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Bioactives-retained non-glutinous noodles from nixtamalized Dent and Flint maize

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ABSTRACT

Nixtamalization is a well-known pre-treatment technique in the tortilla industry. Nixtamalized maize (nixtamal) is known for its modified physicochemical as well as nutritional attributes. In the present study, two types of nixtamalization processes (traditional and ecological) were employed for the development of whole-grain-maize-based noodles using Dent and Flint maize genotypes. Results showed that ecological nixtamalization had resulted in better cooking and textural qualities of noodles compared to the one prepared traditionally. Dent maize noodles from traditional and ecological nixtamalization had lower retention of phenolics (40 and 64%, respectively) whereas, Flint maize noodles retained 50 and 66% phenolics, respectively. Dent maize noodles had undergone phenolics loss of 5–6% on cooking while those of Flint maize lost only 2%. Ecological nixtamalization maintained the pH of the cooking liquor within an acidic-neutral range and yielded noodle with higher retention of phenolics whereas, the traditional process negatively affected the antioxidant compounds and their properties.

1. Introduction

Noodles are one of the many convenience foods considered to symbolize long life and good luck in Asian culture. Wheat is the principal cereal grain that is extensively used for the production of traditional noodles through the processes of mixing of raw materials, sheeting of dough and cutting in form of strands. However, wheat is not considered safe for the people suffering from celiac disease because of its major constituent protein-gluten. On the contrary, the absence of gluten from the other cereals makes it challenging to develop noodle and similar products. In the recent past, a great deal of efforts was made to develop alternate rice-based products comparable in quality to wheat-based foods. However, the primary research was focussed on baked products such as bread. Therefore, the need arises to pay exclusive attention to the products like noodle that is the second most consumed foods in the world, next to the bread. Many researchers have endeavoured to develop gluten free noodles from rice and other non-glutinous sources using cold extrusion process (Ahmed, Qazi, & Jamal, 2015; Hormdok & Noomhorm, 2007; Kumar & Singh, 2011), but data on maize noodle is scarce in the literature.

Previous studies showed that prolamin polymers are formed in maize on cooking (Ezeogu, Duodu, Emmambux, & Taylor, 2008). Zein, a prolamin protein of maize, polymerizes as a result of disulphide bonding during cooking (Emmambux & Taylor, 2009). Guzmán, Flores, Feria, Montealvo, and Wang (2011) showed that nixtamalization (lime cooking of maize) polymerizes maize protein through calcium bridges via calcium-zein and zein-calcium-zein interactions, in addition to disulphide bonding. Calcium bridges are difficult to disrupt and result in thermo-resistance of the protein. The combined effects of lime on starch cross-linking, the formation of zein polymers and calcium-zein interactions during cooking, yielded a stronger and more elastic gel structure. Hence, it was hypothesized that the use of nixtamalization in the processing of maize to develop whole-grain-non glutinous noodle may have a clear implication on the product's desirable quality.

However, the phytochemical profile of foods as affected by processing becomes an important issue (Chávez-Santoscoy, Gutiérrez-Uribe, Serna-Saldivar, & Perez-Carrillo, 2016). Phenolic phytochemicals are a significant group of antioxidant in maize. Processing of cereals and legumes may enhance or reduce the levels of phenolic compounds in foods, their bioactive properties and development of undesirable colour (Emmambux & Taylor, 2009). Investigations on nixtamalization on phytochemical profile

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revealed the leaching of phenolics in the nejayote (cooking liquor). However, it was also documented that nixtamalization releases bound phenolics associated with cell walls due to alkaline hydrolysis (de la Parra, Serna Saldivar, & Liu, 2007; Pozo-Insfran, Serna Saldivar, Brenes, & Talcott, 2007). Carrera et al. (2011) used ecological nixtamalization (use of calcium salts) for tortilla production and found lesser solid loss in cooking liquor. In a similar study, Méndez, Cárdenas, Gómez, and Lagunas (2013) found that the ecological nixtamalization maintains slightly acidic or neutral medium that is desirable for phenolics and retains a higher proportion of the pericarp.

Hence, in the present study whole grain maize noodle with minimalized loss of bioactive phenolic compounds was developed from nixtamalized (traditional and ecological) Dent and Flint maize.

2. Materials and methods

2.1. Materials

Dent and Flint maize, chosen from the Kharif crop of 2010 grown in India, were kindly provided by Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India, and were stored at 5–7 °C before use. The Folin Ciocalteu reagent, phenolic acid standards, trolox, DPPH, catechin and ferrozine were purchased from Sigma-Aldrich (St. Louis, MO). Hydrogen peroxide was used from a fresh bottle and was purchased from Merck Specialities Private Limited, Mumbai, India. Sep-pak C_{18} cartridges were purchased from Waters Corporation, Milford, Massachusetts, USA. Solvents used for HPLC analyses were of HPLC grade. Calcium carbonate (Ca-salt used in ecological nixtamalization), methanol, sodium carbonate, potassium ferricyanide, TCA, ferric chloride, sodium nitrite, aluminum chloride, potassium persulphate and other solvents and acids were of analytical grade, whereas triple distilled water was used wherever necessary.

