ABSTRACT

Purpose: Buckwheat, a pseudocereal, is a nutritionally dense and gluten-free grain which has a great potential especially in the functional food industry. Domestic processing methods like germination and roasting may enhance the nutritional and functional components of the buckwheat.

Design/methodology/approach: The raw, roasted (120°C for 10 min) and germinated (27 ± 3°C for 24 hours) seed flour was analyzed for functional (bulk density, water absorption capacity, oil absorption capacity, swelling power, and emulsifying capacity and activity) and physicochemical (fat, ash, protein, total carbohydrate, total phenolic content and antioxidant activity) parameters.

Findings: Both the methods showed varied deviation of functional properties and nutrients from the raw flour. Germination significantly (p <0.05) increased the protein (11.5%) and moisture (14.66%) whereas, decreased ash (1.8%), carbohydrate (62.84%), fat (1.33%) and fiber (7.87%); roasting significantly (p <0.05) increased the carbohydrate (71.38%) whereas, decreased ash (1.8%), fat (1.33%), fibre (6.32%), moisture (11.66%) and protein (7.6%) content. Germination significantly (p <0.05) increased the phenolic content and antioxidant activity (82.63%). Bulk density and emulsion capacity decreased in both germinated and roasted buckwheat flour. However, both germination and roasting significantly (p <0.05) increased the oil absorption capacity, swelling power, and water absorption capacity.

Originality/value: The present study suggests that germinated and roasted flours can be utilized commercially for the production of economical, better and nutrient-dense food products for people suffering from cereal-based health disorders.

Keywords: Buckwheat, Domestic processing, Germination, roasting, Functional, Nutritional.

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INTRODUCTION

In the recent times, pseudocereals like Amaranth, Buckwheat, and Quinoa have garnered a lot of attention of the food industry and consumers alike, predominantly owing to its excellent composition of protein, complex carbohydrates, fiber, and minerals. Also, they offer a great nutritional alternative to the people suffering from gluten disorders and people suffering from adverse reactions to fermentation of oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP’s) (Békés et al. 2017).

Buckwheat belongs to genus Fagopyrum and family Polygonaceae and its use as a food is believed to have started in the Himalayan region in Western China or Northern India (Léder et al. 2010). Unlike wheat and other cereals, buckwheat proteins have a well-balanced amino acid composition along with the presence of all essential amino acids (Wijngaard and Arendt, 2006). It also contains numerous nutraceutical compounds like rutin, catechins, and polyphenols (Fabjan et al. 2003; Watanabe 1998) which confer health benefits like reducing high blood pressure, lowering cholesterol controlling blood sugar and preventing cancer risk (Fabjan et al. 2003; Kim et al. 2004). However, the presence of some antinutritive factors, like phytates, saponins, tannins or heat-labile trypsin inhibitors and lectins limit its food applications.

Domestic processing methods like germination, roasting, etc. have been advocated as effective treatments for the antinutrient reduction and thus, improving the nutritional as well as functional properties of various grains (Siddhuraju and Becker, 2001). This may broaden the scope of its utilization in the food industries for preparation of various value-added functional foods like bread, cookies, nutribars, etc. Hence, the present study was undertaken to systematically compare the influence of germination and roasting on the functional and nutritional properties of buckwheat flour.

MATERIALS AND METHODS

Procurement of Materials

Buckwheat grains were purchased from the local market in Phagwara, Punjab, and were cleaned manually for any foreign matter.
Germination and Roasting
For germination, the grains were soaked in water for 12 hours at 27 ± 3°C. The soaked grains were allowed to germinate in humid conditions (in the presence of light and in the absence of light) for 24 h at room temperature (27 ± 3°C) and were then dried in a tray drier (Labfit, India) in trays (37.7X15.4) with the feed rate of 150 g/m² at 55°C for 5–6 h or till the moisture content reached 11.5%. For roasting, the grains were roasted at 120°C for 10 min. The dried germinated grains and roasted grains were then milled by using super mill grinder to obtain flour and was sieved through a 52 mesh sieve. It was then packed in airtight containers and stored at room temperature for further analysis.

Determination of Functional Parameters
Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined according to the method described by Anderson and Cronshaw (1970), Sosulski (1962), respectively. Swelling capacity was determined as per the method outlined by Williams et al. (1983). Emulsion activity and emulsion capacity were determined by the method given by Eke and Akobundu (1993). Bulk density (BD) of the different samples of buckwheat flour was estimated as per the procedure described by Wang and Kinsella (1976).

