Nutritional Improvement of Whole Wheat Flour Chapatti by Supplementation of Tartarty Buckwheat Flour

Rahat Bano[1] Shehzad Hussain[1*] Jie Li[1] Sartaj Ali[2] Wenjun Jin[1] Hui Li[1] Amjad Ali[3] Muhammad Hussain[2]

1.College of Food Science and Technology Huazhong Agricultural University, Wuhan, Hubei Province 430070, P.R. China

2.Department of Food Science and Technology, Karakoram International University, Gilgit-Baltistan, Pakistan

3.School of Light Industry and Food Science, South China Agricultural University, Guangzhou P.R. China, 510641

*E-mail of the corresponding author: shehzad85_ngr@hotmail.com

Abstract

Four treatments (T_0, T_1, T_2, T_3 and T_4) of supplemented flours along with control (T_0) were prepared by supplementing tartary buckwheat flour in whole wheal flour @ 5, 10, 15 and 20% to improve the nutritional quality of chapattis. Supplemented flours and chapattis prepared from them were analyzed for chemical composition such as moisture content, ash content, crude fiber, crude protein, crude fat, phytic acid content, minerals (Fe, Zn, P and K) and nitrogen free extract. Supplementation significantly increased the all parameters except NFE and Zn content. Sensory evaluation of chapatti samples showed that chapattis prepared from 5 and 10% supplemented flours were accepted by the judges.

Keywords: Wheat flour, Chapatti, Supplementation, Tartary buckwheat

1. Introduction

Wheat (*Triticum aestivum* spp. aestivum) is the most important cereal crop in the world. Wheat comprises one sixth of the total cultivated land in the world (Temel *et al.,* 2008). Wheat flour is the key dietary staple food used in Pakistan, utilized thrice a day in the form of circular flat bread called chapatti. Pakistani population consumes 80 percent of the total cereal intake in the form of wheat; hence it is the major and reasonable source of energy (Hussain, *et al*., 2004). Human growth depends on a balanced diet containing protein, lipids, and carbohydrates. The existence of malnutrition is due to dependence of our population on whole wheat flour which contains anti nutritive compounds like phytic acid which decrease the bioavailability of some micronutrients (Sandstead, 2000). Buckwheat (*Fagopyrum esculentum* Monch) is an annual pseudocereal crop, but its grains belong to cereals because they have similar chemical composition and it is a minor crops cultivated by cultural groups in developed and developing countries which is anivital part of their diet and culture (Przybylski and Gruczynska, 2009). Buckwheat is known as a potential functional food in some countries such as China, Japan and Taiwan. It is an alternative crop that belongs to the Polygonaceae (Halosava *et al.,* 2002). Buckwheat is as a semi-wild plant suitable for growing without pesticides and synthetic mineral fertilization (Kreft and Mateja, 2008). Many varieties of buckwheat are grown around the world, among various spices only nine have agricultural and nutritional importance (Krkoskova and Mrazova, 2005). Generally, two spices of buckwheat are used as food around the world; common buckwheat (*Fagopyrum* esculentum) and tartary buckwheat (*Fagopyrum* tataricum). Common buckwheat is widely grown and used, while tartary buckwheat is grown in mountainous areas (Bonafaccia *et al.,* 2003a; Li and Zhang, 2001). China, Russian Federation, Ukraine, and Kazakhstan are the main producers of the buckwheat (Li and Zhang, 2001; Bonafaccia *et al.* 2003). In Gilgit-Baltistan buckwheat is cultivated at 948 hectares area and 1798 metric tons buckwheat is produced annually (Agri. Stat., 2007).

Table 1. World's top ten buckwheat producers (production year 2011) (FAOSTAT 2013)

Countries	Production (tonnes)	Area (Ha)	Yield (Hg/ha)
Russia	833936.00*	905911.00*	9205.5†
China	733000.00ǂ	705000.00ǂ	10397.16†
Kazakhstan	276840.00*	202008.00*	13704.41†
Ukraine	179020.00*	168400.00*	10630.64†
France	154800.00*	44500.00*	34786.52†
Poland	90874.00*	70384.00*	12911.17†
United States	81000.00**	77500.00**	10451.61†
Brazil	62000.00**	48000.00**	12916.67†
Japan	33400.00*	61400.00*	5439.74†
Belarus	30553.00*	31403.00*	9665.64†
Total	2475423.00		

* Official
* * Food and Agriculture Organization estimates
† Calculated data
ǂ Aggregate, official, semi official or estimated data

