nut (T) and chickpea-tiger nut (CT). Decreasing concentrations of shortening (5, 2.5 and 0 g/100 g) and emulsifier (2, 1 and 0 g/100 g) and the combination of all them were evaluated in the four basic formulations (S, C, T, CT). Therefore, a total of 36 formulations (9 from each basic formulation) were compared in this study (Table 1). Maximum concentrations of shortening and emulsifier (5 and 2 g/100 g, respectively) and chickpea flour concentration (7.8 g/100 g) were those used in previous studies from our research group (Aguilar et al., 2015; Miñarro et al., 2012). The amount of tiger nut flour was determined in preliminary studies.

Table 1
Gluten-free formulations (S: starch; C: chickpea flour; T: tiger nut flour; CT: chickpea and tiger nut flours) expressed in g/100 g of flour (starch + flour) weight.

Ingredient (g/100 g flour weight)	S	C	T	CT
Water	103	103	103	103
Corn starch	100	92.2	91.4	83.6
Tiger nut flour	–	–	8.6	8.6
Chickpea flour	–	7.8	–	7.8
Shortening	5-2.5-0	5-2.5-0	5-2.5-0	5-2.5-0
Sugar	4.2	4.2	4.2	4.2
Baking powder	2.5	2.5	2.5	2.5
Emulsifier	2-1-0	2-1-0	2-1-0	2-1-0
Xanthan gum	2	2	2	2
Dry yeast	2	2	2	2
Salt	1.7	1.7	1.7	1.7

2.2. Batter analysis

For rheology measurements, batters were prepared as described by Aguilar et al. (2015) but without dry yeast. Oscillatory test was performed as described by Miñarro et al. (2012). A target strain of 5×10^{-4} (0.05%) was used in the frequency sweep test as preliminary studies demonstrated that it was within the linear viscoelastic range. At least two repetitions of three independent batches were analyzed.

To study gluten-free batter behavior during fermentation a Rheofermentometer F3 (Chopin, Villeneuve-la-Garenne, France) was utilized, which measured CO_2 retention during 45 min of fermentation at 30 °C. The analysis was performed with 315 g of batter prepared as explained before and a cylindrical weight of 500 g was used to run the test. Three independent batches were analyzed.

2.3. Bread making

Bread was made as described by Aguilar et al. (2015) method except that, in the present study, breads were baked in $5 \times 8 \times 14$ cm pans in a convection oven (Sveba-Dahlen AB, Fristad, Sweden) at 160 °C for 30 min, with steam injection for 10 s at the start of baking.

2.4. Bread analysis

Loaf volume, bake loss, crumb hardness and crust and crumb color were evaluated by the methods described by Miñarro et al. (2012).

Image analysis (mean cell area) and staling were measured as described by Aguilar et al. (2015).

To evaluate bread characteristics, three independent productions of each formulation were developed. In each experiment, three breads from each formulation were analyzed.

2.5. Statistical analysis

Results were analyzed by analysis of variance (ANOVA) using the general linear models procedure of Statistica 7 software. Student-Newman-Keuls method was applied for comparison of sample data.