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Effects of gamma irradiation on the physicochemical, thermal and functional properties of chickpea flour

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A R T I C L E I N F O

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The physicochemical, functional and thermal properties of the chickpea flour treated with 0.5, 1, 2.5, 5 and 10 kGy irradiation dose at the rate of 0.5 kGy/h were investigated. Results showed that the proximate composition of the flour did not change significantly. However, pasting properties showed a significant ($p \leq 0.05$) decrease in peak viscosity, final viscosity, setback viscosity, trough viscosity and pasting temperature as the dosage increased. Swelling, syneresis and solubility improved with dosage. Oil absorption capacity and water absorption capacity increased significantly with dosage from 1.03 to 1.45 and 1.56–2.63 g/g of flour respectively. pH decreased significantly with dosage. Gelatinization temperature increased, while as enthalpy decreased significantly. Texture profile properties also decreased with dosage.

1. Introduction

Chickpea or bengal gram (*Cicer arietinum*) flour, locally known as besan is an important legume flour in terms of economic importance and a key source of carbohydrates and proteins in the diet of people particularly in India, Pakistan, Afganistan and Turkey (Singh & Jambunathan, 1981; Kaur & Singh, 2005). When mixed with an equal proportion of water, it can be used as an egg-replacer in vegan cooking because of its high protein content (Bashir et al., 2012; Tetrick et al., 2014). Chila, a pancake made with gram flour batter, is a popular street and fast food in India. Chickpea cultivars are broadly divided into two groups, desi and kabuli. Kabuli seeds are large and light coloured grains, and are characterized by their larger size, ram-head shape and low fibre content (Singh, Subrahmanyam, & Kumar, 1991; Kaur & Singh, 2005). The seeds of desi cultivars are small, wrinkled at beak, with brown, black or green colour. Legumes have been considered as the most significant food source for people of low incomes. Chickpea is the world's third most important grain legume after beans and peas (Kaur & Singh, 2005).

The physiochemical and functional properties of the legume flours change with post-harvest handling and storage conditions resulting in the reduction of their cooking, eating, nutritional quality and consumer acceptance as well (Singh, 2001). Since, legumes are meant to kept for long durations but a storage induced defect *hard to cook* occurs because of the interaction between pectinolytic enzymes with pectin and phytic acid and results in increased stability of middle lamella upon cooking and thus seeds fail to soften after cooking (Chhinnan, McWATTERS, & RAO, 1985; Singh & Rao, 1995; Gulati & Singh, 1998). The chickpea consumption can be improved by converting it into flour, as it could meet the nutritional requirements of the consumers, especially in the developing nations (Dzudie & Hardy, 1996; Njintang, Mbofung, & Waldron, 2001). Interest in the consumption of legume flours is growing (Siddiq, Ravi, Harte, & Dolan, 2010) particularly because of their functional properties viz, foaming, emulsification, texture, viscosity, gelation, water and oil absorption capacities (Adebowale & Lawal, 2004; Singh, 2001). The functional properties of legume flours are not only because of the proteins but pectins, mucilages and other complex carbohydrates also play a key role (Wani, Sogi, & Gill, 2013). The functional properties of the legume flours are directly or indirectly altered during various unit operation processes which affect the food quality and ultimately their acceptance and utilization in food and food formulations (Mahajan & Dua, 2002). The application of legume flours as functional ingredients in some foods such as breads, pasta, cakes biscuits, doughnuts and snacks has been reported by several researchers (Petitot, Boyer, Minier, & Micard, 2010; Han, Janz, & Gerlat, 2010).

Gamma irradiation modifies the physical and chemical properties of macro-compounds in foods via free radicle mechanism.

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Nene, Vakil, and Sreenivasan (1975) reported that gamma irradiation reduced the gelatinization viscosity of the starch extracted from red gram. Rao and Vakil (1983) studied the effects of gamma irradiation on the flatulence causing oligosaccharides (stachyose, verbascose and raffinose) in green gram, they reported that the oligosaccharide content was reduced due to fragmentation in the polymeric chains. Similar results were reported by Rayas-Duarte and Rupnow (1993), for northern bean starch with increased maltose content due to the fragmentation and hydrolysis of starch molecules. Graham, Panozzo, Lim, and Brouwer (2002) revealed that the gelatinization properties and viscosity of the chickpea decreased as the dose increased, besides increasing the cooking quality (degree of softness). Similar reports were reported by Rombo, Taylor, and Minnaar (2001), 2004). Abu et al., (2005) studied the effect of gamma irradiation on the functional properties of the cowpea, they reported that the swelling and pasting properties decreased while oil absorption capacity increased significantly. Several other studies have revealed a reduction in viscosity, cooking time, increased digestibility, increased amino acid content in various pulses (Nene et al., 1975; Rao & Vakil, 1985; Afify & Shousha, 1988; Aurangzeb, Badshah, & Bibi, 1990; Diop, Marchioni, Ba, & Hasselmann, 1997; Falade & Kolawole, 2013). India being the number one producer of the chickpea, but due to poor postharvest management about 30–40% of cereals and pulses are wasted by insects, pests, microbes, rodents etc. Although, several processing techniques have been used to prevent the infestation of the grains. In this study gamma irradiation of the chickpea was carried out to study its effects on the physical, chemical, thermal and functional properties of the chickpea flour, which is very limiting.