There is well balanced composition of amino acid in buckwheat proteins with high biological value (Kato *et al.,* 2001). Among them essential amino acids such as, threonine, lysine and tryptophan are in high concentrations (Liu *et al.,* 2001). Buckwheat contains about 80% unsaturated fatty acids and more than 40% are constituted by polyunsaturated fatty acid (Krkoskova and Mrazova, 2005). Moreover buckwheat grains are a rich source of total dietary fiber and soluble dietary fiber which helps to prevent diabetes and obesity (Brennan, 2005). Buckwheat is an important source of microelements like; Mn, Zn, Cu and Se (Stibilj *et al.,* 2004), as well as macro minerals such as; K, Na, Ca and Mg (Wei, *et al.,* 2003). Its grains are also rich source of iron (60-100 ppm), zinc (20-30 ppm) and selemiun (20-50 ppb). Antioxidants are also found in buckwheat in the form of rutin (10-200 ppm), and tannins (0.1-2 percent) (Skrabanja *et al.,* 2004; Ikeda *et al.,* 2000). Plenty of phenolic compounds are also found in buckwheat with useful health effects. However, buckwheat is recognized as a plant rich in rutin and quercetrin (Fabjan *et al.,* 2003).

Hence Buckwheat is rich in minerals like iron, selenium and zinc and antioxidants like rutin and quercertrin and due to presence of some essential amino acids like lysine, it can be supplemented in wheat flour which lack some of these essential nutrients. As whole wheat flour chapatti is used as staple food in the subcontinent and more than 80 percent people have reliance on this single source for their nutrition. As we know that wheat flour is deficient in some important micronutrients, some essential amino acids and antioxidants and this deficiency can be replenished if we supplement whole wheat flour with some suitable source having rich nutrient. So by supplementation of tartary buckwheat flour to whole wheat flour, nutritional value of chapatti can be improved. Malnutrition can be reduced by supplementing buckwheat flour through most reachable and economic food item like chapatti. The present study was designed to improve the nutritional and functional properties of chapattis by supplementation of tartary buckwheat flour and to assess the suitable supplementation level of tartary buckwheat flour by physicochemical and sensory evaluation of chapatti

2. Materials and Methods

The wheat was purchased from the local market and the Tartary buckwheat was collected from Gilgit-Baltistan and was transported to the Department of Food Technology PMAS-Arid Agriculture University Rawalpindi, Pakistan. The wheat and tartary buckwheat grains were milled in a China chaki to make whole wheat flour and buckwheat flour. The supplemented flour samples were prepared by substitution of whole wheat flour with tartary buckwheat flour as given below:

Treatments	T_0	T_1	T_2	T_3	T_4
Whole wheat flour (%)	100	95	90	85	80
Buckwheat flour (%)	-----	5	10	15	20

The dough was made by mixing individual samples with predetermined amount of water for three minutes in mixer and then was allowed to rest for 20 minutes before making dough balls. Dough pieces were rounded and rolled to attain a uniform thickness. The chapatti was cooked on hot plate and after baking from one side it was turned over and baked from the other side. Chapatti was puffed on open flame for 2 to 3 seconds according to the method described by Haridas *et al*. (1986).

Supplemented flour samples and chapattis prepared from them were analyzed for moisture, ash, crude fiber, crude protein, crude fat and gluten content by the methods of AACC (2000). The phytic acid was determined by following the method of Haug and Lantszch (1983). The NFE content was calculated with the given formula;

NFE (%) =100 – (Moisture % - Crude protein % - Crude Fat % - Crude Fiber % - Ash %)

The samples were analyzed for Fe, Zn and P by using Atomic Absorption Spectrophotometer (Model GBC 932 PLUS, UK) according to the method described in AOAC (2000). The flour samples were wet digested according to the method reported by Richard (1969) before running through Atomic Absorption Spectrophotometer. The K content was analyzed through Flame photometer.

The farinographic evaluation of samples was carried out by running through Brabender-Farinograph according to the method described in AACC method No. 54-21. The physical dough properties such as water absorption, dough development time and dough stability were interpreted from each farinograms. The sensory evaluation of chapattis prepared from supplementation of buckwheat flour was carried out by a panel of trained judges for various attributes i.e. color, taste, flavor, texture, foldability, breakability and overall acceptability. A nine point hedonic scale as described by Land and Shepherd (1998) was used for sensory evaluation.

