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Effect of semolina replacement with a raw:popped amaranth flour blend on cooking quality and texture of pasta

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ABSTRACT

The replacement of semolina (SEM) with raw:popped (90:10) amaranth flour blend (AFB) in pasta making at 25, 50, 75, and 100 g/100 g levels (flour basis, 14 g of water/100 g) was carried out to evaluate the effects on cooking quality and texture of the supplemented pasta samples. Significant differences on cooking quality characteristics and texture of the pasta samples were observed. The pasta solid loss increased, weight gain and firmness decreased as the AFB level increased. The semolina pasta showed the lowest solid loss (7 g/100 g) and the highest weight gain (188.3 g/100 g) and firmness (1.49 N), whereas the amaranth blend pasta was the softer (around half of the firmness of semolina pasta) and lost the higher amount of solids (11.5 g/100 g). The raw and popped AFB was suitable for increasing the nutritional quality through dietary fiber and high quality protein and even to obtain gluten-free pasta with acceptable cooking quality (solid loss of 3.5 g/100 g higher than that considered as acceptable for semolina pasta). The amaranth blend used in this study enables the partial or total replacement of wheat semolina in pastas with acceptable cooking quality and texture.

1. Introduction

Pasta products are made from wheat semolina, although more recently other grains have been used to partially replace it (Chillo, Laverse, Falcone, & Del Nobile, 2008; Manthey, Yalla, Dick, & Badruddin, 2004; Petitot, Bayer, Minier, & Micard, 2010). Such new recipes have been developed following one of the ten top trends reshaping the food industry to obtain products with specialty nutritional ingredients (Sloan, 2013). In addition, composite flours have been used to prepare gluten-free (GF) or low glycemic index pastas for special nutrition (Alamprese, Casiraghi, & Pagani, 2007; Caperuto, Amaya-Farfan, & Camargo, 2001; Mariotti, Iametti, Cappa, Rasmussen, & Lucisano, 2011).

The amaranth grain is excellent for new recipes because of its high quality protein, minerals and dietary fiber contents. Blends of raw and popped amaranth flours were used to make GF breads and cookies for celiac disease patients, with good technological characteristics without any additive added (Calderón de la Barca, Rojas-Martínez, Islas-Rubio, & Cabrera-Chávez, 2010).

Durum wheat proteins are characterized by a typical viscoelastic behavior that allows good networking of the matrix and optimal dough formation during the mixing and extrusion phases (Mariotti et al., 2011). The predominant characteristics that define the pasta quality are related to appearance and textural factors such as translucency, bright amber color, absence of a sticky surface, and '*al dente*' eating properties (Antognelli, 1980; Hoseney, 1986; Pomeranz, 1987).

The incorporation of alternative ingredients to wheat for pasta production requires processing adjustments and additives (Mariotti, Lucisano, Pagani, & Ng, 2009; Schoenlechner, Drausinger, Ottenschlaeger, Jurackova, & Berghofer, 2010). Additionally, different heat treatments have been reported to improve the quality of non-wheat pasta (Grugni, Manzini, Viazzo, & Viazzo, 2009; Marti, Seetharaman, & Pagani, 2010; Mastromatteo et al., 2012).

Heat treatments under specific moisture conditions, followed by cooling are useful to give rigidity to cooked pasta, and to reduce both stickiness of the surface and the loss of soluble materials

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during cooking (Mariotti et al., 2011; Mestres, Collonna, & Buleon, 1988). High levels of substitution of semolina lead to pasta with lower cooking properties. In the case of composite pasta made of semolina (70–95 g/100 g) and amaranth flour (5–30 g/100 g), cooking losses ranged from 6.9 to 9.3 g/100 g (Rayas-Duarte, Mock, & Satterlee, 1996). As far as our knowledge, the highest substitution level of semolina with amaranth flour for good quality pasta production is 25 g/100 g (Rayas-Duarte et al., 1996), perhaps our former amaranth flour blends, AFB (Calderón de la Barca et al., 2010) could be suitable for replacing semolina in pasta production. The aim of this study was to evaluate the suitability of an AFB (90:10 raw to popped) to replace semolina in pasta making and to determine the highest proportion of the AFB that provides the required functionality to make an acceptable composite pasta.

2. Materials and methods

2.1. Materials

The raw and popped amaranth (*Amaranthus hypochondriacus* L.) grains were obtained from a local producer (Productores de Tuyehualco, Tuyehualco, Mexico) and manually cleaned, milled separately into flour using a Philips blender model HR 2875 (Philips Mexicana, S.A. de C.V., Mexico, D.F.). The semolina (SEM) was kindly donated by Molinera de México, S.A. de C.V. Distilled monoglycerides and egg white powder were obtained from a local distributor (Serco Santa Lucía, S.A., Hermosillo, Mexico).