Physicochemical Analysis
The moisture content, fat content and the ash content were estimated by following the AOAC method (AOAC 2005). The nitrogen content was estimated by Kjeldhal method (AOAC, 2005). Total protein content was calculated as nitrogen X 6.25. The total carbohydrate was estimated by difference. The determination of the antioxidant activity of the prepared beverage was done by 2, 2-diphenyl-2-picryl hydrazine (DPPH) inhibition method (Bondet et al. 1997), and the total phenolic content was determined by modified Folin–Ciocalteau method (Sadasivam and Manickam, 1992).

Statistical Analysis
All experiments were performed in triplicates. The results were analyzed using Graphpad Prism software for one-way analysis of variance (ANOVA) with Tukey’s test to determine the significant difference between the mean at the 5% level. Differences were measured as statistically significant at p < 0.05.

RESULTS AND DISCUSSION
Effect of Germination and Roasting on Functional Properties
The functional properties of raw, roasted and germinated buckwheat flour are presented in Table 1. The bulk density of unprocessed buckwheat flour was found to be 0.83 g/mL and as evident from the table, there was a significant decreasing (p < 0.05) trend in the bulk density of both germinated and roasted buckwheat flour. The density of processed products dedicate the characteristics of its container or package product as density influences the amount and strength of packaging or mouthfeel (Wilhelm et al. 2004). In the present study, the bulk density decreased in germinated and roasted buckwheat flour by 15.66 and 14.45%, respectively. Our results corroborate with the findings of Elkhalifa et al. 2005; Sharma et al. 2012 and Hussain et al. 2008. The decrease in bulk density of germinated flour sample could be attributed to enzymatic activities leading to the breaking of complex denser compounds into simpler ones during germination. On the other hand, roasting could have led to the loss of integrity between starch-starch protein matrix or due to the formation of spaces between starchy endosperm and thus, decreased the bulk density (Chandrasekhar and Chattopadhyay, 1990). The emulsion activity and capacity of unprocessed buckwheat flour were found to be 0.3 percent and 0.4 percent, respectively. There was a significant (p < 0.05) decrease in the emulsion activity and capacity of germinated buckwheat flour by 62.79 percent and 24.52 percent, respectively whereas, there was a significant increase (p < 0.05) in emulsion activity and emulsion capacity in roasted buckwheat flour by 10 percent and 15 percent, respectively. The oil absorption capacity of unprocessed buckwheat flour was found to be 187.6 percent which increased significantly (p < 0.05) in both germinated and roasted buckwheat flour. The results are in agreement with Elkhalifa et al. 2005, wherein they reported a 7 percent increase in the oil absorption capacity in finger millet flour after germination. Germination of grains enhances the oil absorption capacity due to the entrapment of oil-related to the non-polar side chains of proteins (Adedeji et al. 2014). Similarly, there was 5.54 percent increase in oil absorption capacity in roasted buckwheat flour. The increasing trend was in line with the results reported in finger millet (Abulude et al. 2005), and in flaxseed flour (Sharma et al. 2012). Swelling power helps to determine the type of bonds within starch granules of flour and flour blends. The swelling power of unprocessed buckwheat flour was found to be 14.77 percent which showed a significant (p < 0.05) increase in both germinated and roasted buckwheat flour by 48.07 and 23.29 percent, respectively. The observed higher swelling power may be due to the reduced fat content of the flour as fats make complexes with starch and limit the swelling (Ocheme and Chinma, 2008). This is in line with the present results since the swelling power increased with decrease in the fat content. Similar results were reported in pearl millet flour (Ocheme and Chinma, 2008). Water absorption activity in germinated buckwheat flour by increased 25.78 percent. The higher water absorption and hygroscopicity of flour derived from germinated flour may be due to high protein content and change in the quality of protein upon germination and also breakdown of polysaccharide molecules. The water absorption increased in roasted buckwheat sample by 23.31 percent. A similar trend of increase in water absorption capacity was reported in flaxseed flour (Hussain et al. 2008).

