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Nutritional and physico-chemical properties of flour from native and roasted whole grain pearl millet (*Pennisetum glaucum* [L.]R. Br.)

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ABSTRACT

The effect of roasting on the nutritional and physico-chemical properties of pearl millet flour was investigated. Pearl millet grains were subjected to different temperature-time conditions (120 °C, 140 °C for 5, 10 and 15 min and 160 °C, 180 °C for 3, 5 and 10 min). The samples were milled into flour and analyzed for their nutritional composition, amino acid profile, phenolic content and functional properties using standard methods. Protein, total ash and crude fiber contents of the flours ranged from 7.40 to 8.38%, 1.68–2.21%, 0.50–1.06%, respectively. Lysine and methionine ranged from 0.10 to 0.26 g/100 g protein, 0.01–0.06 g/100 g protein, respectively. Potassium was the dominant mineral in all samples and samples roasted at 180 °C for 10 min had the highest iron content. Roasting increased the water solubility index and oil absorption capacity of the flour samples. An increase in roasting temperature led to a significant decrease in the phenolic content of the samples. Roasting reduced some of the nutrients of the pearl millet flours and increased their functional properties.

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1. Introduction

One of the globally grown cereals is millet and it is characterized with different importance across continents and within regions of the world. Nine species of millet has been identified as major sources of energy and protein for about 130 million people in Sub-Saharan Africa but among these only four are produced significantly in Africa which includes pearl millet, finger millet, teff and fonio. Nigeria was the 2nd top producer of millet in 2009 with total production of 4.8 MT (FAOSTAT, 2014) and the crop is a major source of kilocalories and vital component of food security in the developing world (ICRISAT, 1996). The most important millets are pearl millet (*pennisetum gluacum*), proso millet (*Panicum miliaceum)*, finger millet (*Eleusine coracana*) and foxtail millet (*Setaria italic*). The Ex-Borno is one of the improved, recommended and locally available variety among the pearl millet variety available in Nigeria (Ojediran et al., 2010). The grain is processed in many ways for preparation of various food products, some of the resultant products of millet processing are; *kununzaki*, *tuwo* and *fura* the grains are also cooked whole and made into thin and thick porridges. *Fura* is obtained by grinding pearl millet into flour, rolling into large balls, parboiling and liquefying into a watery paste with fermented milk while *tuwo* is a stiff porridge made from pearl millet. *Kununzaki* is produced by steeping pearl millet in water for about 24 h after which is wet milled and sieved. The sediment is divided into two, a part is cooked and ten added to the uncooked part and the mixture is allowed to ferment for 8–10 h (Efiuvwevwere and Akoma, 1995).

Roasting is a simple and a commonly used household technology which has been reported to improve the edibility and digestibility of grains, reduce their antinutrient and prevents the loss of nutritious components (Huffman and Martin, 1994). Singh and Singh (2012) reported a study where a significantly higher net protein utilization from roasted composite flours of sorghum, pearl

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millet, finger millet, chicken peas and green gram was recorded as compared to dehulled, boiled, malted and baked composite flours.

Roasting has been reported to increase iron bioavailability in weaning foods prepared with other millet species such as barnyard and finger millet (Gahlawat and Sehgal, 1994). Also, the technology of roasting has been used to increase the utilization of many cereals such as maize, oat, sorghum e.t.c but information on the effect of roasting at different temperatures and times on the properties of flour from pearl millet "Ex Borno variety" is scarce in literature. Thus, this study evaluated the effect of different roasting temperatures and times on the nutritional and physico chemical properties of roasted pearl millet flour.

2. Materials and method

2.1. Materials

Pennisetum glaucum L.R.Br. variety locally recognized as 'Ex-Borno' which were harvested in 2013 (Kharif) were purchased from Osiele market in, Abeokuta, Nigeria. Upon harvesting and prior to sale, the grains were stored in jute sacks which were placed in a dry and well ventilated storage room for two months. The purchased grains were then transported to the laboratory and were visually inspected for shafts, foreign objects, stones and defective grains, which were discarded after winnowing and handpicking. They were kept in airtight polyethylene containers in a dry and cool environment for 2 days.

2.2. Sample preparation

Roasting temperature and time range used for sample preparation were based on previous roasting studies of Ranganathan et al. (2014) for sorghum flour and also preliminary test which showed that higher temperature than 180 °C promoted an unappealing colour change in pearl millet. 500 g of pearl millet grains were weighed and roasted at: 120 °C (5, 10 and 15 min), 140 °C (5, 10, 15 min) 160 °C (3, 5, 10 min) and 180 °C (3, 5, 10 min) in and electric pan with controlled temperature (FP-10A, Sunbeam, New Zealand). After roasting, the samples were brought to and stored under room temperature (26 ± 2 °C) in a cool dry place. The roasted samples were milled using hammer mill (Henan Allways, China) and were sieved through a 250 μm mesh screen to obtain roasted whole pearl millet flour. Also, the retentates were grinded repeatedly and passed through the 250 μm mesh screen to ensure that the pearl millet flour is maximally recovered and of uniform particle size. Native whole pearl millet flour was used as control and all the samples were subjected to analysis.

