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Production of maize tortillas and cookies from nixtamalized flour enriched with anthocyanins, flavonoids and saponins extracted from black bean (*Phaseolus vulgaris*) seed coats

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ABSTRACT

Ethanolic extract from black beans coat is a source of flavonoids, saponins and antocyanins. Nixtamalized maize flours (NF) are used for the preparation of products such as tortillas, tortillas chips, cookies among others. The objective of this research was to study the effect on textural parameters and color after adding flavonoids, saponins and anthocyanins from black bean seed coat in NF used for the production of tortillas and gluten-free cookies. Furthermore, the retention of bioactive compounds after tortilla and gluten-free-cookie preparation was assessed. Ethanolic extracts of black bean seed coats were added (3 g/kg or 7 g/kg) to NF in order to prepare corn tortillas and gluten free cookies characterized in terms of dimensions, color and texture. Addition of 7 g/kg affected the color of cookies and tortillas without effect on texture and dimensions. It was possible to retain more than 80% and 60% of bioactives into baked tortillas and cookies, respectively.

1. Introduction

Nowadays, foods are not intended to only provide necessary nutrients but also nutraceuticals which improve physical and mental well-being and prevent nutrition-related or chronic diseases (Siró, Kápolna, Kápolna, & Lugasi, 2008). Thus, functional foods play a critical and unique role in new product developments.

Maize tortillas, obtained from the nixtamalization process, are considered the most relevant staple for the Mexican population. For Mexicans and other Latin-Americans, tortillas are the most important sources of protein, calcium, fiber and energy (Palacios-Fonseca, Vazquez-Ramos, & Rodríguez-García, 2009). Maize tortillas and derived products such as tortilla chips, corn chips, taco shells, among others, have increased their commercial importance. Unfortunately, nixtamalization and other alternative processes for tortilla elaboration promote the loss of phenolic and antioxidants (Mora-Rochin et al., 2010). De la Parra, Serna-Saldivar, and Liu (2007) have demonstrated that in five types of maize (white, yellow, high carotenoid, blue, and red), lime-cooking significantly reduced the phytochemical content and antioxidant activities of finished products. Thus, the addition of phenolic compounds after the process of nixtamalization could be an alternative to increase phytochemical and antioxidant activity in finished products.

Recently, compounds from black bean seed coats (flavonoids, phytosterols and saponins) have been studied because of their hypocholesterolemic effect (Chavez-Santoscoy et al., 2014; Chavez-Santoscoy, Tovar, Serna-Saldivar, Torres, & Gutiérrez-Uribe, 2014). Particularly, black bean seed coats could be an efficient source of bioactive compounds that can be added to food for the purpose of exerting health benefits.

There are some reports about the resistance of black bean seed compounds to heat formulations. Interestingly, it has been previously reported that heat treatment, such as microwave, significantly increased the total phenolic content (20%) and antioxidant activity (18%) of some varieties of beans depending on bean cultivar/market class (Oomah, Kotzeva, Allen, & Bassinello, 2014). But also heat treatment during canning reduces the concentration of

Abbreviations: 3GBBE, formulation with 3 g/kg of black bean seed coat extract; 7GBBE, formulation with 7 g/kg of black bean seed coat extract; CN, formulation without black bean seed coat extract (control); RVA, Rapid Visco Analyser; TPA, texture profile analysis; WAI, water absorption index; WSI, water solubility index.

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anthocyanins and flavonoids in common beans (Pedrosa et al., 2015). Therefore, the extraction of bioactive compounds from seed coats and their use as food ingredient represents an excellent alternative but little is known about their stability during dry cooking.

Due to the demonstrated hypocholesterolemic effect of saponins, they have been incorporated into bread as isolates, extracts o legume flours. Saponins from soy and chickpea not only are stable after baking but also they were more bioaccessible. Particularly, saponin isolates had demonstrated to improve textural properties of bread (Serventi et al., 2013) but little is known about their effects into tortillas or cookies.

The objective of this research was to study the effect on textural parameters and color after adding flavonoids, saponins and anthocyanins from black bean seed coat in NF used for the production of tortillas and gluten-free cookies. Furthermore, the retention of bioactive compounds after tortilla and gluten-free-cookie preparation was assessed.

2. Experimental

2.1. Black bean seed coat extract

The black beans (*Phaseolus vulgaris* L. var. San Luis) were obtained from Sinaloa, Mexico and were stored at 4 °C and relative humidity of 85%. In preparation for decortication, the beans were hydrated in a plastic bag with distilled water at a 100:1 (w:v) ratio and maintained at room temperature for 24 h before drying during 6 h at 60 °C. Later, the seed coats were removed using a dehuller (Nutana Machine, Saskatoon, SK, Canada) equipped with a set of five 30 cm diameter carborundum (60 grit) disks. Seed coat extraction of bioactive compounds was performed with 60% ethanol in water (v/v) acidified with 0.1% acetic acid using a mass-solvent ratio of 1:10 w/v at 27 °C. The mixture was stirred for 12 h at 250 rpm and left without stirring for one additional hour to allow sedimentation.

