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Effect of partial replacement of wheat flour with varying levels of flaxseed flour on physicochemical, antioxidant and sensory characteristics of cookies

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ABSTRACT

Replacement of wheat flour with varying levels of flaxseed flour (0–30%) on nutritional, functional and antioxidant properties of cookies was investigated. Cookies produced from composite flour mixes were significantly ($p < 0.05$) higher in protein, fat, ash and fiber contents than the control. Flaxseed was found to be rich in antioxidant potential as evident from the higher total phenolic content, free radical scavenging activity and reducing power of composite flour cookies in comparison to control. The results indicated that as the concentration of flaxseed flour in the blend increased, the cookies became darker in color with a significant ($p < 0.05$) increase in their spread factor. Sensory panellists rated cookies containing 15% level of flaxseed flour as highly acceptable in relation to their overall acceptability scores. Beyond this level of replacement the texture and flavour of cookies was adversely affected. Principal component analysis revealed that physicochemical and sensory properties of cookies produced by 10% replacement with flaxseed flour were closest to the control cookies.

1. Introduction

Flaxseed (*Linum usitatissimum* L.) also known as linseed, is enjoying an upsurge in popularity as a result of reports on its health benefits to human and its potential to reduce the risk of certain diseases (Oomah & Mazza, 2000). The seed is oval and flat with a pointed tip and has a smooth glossy surface. It differs in dark brown to yellow in color according to its different varieties (Freeman, 1995). Flaxseed has a pleasant nutty taste with crisp and chewy texture (Carter, 1996). Although, flaxseed is an oilseed crop, but proximate composition of flaxseed makes it more beneficial for its utilization in various food products as a functional food ingredient. Flaxseed contains approximately 38–45% oil, 28% dietary fiber, and 21% protein (Daun, Barthet, Chornick, & Duguid, 2003). The functional components in flaxseed that provide health benefits include α-linolenic acid, lignans and dietary fiber (Hall, Tulbek, & Xu, 2006). Antioxidant activity of lignans may contribute to the anticancer activity of flaxseed (Kangas, Saarinen, & Mutanen, 2002; Prasad, 1997; Yuan, Rickard, & Thompson, 1999). Flaxseed is a rich source of different types of phenolic compounds such as phenolic acids, flavonoids, phenylpropanoids and tannins (Kasote, 2013).

The behavior of proteins in a food system is affected by their techno-functional properties which are mainly dependent on structure of the protein, their hydration mechanisms for solubility and water or oil retention capacity, rheological characteristics for viscosity and gelation, and their interfacial properties for emulsions and foams (Moure, Sineiro, Dominguez, & Parajo, 2006). The physico-chemical parameters such as temperature, pH, ionic strength and particle size have influence on the techno-functional properties (Dev & Quensel, 1986; Oomah, Kenaschuk & Mazza, 1995; Krause, Schultz, & Dudek, 2002; Martinez-Flores, Barrera, Garnica-Romo, Penagos, Saavedra & Macazaga-Alvarez, 2006). Flaxseed proteins have real potential for use as techno functional food ingredient in several food products particularly in breads, meat emulsions, and sauces. According to Oomah and Mazza (1998), compositional changes which occur during processing of flaxseed are to be kept in mind when adding value to flaxseed products. Rabetafika, Remoortel, Danthine, Paquot, and Blecker (2011) reported the comparison of functional properties of flaxseed proteins to those of other oilseed proteins. Rathi and Mogra (2013) studied the acceptability of biscuit making quality of flaxseed flour and found that the acceptable level of flaxseed flour in biscuit was 20–40% addition to wheat flour. Rajiv, Indrani, Prabhasankar, and Rao (2011) studied the effect of replacement of roasted and ground flaxseed (RGF) at 5–20% level on the wheat flour dough. The baking test of cookies showed a marginal decrease in spread ratio but beyond replacement of 15% RGF the texture and flavour of the cookies was adversely affected. Khouryieh and Aramouni (2012) investigated the physical and sensory characteristics of cookies prepared from varying levels of replacement of flaxseed

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flour (0–18%) with wheat flour. Alpaslan and Hayta (2006) suggested that flaxseed flour could be added to a typical snack formulation up to levels of 10% with a reasonable acceptance offering promising nutritious and healthy alternative to consumers. Though there have been previous reports on physical and sensory characteristics of flaxseed fortified cookies, but there has been a scarcity of reports on antioxidant potential of flaxseed and how much level is enhanced and losses which occur upon baking of flaxseed incorporated cookies. This prompted us to undertake the present investigation with the objective to evaluate the physical, chemical, sensory, and antioxidant characteristics of cookies containing various levels of flaxseed flour. Accordingly a level of flaxseed flour substitution to wheat flour was suggested with reasonable acceptable sensory scores and superior nutritive value and antioxidant potential than wheat flour cookies.

2. Materials and methods

2.1. Materials

Flax seeds and wheat flour were procured from the local market of Amritsar, Punjab, India. The seeds were ground in a laboratory grinder and the flour so obtained was stored in an air tight container till further used. All the chemicals and reagents used were of analytical grade.