Effect of Germination and Roasting on Proximate Composition
The effect of processing on the proximate composition of buckwheat flour is presented in Table 1. The ash content of unprocessed
Buckwheat flour was 2.33 percent which showed a non-significant (p > 0.05) decreasing trend in both germinated and roasted buckwheat flour. A similar decrease in ash content after germination and roasting was reported in finger millet by Chaudhary and Vyas, 2012 and Gunashree et al., 2014, respectively. The carbohydrate content in unprocessed buckwheat flour was 68.39% which showed a significant decreasing trend after germination and increasing trend after roasting. The decrease in the germinated seeds might be attributed to the fact that carbohydrate is used as an energy source during embryonic growth resulting in a decrease in carbohydrate content (Vidal-Valverde et al., 2002), also during germination the β-amylase activity increases which breaks down the carbohydrates (Ohitsubo et al. 2005) for providing energy in seed growth. The fat content decreased non-significantly (p>0.05) in both germinated and roasted buckwheat flour. During germination fat is used as the main energy source of carbon for seed growth, as the fatty acid is converted to carbon dioxide and water for generation of energy (Chuaudhary and Vyas, 2012) and during roasting lipid starch complex is formed which are resistant to lipid extraction and can cause a decrease in the lipid content (Camire, 2001). Crude fiber is the indigestible carbohydrate which has various health benefits. The fiber content in unprocessed buckwheat flour was 8.33 percent which showed significant (p < 0.05) decrease in germinated buckwheat flour and roasted buckwheat flour. The decrease may be attributed to the fact that during germination there is an increase in the internal temperature which causes cleavage of glycosidic bond causing solubilization of dietary fiber and thus, decreased the fiber content. The moisture content of buckwheat flour was 12.66 percent which showed significant (p < 0.05) increase in germinated buckwheat flour and significant (p < 0.05) decrease in roasted buckwheat flour. During soaking and germination, the whole grains absorb moisture from soaking medium for initiation of metabolism (Chaudhary and Vyas, 2012). Moisture content decreased significantly by 7.89 percent in roasted buckwheat flour and could be attributed to dehydration associated with the roasting process (MO and Akinsola, 2015). Proteins are the long chain of amino acids and an important macromolecule needed for the growth and development of our body. The protein content in unprocessed buckwheat was 11 percent which showed a significant (p < 0.05) increase in germinated buckwheat flour whereas significant (p < 0.05) decrease in roasted buckwheat flour. Several researchers have reported an increase in protein in germinated grains (Modgil et al. 2016; Nazni and Shalini, 2010; Khatoon and Prakash, 2006; Urbano et al. 2005). Various studies have reported that there is a synthesis of enzyme protein which results in compositional changes and degradation of other components; thus, increasing the protein content in grain (Chuaudhary and Vyas, 2012). However, the decrease in protein content after roasting could be due to the high temperature of roasting which caused protein denaturation (Wangui, 2015).

**Effect of Germination and Roasting on Phenolic Content and Antioxidant Activity**

Phenolic compounds exhibit potential antioxidant, antimicrobial, anti-cancer, antiobesity, anti-diabetic as well as...
antimutagenic effects (Fresco et al. 2006; Vita, 2005). The total phenolic content in unprocessed buckwheat flour (Graph 1A) was found to be 198.6 percent which showed a significant increasing (p <0.05) trend in both germinated and roasted buckwheat flour. There was 26.12 percent increase in the total phenolic content of germinated buckwheat flour. Increase in phenol content in buckwheat after germination was reported in many studies (Alvarez-Jubete et al. 2009; Ren and Sun, 2014). The increase in the total phenolic content can be attributed to the fact that the level of gallic, vanillic, coumaric and ferulic acids in free form increase during germination (Rao and Muralikrishna, 2002 Kaur et al. 2016) which increases the total phenolic content. On the other hand, the increase in the phenolic content after roasting may be due to the formation of higher Maillard reaction products during roasting (Maillard and Berset, 1995). The antioxidant activity of buckwheat flour is shown in Graph 1B. The antioxidant activity of unprocessed buckwheat flour was 48.2 percent and there was a significant increase (p <0.05) in the antioxidant activity in both germinated and roasted buckwheat flour. The increase in antioxidant activity may be due to the accumulation of flavonoids and vitamins during germination (Zhou et al. 2015). Also, during germination, many metabolic changes take place due to the increase in the activity of endogenous hydrolytic enzymes which in turn increases the antioxidant activity in the seeds (Chavan et al. 1989). On the other hand, 21.71 percent increase in the antioxidant activity of roasted buckwheat flour can be attributed to the formation of non-enzymatic browning products especially melanoids at high temperatures which contribute to antioxidant activity.

**Conclusion**
The present study indicated that domestic treatments like germination and roasting have tremendous effects on the functional and nutritional properties of buckwheat flour. From the results, it can be concluded that both the processes not only led to a significant increase in the functional properties but also enhanced the nutritional and antioxidant profile of the flour effectively. Hence, germinated or roasted buckwheat flour can be utilized in the production of economical yet nutrient-dense foods for people suffering from cereal-based health disorders.

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