The data obtained was analyzed by using analysis of variance (ANOVA) technique and the comparison of means was done by using Statistix 8.1 and interpreted by following Steel *et al.,* (1997).

3. Results and Discussion

3.1 Proximate Composition of Supplemented Flours

The chemical composition of whole wheat flour and buckwheat flour has been given in Table 2. The buckwheat flour was reported to contain higher amounts of moisture, ash, crude fiber, crude protein, crude fat and phytic acid with mean values of 13.45, 1.79, 8.65, 13.93, 2.99 and 4.88% respectively, while the NFE content, gluten (dry and wet) were found highest in whole wheat flour with mean value of 74.91, 9.27 and 30.76%, respectively. The proximate composition of supplemented flours has been presented in Table 3. The maximum and minimum mean values of above stated nutrients in all treatments except T_0 (whole wheat flour) ranged from 9.67 to 11.71% for moisture, 0.85 to 1.17% for ash, 2.67 to 4.03 for crude fiber, 11.50 to 12.47 for crude protein, 1.11 to 1.50 for crude fat and 74.17 to 69.11 for NFE 1.70 to 2.39 for phytic acid content and content. The nutrients were found to be increase with increase in supplementation of buckwheat flour to whole wheat flour except NFE, which was decrease with increase in supplementation level. The mean values for T_0 (whole whet flour for moisture, ash, fiber, protein, fat, phytic acid and NFE content were 9.02, 0.82, 2.34, 11.23, 0.99, 1.48 and 74.91% respectively. The treatment T_4 (20% buckwheat flour) has been found to be contain highest amounts of moisture (11.71), ash (1.17), fiber (4.03), protein (12.47), fat (1.50) and phytic acid (2.39).

Phytic acid and gluten content of supplemented flours have been given in Table 4. The means values of gluten content were found to be decrease while phytic acid content was found to be increase with increase in supplementation level. The maximum and minimum value of phytic acid was found to be in range of 2.38 to 1.48%, while gulten content (dry and wet) was in range of 9.27 to 7.19 and30.36 to 23.89%.

The results of current study are in line with findings of Fessas *et al.* (2008) and Shalini (2007) who studied higher moisture content (13.6%) in buckwheat flour than wheat flour. In another similar study Li and Zhang (2001) and Bonfaccia *et al.* (2003) reported 11.28% and 11.4% crude protein content in buckwheat flour and Rehman (2006), Bilgicli (2009) and Butt (2004) found similar results in whole wheat flour i.e. 10.58, 11.4 and 10.94% respectively. The results regarding fat content are at par with the finding of Bonfaccia *et al.* (2003) and Li and Zhang (2001) who reported 2.45% and 3.2% fat content in buckwheat flour and Horsfall *et al.* (2007) reported 1.1% and 0.82% fat content in whole wheat flour. In another study Akhtar *et al.* (2008) reported 1.95% ash content in buckwheat flour and 1.62% in whole wheat flour respectively. Our results of present study for crude fiber in buckwheat flour are in agreement with findings of Li and Zhang, (2001) who reported 8.3% and Khetarpaul and Rajni (2009) evaluated 1.85% in whole wheat flour. The results of current work regarding NFE in whole wheat flour are in accordance with the findings of Natasha (2008) and Wahab (2001) who studied 83.29% and 75.80%, respectively.

The results of current study regarding phytic acid in whole wheat flour are in accordance with findings of Khan (2005), Akhter *et al.* (2008)) and Said Wahab (2001) who reported 1.77%, 1.62% and 1.66% respectively. Findings of present study for gluten content are also well supported by the findings of Simic *et al.* (2006) and Shaikh *et al*. (2007) who reported 26% and 23.27 % wet gluten in whole wheat flour, while Shalini and Laxmi (2007) reported 9.6% dry gluten in WWF. The dry gluten 10.17% of WWF is also supported by the similar results of Shaikh *et al*. (2007).

3.2 Minerals Estimation of Supplemented Flours

The mineral content estimation of supplemented flour samples has been presented in Table 5. The mineral content were found to be in 20% supplemented flour sample (T_4) iron (63.45 ppm), potassium (1720.1 ppm) and phosphorus (2123.5 ppm), while the zinc content was found to be highest in whole wheat flour (T_0) which is 32.05 ppm, The statistical results of present research work regarding the mineral content of supplemented flour samples showed a pronounced increase with increasing concentration of buckwheat flour except zinc. A decrease in zinc content was observed as the supplementation level increased. It may be due to the reason that the whole wheat flour contain higher amount of zinc content as compared to the buckwheat flour. The concentration of minerals in flour samples correlated with the quantity of buckwheat flour added, as buckwheat is a rich source of minerals.