2.2. Composite flour mixes

Besides the control sample (100% wheat flour), various blends of composite flour mixes (95WF:05FF, 90WF:10FF, 85WF:15FF, 80WF:20FF, 75WF:25FF and 70WF:30FF) were formulated and stored in air tight containers.

2.3. Preparation of cookies

Cookies were prepared from both the control sample and composite flour mixes using AACC method (1995). Formula adopted was shortening 32 g, sugar 70 g, salt 1 g, sodium bicarbonate 1.25 g, dextrose solution (8.9 dextrose in 150 ml distilled water) 16.5 g, distilled water 8 g and flour 112.5 g. Dough was prepared in pin mixture (Morse ED series, USA) and flattened into a sheet of 0.5 cm thickness. It was then cut with the help of a cookie cutter into circular discs of diameter 4.5 cm and transferred to a lightly greased baking tray. Cookies were baked at 200 °C for 11 min in a reel oven (National Mfg. Co. Lincoln, USA).

2.4. Proximate composition

The samples of flours and cookies were estimated for their moisture, ash, fat, crude fiber and protein (N×6.25) content by employing the standard methods of analysis (AOAC, 1990).

2.5. Functional properties

The flours from both flaxseed and wheat were analysed for various functional properties. For the determination of bulk density, method given by Kaur and Singh (2005) was adopted. Color measurements of flours and cookies were carried out using Hunter colorimeter Model D 25 optical Sensor (Hunter Associates Laboratory Inc., Reston, VA., U.S.A) on the basis of L*, a* and b* values. Water and oil absorption capacity of the flours was measured by centrifugation method of Sosulski (1962) and Lin, Humbert, and Sosulski (1974), respectively. Least gelation concentration was determined by the method of Coffmann and Garcia (1977). The emulsifying activity and stability were determined by the method of Yasumatsu et al. (1972).

2.6. Antioxidant properties

The antioxidant properties of flours, composite flour mixes and cookies prepared from them were estimated as follows:

2.6.1. Total phenolic content (TPC)

TPC of different samples was determined according the Folin–Ciocalteu spectrophotometric method (Sharma & Gujral, 2011). Sample (200 mg) was extracted at room temperature (25 °C) with 4 ml of acidified methanol (HCl/methanol/water, 1:80:10, v/v/v) for 2 h. An aliquot of extract (200 µl) was added to 1.5 ml freshly diluted (10 fold) Folin–Ciocalteu reagent. After equilibration for 5 min, the extract was then mixed with 1.5 ml of sodium carbonate solution (60 g/l). It was then incubated at room temperature (25 °C) for 90 min, and the absorbance of the mixture was read at 725 nm (Shimadzu, UV-1800, Japan). Acidified methanol was used as a blank. The results were expressed as µg of gallic acid equivalents (GAE) per gram of sample.

2.6.2. Antioxidant activity (AOA)

AOA was measured by modified method of Brand-Williams, Cuvelier, and Berset (1995). Samples (100 mg) were ground and extracted with 1 ml methanol for 2 h and centrifuged at 3000*g* for 10 min. The supernatant (100 µl) was separated and reacted with 3.9 ml of 6×10^{-5} mol/l of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution. Absorbance of the extract (A) at 515 nm was read at 0 and 30 min using methanol as blank. Antioxidant activity was calculated as % discolouration.

% Antioxidant activity $=(1-(\text{A of sample}_{t=30} / \text{A of control}_{t=0}))\times100$.

2.6.3. Reducing power

The reducing power of sample was measured as described by Zhao et al. (2008). Sample (0.5g) was extracted with 80% methanol (0.5 ml) on metabolic shaker for 2 h. To the extract (1 ml) was added 2.5 ml potassium ferricyanide (1%) and phosphate buffer (2.5 ml, 0.2 mol/l, and pH 6.6) followed by incubation at 50 °C. Trichloroacetic acid solution (10%) was then added to the mixture, and then centrifuged at 10,000*g* for 10 min. The upper layer of solution (2.5 ml) was mixed with 0.5 ml ferric chloride (0.1%) and 2.5 ml deionized water. The absorbance of the mixture was measured at 700 nm. A standard curve was prepared using various concentration of ascorbic acid and the results were reported as µmol ascorbic acid equivalents/g of sample. Increased absorbance of the mixture indicated increased reducing power.

2.7. Physical properties of cookies

2.7.1. Thickness

After baking, the cookies were allowed to cool for 30 min. Five cookies were stacked one upon another on a flat surface and the stack height was measured with the help of vernier calliper. The cookies were restacked and remeasured to get the average thickness in cm. Readings were taken to nearest ½ cm.

2.7.2. Diameter

Cookies were laid edge to edge and were measured for diameter. The cookies were rotated through 90 °C and were remeasured for width (cm). Readings were taken to the nearest ½ cm.

2.7.3. Spread factor

The spread factor was obtained by finding the ratio between the average width and thickness of the cookies. It gave an indicator of cookie quality.