2.3. Methods

2.3.1. Nutritional composition

The roasted millet flour samples were analyzed for their proximate composition namely; moisture, ash, fat, protein and crude fiber using method number 931.04, 923.03, 945.38, 2001.11, 985.29, respectively (AOAC, 2010). The moisture contents of native and roasted pearl millet flour were determined after drying at 100 °C for 24 h. Kjeldahl method was employed in determining the protein content and lipid was extracted with petroleum ether with intermittent reflux for 16 h with a boiling range between 35 and 50 °C, using a Soxhlet apparatus. Ash contents (gravimetric) were determined based by ashing the samples at 500 °C for 6 h. Crude fiber content was determined by acid/alkaline hydrolysis of insoluble residues. Total carbohydrate content was calculated by difference and the energy value of the sample was calculated by applying factors 4, 9, and 4 for each gram of protein, lipid, and carbohydrate, respectively according to the method of Shrestha and Noomhorm (2002)

2.3.2. Mineral content

The mineral compositions of the samples were determined using the principles of flame photometry, atomic absorption spectrometry and colorimetry as described by AOAC (2005). 1 g of sample was measured into a digesting glass tube and 12 ml of nitric acid was added and it was allowed to stand overnight at room temperature after which 4 ml perchloric acid added. The mixture was digested in a fume block whose temperature was allowed to increase to 300 °C. The presence of white fumes within 85 min indicated complete wet digestion and the mixture was allowed to cool down and made up to 100 ml with distilled water. Magnesium, calcium and iron were analyzed, using Atomic Absorption Spectrophotometer (AAS, Buck Model 20A, Buck Scientific, East Norwalk, CT06855, USA). Elements standards were ran on the equipment to ensure accuracy and the dilution factor (df) of magnesium was 10,000 while the df of iron and calcium was 100 but 1.0 ml lithium oxide was added to the original solution to unmask magnesium from calcium. The concentration of the minerals that were recorded in ppm was converted to milligrams by multiplying the ppm with dilution faction and dividing by 100. A flame photometer (Model PFP 7, Jenway, UK) was used to measure the concentration of potassium in the digested solution while phosphorus was determined by the phosphovanado-molybdate (yellow) colorimetric method where 12 g of ammonium molybdate solution was mixed with 250 ml of distilled water (A) and 0.29 g of antimony potassium was dissolved in 500 ml of 5N sulphuric acid and made up to 1000 ml (B). A and B were mixed and made up to 2000 ml while 0.739 g of ascorbic acid was mixed with 140 ml of mix reagentto make colour reagent. 1 ml of digested sample was made up to 5 ml with distilled water and 5 ml of colour reagent was added to this volume and they were made up to 25 ml which turned blue afterwards. The df was 2500 (100 × 25) and the final blue solution was measured with the spectrophotometer.

2.3.3. Amino acid profile

One gram of sample was dissolved in 20 ml of 6N HCL and this was then poured into a hydrolysis tube with screw cap and hydrolyzed for 22 h under a nitrogen atmosphere. The acid was evaporated using a rotary evaporator (R-1001-VN, Great Wall, China) and residue washed three times with distilled water. The extracted sample was dissolved in 1 ml acetate buffer of pH 3.1. After dilution to a known volume, the hydrolysate was transferred into a high performance amino acid analyzer (Sykam-S7130, Biokal, Germany) based on high performance liquid chromatography technique. The amino acid composition was calculated from the areas of standards obtained from the integrator and expressed as percentages of the total protein.

2.3.4. Swelling capacity and water solubility index

The swelling capacity and water solubility index were determined as described by Lan et al. (2008). A starch suspension in water (2%, w/v) was incubated in a water bath for 30 min at various temperatures ranging from 50 to 90 °C. The suspensions were centrifuged at 980 g for 15 min in a centrifuge (Hettich Zentrifugen Company, Germany), the supernatant was removed and the sediment was weighed. Aliquots of supernatant were dried in an oven at 105 °C till constant weight. The Swelling power (g/g on dry weight basis) and water solubility index (%) were calculated. Swelling power is equal to sediment weight × 100/starch x (100% − %total mass of dried supernatant) while solubility index is equal to total mass of dry supernatant/starch × 100%.

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