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Extruded products with Fenugreek (*Trigonella foenum-graecium*) chickpea and rice: Physical properties, sensory acceptability and glycaemic index

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ABSTRACT

The present study investigated the effects of fenugreek flour (*Trigonella foenum-graecum*) and debittered fenugreek polysaccharide (FenuLife®) inclusion on the physical and sensory quality characteristics, and glycaemic index (GI) of chickpea–rice based extruded products. Based on preliminary evaluation with different proportions of chick pea and rice, a blend of 70:30 chickpea and rice was chosen as the control for further studies. The control blend, replaced with fenugreek flour at 2%, 5% and 10%, or fenugreek polysaccharide at 5%, 10%, 15% and 20%, was extruded at the optimum processing conditions as specified in the detailed study. The extruded products were evaluated for their physical (moisture retention, expansion, hardness, water solubility index (WSI) and water absorption index (WAI)), sensory (flavor, texture, color and overall acceptability) characteristics and *in vitro* GI to evaluate their suitability as extruded snack products.

Due to the distinct bitter taste, inclusion of fenugreek flour was not acceptable at levels more than 2% in extruded chickpea based products. Addition of fenugreek polysaccharide resulted in slight reduction in radial expansion ($P < 0.05$), while longitudinal expansion increased. WAI increased while WSI decreased compared to the control ($P < 0.05$). The mean scores of sensory evaluation indicated that all products containing fenugreek polysaccharide up to 15% were within the acceptable range. There were no significant differences ($P > 0.05$) between products containing 5–15% fenugreek polysaccharide in their color, flavor, texture and overall quality.

Fenugreek, in the form of debittered polysaccharide (FenuLife®) could be incorporated up to a level of 15% in a chickpea–rice blend to develop snack products of acceptable physical and sensory properties with low GI Index.

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1. Introduction

In recent decades, health benefits and physiological effects of leguminous seeds and spices have been highlighted in a number of studies based on experimental animals as well as on clinical trials (Srinivasan, 2005). Fenugreek (*Trigonella foenum-graecum*), a leguminous herb cultivated in India and North African countries, has been used as a spice worldwide to enhance the sensory quality of foods and also known for its medicinal qualities. Fenugreek seeds are reported to have restorative and nutritive properties and are shown to stimulate digestive processes (Khosla et al., 1995). The seeds have been shown to lower blood glucose levels and partially restore the activities of key enzymes of carbohydrate and lipid metabolism close to normal values (Basch et al., 2003; Srinivasan, 2006). Fenugreek seeds have been successfully tested in laboratory animals and in humans with both types 1 and 2 diabetes as a hypoglycemic agent (Sharma et al., 1990; Madar et al., 1988). Fenugreek seeds also have antioxidant activity and have been shown to produce beneficial effects such as neutralization of free radicals and enhancement of antioxidant apparatus (Anuradha and Ravikumar, 1998, 2001).

The health beneficial effects of fenugreek are attributed to its chemical composition (3–5% moisture, 25–30% protein, 20–30% galactomannan, 20–25% insoluble fiber, 7–9% lipids, 5–7% saponings and 3–4% ash) that include mucilaginous fiber, lysine-rich protein, free amino acids, saponins, flavonoids, and volatile oils (Raju and Bird, 2006). About 20% of fenugreek seed is gel-forming soluble fiber, similar to guar gum, oat bran and psyllium husk. The insoluble fiber, which constitutes 30% of fenugreek seed, is bulk-forming like wheat bran (Mathur and Mathur, 2006; Srinivasan, 2005).

Adding fenugreek fiber to refined flours helps to fortify with a balance of soluble and insoluble fiber. Flour fortified with 8–10% fenugreek fiber has been used to prepare bakery foods like pizza, bread, muffins, and cakes with acceptable sensory properties. (Srinivasan, 2005). However, no research has been carried out on effects of fenugreek inclusion in extruded products. Furthermore, the seeds possess a distinct aroma and a bitter taste which may

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limit wider application in the food industry without significant processing. It has been possible, however, to debitterize fenugreek seeds without compromising their beneficial properties and a debittered form of fenugreek polysaccharide extract (FenuLife®) is commercially available. Fenugreek polysaccharide mainly contains 75% soluble dietary fiber and 15% insoluble dietary fiber of its composition according to the FenuLife® product specification. Thus research into the effects of fenugreek inclusion during the extrusion cooking will be of interest.

Chickpea (*Cicer arietinum* L.) is another legume, grown in tropical and subtropical areas, that presents high potential as a functional ingredient for the food industry. The chickpeas contain moderately high protein (17–22%), low fat (6.48%), high available carbohydrate (50%) and crude fiber contents of 3.82% dry basis (Saleh and Tarek, 2006). The available carbohydrate is mainly starch which is reported to be slow digestible, thus eliciting low-glycaemic responses in human nutrition. Hence chickpea seeds can play an important role as a low-glycaemic functional ingredient in a healthy diet.