2.2. Nixtamalization processes

Traditional and ecological nixtamalization processes were performed as per the method of Carrera et al. (2011) with some modifications. For traditional nixtamalization, 1 kg of maize was boiled in 2 L of water and 1% (w/w) calcium hydroxide solution for 23 min. The cooked grains were steeped for 16 h at room temperature before the cooking liquor was decanted and collected. The cooked maize called nixtamal was then rinsed with purified water to eliminate the excess calcium hydroxide and dried in a hot air oven at 50–55 °C to a moisture level of 10–12%. In the ecological nixtamalization process, calcium carbonate was used instead of calcium hydroxide.

2.3. Flour preparation

The resulting nixtamal obtained from the above traditional and ecological nixtamalization processes was ground to flour in a hammer mill and passed through 150 μm (100 mesh) screen, packaged in polyethylene bags and stored in a cold room at 4 °C until use. Whole grain Dent and Flint maize (at a moisture level of 10–12%) were also milled to flours through the above method to use them as control flours. There were totally three types of flours for the preparation of noodle *viz.* CF (control flour), TF (traditional-nixtamalized flour) and EF (ecological-nixtamalized flour) from each of Dent and Flint maize.

2.4. Noodle preparation

Flour from control and nixtamal was used to prepare noodles. Flour and tapioca starch in a proportion of 98:2 was taken and mixed with gum Arabic (0.3%, w/w), salt (2%, w/w), sodium bicarbonate (0.2%, w/w) and purified water (300 mL) for 2 min in a laboratory model Hobart dough mixer (Hobart Corporation, model # N50CE, Troy, Ohio, USA) at a speed of 60 rpm to obtain a homogeneous dough (~30% moisture content). The dough was then extruded through a low-pressure, single-screw extruder (La Prestigiosa 4500, Italy) in the form of a noodle strand followed by steam-cooking (open atmosphere) in an autoclave for 30 min, dried in a hot air oven at 50–55 °C for about 2 h and packed in polyethylene pouches. A total of six noodle samples were prepared from three types of flours of Dent and Flint maize. These are CN (control noodle) of Dent and Flint maize, TN (traditional-nixtamalized noodle) of Dent and Flint maize and EN (ecological-nixtamalized noodle) of Dent and Flint maize.

2.5. Viscoamylography analysis

The gelatinization temperature and viscosity of the control, nixtamalized flour and noodle flour were measured in a Micro Visco-amylograph (Model No. 803202, Brabender, Duisburg, Germany). A 13% slurry was heated from 30 to 92 °C at the rate of 7 °C/min and held at 92 °C for 5 min followed by cooling to 50 °C with 1 min holding. The pasting curves obtained were measured for the pasting parameters *viz.* peak viscosity or PV (maximum viscosity during heating phase), hot paste viscosity or HPV (minimum viscosity at 92 °C), cold paste viscosity or CPV (final viscosity at 50 °C), break down viscosity or BD (PV-HPV) and total set back viscosity or SBt (CPV-HPV) and were recorded as Brabender unit (BU).

2.6. Instrumental colour measurement

The colour of uncooked noodles was measured with Labscan-XE (Reston, USA) equipped with D-65 illuminant with 10° view angle and a slit width of 2 mm. All the samples were subjected to five measurements, and the average value was reported. The colour parameters are indicated as L^* (lightness/brightness dimension), a^* (red-green) b^* (yellow-blue) values.

2.7. Instrumental texture analysis

The 3-point bending rig of texture measuring system (TA-HD Plus, Stable Micro Systems, Surrey, UK) having a round end blade was used with a gap of 25 mm between the bridge supports. The fracture force of the dried uncooked noodle was determined employing compression test at a crosshead speed of 1 mm/s using a 50 kg load cell. The distance travelled by the blade was up to 26.5 mm to ensure complete failure during testing. Five samples were examined each time, and the experiment was repeated twice (Devisetti, Ravi, & Bhattacharya, 2015). A wheat noodle sample procured from the local market was also analyzed alongside to compare the results.

2.8. Cooking quality of the noodles

Cooking quality of the maize noodles was analyzed according to AACC method (AACC, 2011). Noodle strands were cut to approximately 5 cm by length. The strands (25 g) were cooked in 250 mL of boiling water. At an interval of every 30 s a noodle strand was examined by pressing between two glass slides to check the disappearance of the white core indicating complete cooking. Once the optimum cooking time was determined, fresh batches of sample