2.2. Particle size distribution, water absorption capacity and pasting properties

Particle size distribution of semolina and amaranth flour blend was determined by sieving 50 g of each sample by triplicates for 5 min over 8 inch sieves #40, #60, #80, and #100 with aperture of 425, 250, 180, and 150 μm, respectively, using an Advantech Tap sieve shaker DT168 model (Advantech Manufacturing, New Berlin, WI, U.S.A.). The weight of sample retained over each sieve was recorded and expressed as g/100 g. Two grams of semolina, amaranth flour blend, or semolina–amaranth mix were mixed with 20 mL of deionized water. The mixture was periodically stirred, centrifuged (8000 × g, 15 min) and decanted, and the difference in weight was reported as water absorption capacity (Ayo, 2001). The pasting properties of SEM, AFB, and their mixes were studied by using Rapid Visco Analyzer (RVA Super-4 model, Newport Scientific Pvt. Ltd, Australia). The viscosity profiles were recorded using sample suspensions consisting of 3.5 g (14 g of water/100 g) of sample milled with a Cyclotec mill model 1093 (Foss Tecator, Häganäs, Sweden) and 25 mL of water. The sample was heated from 50 to 95 °C at 6 °C per min after equilibrium time of 1 min at 50 °C and holding time of 2.5 min at 95 °C. The cooling was carried out from 95 to 50 °C at 6 °C per min with a holding for 2 min at 50 °C. Each test was completed in 13 min.

2.3. Physical dough properties

The mixing characteristics of SEM, AFB, and their mixes were evaluated with the National Mixograph (National Manufacturing Co., Lincoln, NE) using a 10 g sample (14 g of water/100 g) maintaining the water addition in 5.8 g/10 g. The proportion of raw to popped amaranth flour in the AFB to replace semolina in the pasta making was chosen according to preliminary tests. The 90:10 proportion AFB showed good dough consistency and more closely resembled that of semolina dough, therefore, this was used to replace semolina for the assays. The percentages of AFB in the mixes were 25, 50, and 75 g/100 g. Mixograms were determined by duplicate using the method 54-40A (AACC 2000) and they are shown in Fig. 1A–E. The moisture and protein content of the SEM and the AFB were 9.2 g/100 g and 12.1 g/100 g, and 8.8 g/100 g and 14.2 g/100 g, respectively. Other quality characteristics of SEM were 0.62 g of ash/100 g and gluten index of 11 g/100 g.

2.4. Pasta manufacture

Pastas were made in a pasta machine (Columbian Home Products, Terre Haute, IN, Item # 330-54) with AFB to SEM ratios of 25:75, 50:50, and 75:25. Semolina pasta was also prepared for comparison. Two batches of these blends (280 g each, 14 g of water/100 g) were mixed at room temperature with 1.2 g distilled monoglycerides/100 g and 9 g egg white powder/100 g in a Kitchen Aid Mixer model MK 45 GPWH (Kitchen Aid, St. Joseph, MI) at low speed (set 1) for 1 min, and 50 g of warm distilled water (42–44 °C)/100 g was slowly added and mixed for ten more minutes. Afterward, the dough was allowed to rest for 30 min in a proofing chamber model C (National Mfg. Co., Lincoln, NE) at 30 °C and 95% rh. Firstly, the proofed dough was laminated in the pasta machine at setting 1, and finally at setting 3. The pasta was hand cut into strips approximately 20 cm long (fresh pasta) using a scissor and dried at 95 °C and 91% rh for 45 min (dried pasta) in an Enviro-Pak oven model Micro-Pak Series MP500 (Enviro-Pak, Clackamas, OR). These drying conditions were set in preliminary tests. The use of lower drying temperatures did not favor the stability of the product. The five pasta samples were allowed to cool, placed in individual sealed containers to avoid moisture exchange, and stored at room temperature until analyzed.

2.5. Pasta analysis

Physical (thickness and color), proximate composition, gluten content, cooking quality, and texture analyses of the pasta were carried out according to official methods (AACC, 2000; AOAC, 2000), Abecassis, Faure, and Feillet (1989), and Marti et al. (2010). A brief description of these methods is given in subsequent subsections.

2.5.1. Physical characteristics

The raw pasta samples (dried pasta) were characterized according to thickness and color. Thickness measurements of ten strips of each pasta were taken with a digital caliper model 14-648-17 (Fisher Scientific de Mexico, S.A de C.V., Monterrey, Mexico) and the average was reported. Also, color measurements on fresh (before drying) and cooked pasta samples were carried out according to Mariotti et al. (2011) using a Minolta colorimeter model CR-400 (Konica Minolta Sensing Americas, Inc., Ramsey, NJ). Results were expressed in the CIELAB space as L^* (lightness; 0 = black, 100 = white), a^* (+a = redness, −a = greenness) and b^* (+b = yellowness, −b = blueness) values. The colorimeter calibration parameters L^*, a^*, and b^* were 97.11, −4.83, and 7.02, respectively.

2.5.2. Proximate analysis of the raw pasta

Moisture (method 934.01), ash (method 942.05), total protein by the micro-Kjeldahl method (%N × 6.25), and fat content (method 920.39) were quantified according to AOAC (2000), and carbohydrates content were determined by difference.

2.5.3. Gluten content

Gluten content of the final products was quantified by the Ridascreen® gliadin kit (R-Biopharm, Darmstadt, Germany) which uses anti-R5 antibodies as recommended (Codex Alimentarius Comission 2008).