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Nutritional implications and flour functionality of popped/expanded horse gram

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Abstract

Utilization of horse gram and its flour in legume composite flours and products is limited due to the presence of antinutritional components, poor functional and expansion properties. Enzymatic treatment was used to improve the expansion and functional properties of horse gram to facilitate its use as an ingredient in food processing. Xylanase-mediated depolymerization of cell wall polysaccharides of horse gram lead to the development of a new expanded/popped horse gram. Expansion process of enzyme treated horse gram resulted in increased length (5.3–6.8 mm) and higher yield of expanded grains (63–98%). The expanded horse gram had lower bulk density, higher protein digestibility and more resistant starch compared to the control raw grains. Dietary fibre content of raw and processed horse gram was in the range of 14.57–16.14%. High temperature short time (HTST) conditions used during expansion process lowered the levels of phytic acid, tannins and protease inhibitors by 46%, 61% and 92%, respectively. The flour obtained from xylanase treated and expanded horse gram had higher water (204.3 g/100 g) and oil absorption capacities (98.4 g/100 g) than unprocessed flour, which had 135.8 g/100 g and 74.6 g/100 g, respectively at ambient conditions. There was a decrease in foaming capacity and foam stability in expanded gram flour. However, emulsion stability increased significantly in the processed samples. Thus, the study indicated that nutritional value and flour functionality of horse gram could be improved by processing it into a new expanded product that can be used as an ingredient in food processing.

Keywords: Horse gram; *Macrotyloma uniflorum*; Xylanase; Popped legume; Expanded dhal; Protein digestibility; Antinutritional factors; Functional properties

1. Introduction

Horse gram (*Macrotyloma uniflorum*, previously *Dolichos biflorus*) is a minor, under-exploited legume of tropics and subtropics grown mostly under dry-land agriculture. It is an important source of protein, iron and molybdenum. It has been identified as one of the potential food sources for the future by the US National Academy of Sciences (1979). It is extensively grown in India, mainly for animal feed. The use of dry seeds of horse gram as human food is limited due to its poor cooking quality, presence of high levels of enzyme inhibitors and heamagglutinin activities (Ray, 1969). The seed is reported to be high in tannins and polyphenols compared to other legumes (Kadam & Salunkhe, 1985). Horse gram is however, consumed as sprouts in many parts of India (Ghorpade, Kadam, & Salunkhe, 1986). Poor functional properties of horse gram are major limitations to use its flour in legume composite flours. Utilization of horse gram can be maximized through an understanding of its physical and chemical components and through the implementation of diverse processing strategies to facilitate the development of economically viable alternative products. Nutritional value and consumption of horse gram could be improved by processing it into a new product or ingredient that can be used in food processing.

Thermal processing has previously been suggested to improve the texture, palatability and inactivation of heat

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labile toxic compounds and enzyme inhibitors in legumes (Ghorpade et al., 1986). Popping of legumes by subjecting them to high temperatures for a short time (HTST) has been practiced in Asia, Africa and Latin America for many years. Chickpea is the most commonly puffed legume in many countries probably, because of its ideal cell wall polysaccharide composition, starch properties and relatively high content of oil. Popped kernels of chickpea and its flour are being used extensively in food processing. Similar to popped chickpea, popped horse gram may find applications in snack, confectionary and other traditional food industries. However, unlike chickpeas, cell wall polysaccharide and starch properties of horse gram renders it difficult-to-pop legume. Modification of cell wall polysaccharides by enzymatic hydrolysis may alter the cell wall structure and may lead to the popping of horse gram. The use of popped horse gram as ingredient for food processing is dependent on its functional and antinutritional properties. To convert expanded gram into flour for use as an ingredient in food processing, research must be carried out to ascertain the functional properties of the flour as well as the sensory qualities that would render the end product acceptable to consumers.

The present study is aimed at producing expanded/popped kernels and their flours from little-known legumes and explores the possibility of using them as ingredients for food processing. Specifically the study was carried out first, to prepare a popped/expanded horse gram by enzymatic modification of cell wall components and, second to evaluate the processing effects on nutritional quality and functionality of the popped horse gram flour. This is expected to give an insight into the possible utilization of popped horse gram and its flour in different food applications.

2. Materials and methods

2.1. Materials

The horse gram seeds were purchased from a local market in Mysore, India. Care was taken to purchase all the seeds from a single batch. The seeds were then taken to the laboratory in air-tight polyethylene bags, cleaned and kept in a cool and dry place prior to use. Crude xylanase from *Aspergillus niger* obtained from M/s. Kaypeeyes Biotech Pvt. Ltd., Mysore. This enzyme preparation is free from proteases and amylases. However, it does contain small amounts of hemicellulase and cellulase activities (<1% on unit basis). Termamyl was from Novozyme, Bagsvaerd, Denmark. Protease, amyloglucosidase, porcine pepsin and pancreatin were from Sigma Chemical Co., (St. Louis, MO, USA). All other reagents were of analytical grade.

2.2. Endo-xylanase assay

The activity of crude (1,4)-β-endo-xylanase from *A. niger* was assayed according to the method of Bailey, Biely, and Poutanen (1992). The reaction mixture containing 0.9 mL of 1.0% (w/v) xylan and 0.1 mL of a suitably diluted enzyme solution was incubated in 0.01 M sodium acetate buffer, pH 5.0 for 10 min at 50 °C. The reaction was stopped by adding 1 mL of 1.0% (w/v) dinitrosalicylic acid (DNS). The amount of reducing sugar liberated was determined by DNS method using xylose (Sigma) as standard. One unit of xylanase activity was defined as the amount of enzyme that produced 1 μmol of xylose equivalent per minute.

2.3. Endo-xylanase treatment of horse gram seeds

Seeds (100 g) were treated with optimized concentration of crude xylanase (2 U/g; w/w) in 300 mL of 0.01 M sodium acetate buffer, pH 5.0. This concentration was chosen after evaluating different concentrations of enzyme in the range of 0.5–5 U/g (w/w) on the expansion properties of horse gram. The enzyme treated seeds in a closed container were incubated at 50 °C in a rotary shaker (100 rpm) for 3 h. At the end of incubation time, the buffer was decanted. The enzyme reaction was terminated by treating the grains with 300 mL of 0.1 M sodium phosphate buffer, pH 7.8 and allowed to equilibrate in the same buffer at 50 °C in a rotary shaker (100 rpm) for 3 h. After equilibration, enzyme treated grains were separated from the buffer by decanting and dried at 70 °C for 7–8 h. Control samples were also subjected to the same processing treatments without adding xylanase and designated as untreated control.

2.4. Popping of horse gram seeds

The enzyme treated grains and untreated control grains were soaked in three volumes (w/v) of distilled water for 4–5 h to attain saturation. The grains at saturated moisture content (57.2%) were popped using hot sand (1:6) at a temperature ranging from 230 to 250 °C for a short time (20–30 s) (Kurian, 1981). Expanded horse gram was separated from the sand by sieving and husks were manually removed. Dehusked kernels were dried at 70 °C for 7–8 h. Dried and expanded kernels were used for determining the physico-chemical properties and powdered as described below.

2.5. Physico-chemical properties

The percentage of expanded grains was calculated by manually separating the expanded grains from unexpanded grains. Bulk density of raw and enzyme treated grains was determined by using the method of Okezie Onuma, and Bello (1988). Length, breadth and thickness of grains were measured using vernier calipers. Expansion volume was determined by measuring the volume of the sample before and after subjecting to expansion according to the method of Chen, Shyong, and Chang (1997).

Proximate composition was determined by the Association of Official Analytical Chemists (1975) methods. Total