In view of the promising health benefits of fenugreek polysaccharides, fenugreek flour and debittered fenugreek polysaccharide were incorporated as natural functional ingredients in chickpea–rice blends to develop acceptable snack products utilizing extrusion technology. The choice of rice flour was due to its bland taste, its low protein content that could limit the non-enzymatic browning reaction rate and its good capacity of expansion (Sacchetti et al., 2004). Rice contains approximately 7.3% protein, 2.2% fat, 64.3% available carbohydrate, 0.8% fiber and 1.4% ash content (Zhoul et al., 2002). Extrusion was the choice of technology due to its versatility and ability to change the intrinsic taste, texture and structural characteristics of products.

The objective of the present study was to develop novel low GI extruded products with fenugreek using chick pea and rice as the base and to study the effect of the inclusion on the physical (moisture retention, expansion, WSI and WAI, hardness and color), sensory (flavor, texture, color and overall acceptability) characteristics and glycaemic index (GI) of extruded snack products.

2. Materials and methods

2.1. Raw materials

Chickpea flour, rice (Basmati variety) and fenugreek flour were purchased from local commercial suppliers. FenuLife®, a debittered fenugreek polysaccharide, was supplied by PhytoHealth Pty Ltd., Hornsby, NSW, Australia. Rice was ground in a hammer mill (Bisley's Farm Machinery, Auckland, New Zealand) to pass through a 2.5 mm screen. All chemicals used were analytical grade.

2.2. Extruder

Clextral BC 21 (Firminy Cedex, France) twin-screw co-rotating, self wiping extruder with length/diameter ratio of 25, screw speed up to 600 rpm and outer screw diameter of 25 mm was used. The screw configuration (from feed section to die) used to process the extrudates consisted of three sections with forward elements. First section had four elements each 50 mm length having three screw flights and 13 mm pitch. The second zone consisted with five elements each 50 mm in length having four screw flights and 10 mm pitch. Third zone again consisted with five elements each 50 mm in length having six screw flights with 7 mm pitch. The total length of the screw was 700 mm with 14 elements in three zones. The extruder was equipped with a bulk solids metering feeder (KTRON T20, Switzerland). A die with a single circular opening (2.5 mm diameter), equipped with a rotary die face cutter (speed of 130 rpm) was used.

2.3. Extrusion processing

2.3.1. Preliminary study

A preliminary extrusion trial was conducted with different proportions of chickpea and rice at 50:50, 60:40, 70:30, 80:20, 90:10 and 100:0, respectively, at a range of extruder conditions, temperature from 50 to 200 °C, water feed rate from 0.2 to 1.0 kg/h and screw rotation from 100 to 350 rpm). Based on the most stable product expansion and stability of the extruder conditions the extrusion conditions were used. The temperatures of the seven zones of extruder from the feeder end were set at 50, 50, 70, 110, 150, 150 and 160 °C, respectively. Samples were collected at the most stable die temperature which was around 118 °C. Screw speed was set at 300 rpm and the stable motor torque when running at the above set conditions was 2.8 N. The input feed rate was 25 kg/h and water feed rate was adjusted at 0.42 kg/h. The cutter (with one blade) speed was set to 130 rpm.

A complete randomized design was used in this study and the optimum ratio of chickpea and rice flour blend to be used as the base mixture in the detailed study with different levels of fenugreek flour or fenugreek polysaccharide was identified.

2.3.2. Detailed study – experimental design and conditions

Based on the results of the preliminary evaluation, a blend of 70:30 chickpea and rice flours was chosen as the control for further studies. Detailed studies were conducted at optimum processing conditions using the 70:30 chickpea–rice blend, replacing this blend with 2%, 5% and 10% fenugreek flour or 5%, 10%, 15% and 20% debittered fenugreek polysaccharide using a complete randomized design as the levels of two types of fenugreek were different. Due to the prominent bitter flavor of fenugreek flour 2–10% was used. However, fenugreek polysaccharide was possible to use at higher levels and in the view of incorporating highest possible level of fenugreek 5–20% was used. The optimum temperatures of the seven zones of extruder from the feeder end were of 50, 50, 70 110 150, 150 and 160 °C, respectively, and the die temperature were set at 118 °C. Screw speed was set at 300 rpm and torque was of 2.8 N. The input feed rate was 25 kg/h and water feed rate was adjusted at 0.42 kg/h. The cutter speed was set to 130 rpm.

Extrudates were collected over a period of 3–5 min, during which time the main extrusion variables showed maximum stability. The extrudates were collected and allowed to cool to room temperature. The samples were packed into hermetically sealed polyethylene bags and stored at room temperature until analysed.

2.4. Product analysis

2.4.1. Moisture retention

The moisture content (dry basis) of the feed and extruded samples was determined by AOAC method 925.10 (AOAC, 2005). Moisture retention (%) was calculated using Eq. (1).

$$\text{Moisture retention} = \text{product moisture}/\text{feed moisture} \times 100 \tag{1}$$

2.4.2. Expansion ratio

The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate (Fan et al., 1996a). The diameter of extrudate was determined as the mean of 10 random measurements made with a Vernier caliper. The extrudate expansion ratio was calculated using Eq. (2).

$$\text{Expansion ratio} = \text{extrudate diameter}/\text{die diameter} \tag{2}$$

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