2. Materials and methods

2.1. Materials

The chickpea grains were procured from the local supplier and were then milled and ground in the local flour machine. The flour was then packed into airtight 300g polyethylene pouches of food grade, purchased from the registered suppliers. All the chemicals used in this study were of analytical grade.

2.2. Gamma irradiation treatment

The packed chickpea flour was subjected to five different doses of gamma irradiation viz, 0 (un-irradiated, used as control), 0.5, 1, 2.5, 5 and 10 kGy using cobalt-60 as source irradiator with a dose rate of 0.5 kGy/h at room temperature of 23 ± 2 °C. The irradiation treatments were performed at Shri Ram Institute for Industrial Research, New Delhi, India.

2.3. Physicochemical properties

2.3.1. Composition

Moisture, Ash, Fat, Protein, Moisture and Crude fibre content were determined as per the AOAC standards (1990). Carbohydrate content was calculated by difference method (Kaur et al., (2005). All the samples were analysed in triplicates.

2.3.2. Color

Colour of the gamma irradiated flour was determined by Colorimeter (Hunter Lab D25 LT) on the basis of L, a and b values. The equipment was calibrated each time the irradiation dosage changed using white color standard tile. The total colour difference (ΔE) was calculated by applying the equation:

$$\Delta E = \sqrt{(L^* - L)^2 + (a^* - a)^2 + (b^* - b)^2}$$

where the L value indicates the lightness, its value range from 0 to 100, a value gives the degree ofthe red–green colour, with a higher positive a value indicating more red. The b value indicates the degree ofthe yellow–blue colour, with a higher positive b value indicating more yellow (Kaur & Singh, 2005).

2.3.3. pH of the flour

The pH of the each sample was determined using digital pH meter (LAB India). For pH measurement 1g of sample was mixed with 25 mL distilled water at 23 ± 2 °C (Wani et al., 2014). Three data points were recorded for each sample.

2.3.4. Bulk density

The flour samples were gently filled into 10 mL graduated plastic cylinders. The bottom of the cylinder was gently tapped on a laboratory bench covered with foam several times until there was no further diminution of the sample level. The weight of the sample was calculated and the bulk density was calculated as weight of sample per unit volume of sample (kg/m^3) (Kaur et al., 2005).

2.3.5. Swelling index and solubility index

Swelling and solubility index of the samples were performed as per the method of Wani et al., (2014) with slight modifications. Preweighed centrifuge tubes were filled with flour samples (2.5 g), dispersed in 30 ml of distilled water. The suspension was vortexed for 1 min. All the suspensions were then heated in water bath for 30 min at 50 °C with regular vortexing after every 5 min. The samples were then cooled to room temperature and centrifuged at 4500 rpm for 15 min. The supernatant was decanted in to preweighed moisture dishes and were dried at 110 °C for 12 h and then cooled to room temperature in desiccator, the gain in weight of the moisture dishes represents the solubility index (solid content). The gain in weight of the centrifuge tubes was expressed as swelling index. Similarly, solubility and swelling index were calculated at 60, 70, 80 and 90 °C for all the samples. All the data were taken in triplicates.

2.3.6. Light transmittance (%)

Light transmittance as done as per the procedure given by Sofi, Wani, Masoodi, Saba, and Muzaffar (2013), with slight modifications. 1% (db) of the sample was cooked in the water bath for 30 min with continuous stirring using magnetic stirrer. The suspensions were then cooled and the samples were stored at refrigerated conditions for five days and the transmittance was calculated after every 24 h at 640 nm against the distilled water as blank using UV-spectrophotometer (Inkarp Sican 2301). All the data were taken in triplicates.

2.3.7. Syneresis

Syneresis was determined by the modified method of Wani et al., 2014. 6% (db) of the sample for flour and heated at 90 °C for 30 min in a water bath (Khera Instruments Pvt. Ltd.) with constant stirring. The heated samples were stored in centrifuge tubes at refrigerated conditions for 5 days. Each day one sample from each treatment was subjected to centrifugation at 4500 rpm for 10 min and the per cent of the water released represented the syneresis. All the samples were analysed in triplicates.

2.4. Pasting properties

Pasting properties of chickpea flours were studied by using a