The supernatant was recovered by vacuum filtering through Whatman paper No. 1. The resulting extract was concentrated in a rotary evaporator to remove ethanol. The bath temperature was set at 50 °C, and pressure in the vacuum pump at a range of −70 to −90 kPa. Once ethanol was removed, the concentrated extract was lyophilized and the resulting freeze-dried powder stored at −80 °C.

2.2. Traditional nixtamalized maize flour production

Dent white maize (*Zea mays L.*) was procured from the 2010 harvest of Mochis, Sinaloa. The germplasm was Asgrow brand 773 with intermediate endosperm texture preferred by the tortilla industry. The maize sample was stored at 4 °C until use. The lime-cooking properties of the white maize were determined according to the nylon bag procedure previously described (Serna-Saldivar, Gomez, Almeida-Dominguez, Islas Rubio, & Rooney, 1993). White maize was lime-cooked at 95–100 °C for 45 min. Optimum cooking time was considered the time sufficient to increase nixtamal moisture to 48% after 16 h steeping. The cleaned and washed lime-cooked maize was stone-ground into dough using a commercial mill (Fertitor, Puebla, Mexico) equipped with a pair of carved 23-cm-diameter volcanic stones. Water (181 mL/kg nixtamal) was gradually added during grinding to increase the dough moisture to approximately 56% and to prevent excessive heat generation. The resulting dough was dried at 50 °C for 48 h. The dehydrated dry dough was remilled using a knife mill (Wiley Mill®, Swedesboro, NJ) equipped with a 2.0 mm screen.

Nixtamalized maize flour (NF) samples were enriched by mixing two different concentrations of the freeze-dried black bean seed coat extract. Thus, three composite flours were obtained: NF used as control (CN), NF with 3 g of black bean extract/kg (3GBBE) and NF with 7 g of extract/kg (7GBBE). Resulting composited flours were packed in plastic bags under vacuum conditions for further processing and analysis.

2.3. Flours and dough characterization

Moisture contents of the NF were analyzed using the AOAC (1999) method (925.09B). Flour particle size distribution was determined after rotaping for 10 min 100 g of flour with a nest of US standard sieves No. 60, 80, 100 and a collection pan. The fractions retained in each of the different meshes were separated, weighed and expressed on percentage. The water absorption (WAI) and water solubility (WSI) indexes were obtained according to (Anderson, Conway, Pfeifer, & Griffin, 1970) using the formula (g precipitate/g dry sample) for the WAI and (g soluble solids/g dry sample) * 100 for the WSI.

The relative viscosities of the water suspensions of maize flour dough were determined using a Rapid Visco Analyser, RVA (StarchMaster, Perten, Warriewood, Australia) according to Fernandez-Muñoz, Acosta-Osorio, Zelaya-Angel, and Rodríguez-García (2011). Dough samples were adjusted to 14% moisture content, and distilled water was added to keep the total weight of water and sample at 28 g. The sample was heated over 5 min from 50 °C to 90 °C at a rate of 5.6 °C/min, and then held at a constant temperature of 90 °C for 5 min, the sample was then cooled down to 50 °C over 5 min, the total time for the test was 15 min at 160 rpm. All the analyses were conducted in triplicate and average values were reported.

Dough adhesiveness was determined according to the method described by (Ruiz-Gutiérrez et al., 2012) a fresh tortilla dough was rested for 15 min in a polyethylene bag and 80 g were roll into a 4 cm diameter cylinder and then tested using a TA.XT2 texturometer (Texture Analyzer plus, TA Instruments, Surrey GU7 1YL, UK) with a 0.048 N (kg_f) trigger force at test speed 5 mm/s. Rheological parameters were determined using a Rheometer (RHEOPLUS 32 V3.40, Germany) with the accessory PP50-SN22586 using 2 g of each fresh tortilla dough previously rested for 15 min in a polyethylene bag. Each sample was placed between the plates with a 3.0 cm gap. Frequency sweep test were performed at a deformation of 0.04% at 25 °C. The viscoelastic parameters obtained were the storage modulus (G') loss modulus (G'') and complex viscosity (η^*) in kPa. All the measurements were made in five replicates and average values were reported.

2.4. Tortilla preparation

Tortillas were made by mixing 400 g of respective composite flour with 418 mL of water to achieve an adequate consistency of the resulting dough. According to Cuevas-Rodríguez, Reyes-Moreno, Eckhoff, and Milán-Carrillo (2009), the fresh dough was divided into 30 g pieces and pressed into flat discs using a manual tortilla pressing machine. The resulting discs were baked on a hot griddle at 220 ± 5 °C for 10 s on one side, turned over and heated for 15 s on the other side and finally an additional 5 s on the initial side.

2.5. Tortillas characterization

Physical tortilla characteristics such as weight, diameter and thickness were measured. Color parameters L^*, a^* and b^* were also obtained using a colorimeter (CR-300 Series, Minolta, Japan). All the measurements were made in triplicate and average values reported.