The results of present study regarding the iron content are in accordance with the findings of Bilgicli (2009) and Bonfaccia (2003) who studied 272 ppm and 149 ppm iron content in buckwheat flour while Ihsaullah (2002), Khan (2005) and Natasha (2008) studied 16 to 33 ppm and 14 to 34 ppm iron content in whole wheat flour. Similarly Bilgicli (2009), Bonfaccia *et al.* (2003) who reported 20.90 ppm and 26.30 ppm zinc content in buckwheat flour and Natasha, (2008), Francischi *et al.* (1994) and Khan (2005) studied 16.8 to 24.6 ppm, 35 ppm and 34 ppm zinc content in whole wheat flour respectively. In another study Bilgicli (2009) reported 3994 ppm potassium content in buckwheat and 1324.4 ppm in whole wheat flour. In a similar study Bilgicli (2009) studied 4606 ppm phosphorus content in buckwheat and 1394 ppm whole wheat flour.

3.3 Farinographic Evaluation of Supplemented Flour Samples

The farinographic evaluation of supplemented flours has been presented in Table 6. It is clear from the results that water absorption of four samples was decreased with the supplementation of buckwheat flour. The highest water absorption was recorded 71.00% in T_0 (whole whet flour) followed by T_1, T_2 and T_3 with non significant differences, while the lowest water absorption was found to be 68.90% in T4 (20% buckwheat flour), buckwheat supplemented flours were non significant with respect to water absorption. The results regarding dough development time it was dough development time was increased with supplementation of buckwheat. The highest dough development time was found to be 6.8 min in T_4 (20% supplemented flour) while the lowest dough development time was recorded 3.5 min in T_0 (whole wheat flour).

As the result regarding dough stability the maximum dough stability was found to be 6.6 min in T_4 (20% supplemented flour) and lowest was recorded (3.7 min) in T0. It was observed that there was no significant effect of supplementation level among (T_0), 5%, 10% and same trend was observed in 15%, 20% supplementation level of buckwheat flour but there was significant difference between 10% and 15% on the dough stability. The dough stability was affected due to the addition of buckwheat flour and the data indicated that the dough stability increased with increase in supplementation. Randhawa *et al.* (2002) also studied the dough stability in wheat flour and our results of current study are somewhat in line with their findings i.e. in the range of 2.30 to 16.71 min. It is obvious from the data that the arrival time of whole wheat flour upto the supplementation level of 10% was not affected but as the supplementation level increased upto 15 and 20% there was significant decrease observed in supplemented flour samples and there was also non-significant difference recorded in 15 and 20% supplementation level. The significantly highest arrival time (3.80 min.) was recorded in T_4 (20% supplemented flour) and T_3 (15% supplemented flour) while significantly the lowest arrival time (1.90 min.) was observed in T_0.

The statistical results revealed that treatments of supplemented flours do not varied significantly with respect to arrival time. It is evident from the results that the departure time of the treatments T_3 and T_4 were significantly higher than that of other treatments containing supplemented flours. The significantly highest departure time (10.20min.) was recorded in T_4 (20% supplemented flour) and T_3 (15% supplemented flour) while significantly the lowest arrival time (5.70min.) was observed in T_0. The statistical results revealed that treatments of supplemented flours varied significantly with respect to departure time. The data indicate that there was significant difference between whole wheat flour and 5% supplemented flour and same trend was observed between 10% and 15% supplemented flour samples. Results regarding the departure time revealed that the treatments T_3 and T_4 were significantly higher than that of other treatments. The significantly highest departure time (10.20min.) was recorded in T_4 (20% supplemented flour) and T_3 (15% supplemented flour) while significantly the lowest arrival time (5.70min.) was observed in T_0. There was no significant difference between 5% and 10% and between 15% and 20% level of buckwheat flour supplementation on departure time of supplemented flour samples

3.4 Proximate composition of supplemented flour chapattis

The chapattis prepared from supplemented flours were also analyzed for chemical composition as presented in Table 7. The results regarding the chemical composition were significant and were in accordance with the particular supplemented flour from which that chapattis were prepared. The chapattis prepared from 20% supplemented flour (T_4) were reported to contain highest amounts of moisture (30.32%), total ash (1.47%), crude fiber (3.93%), crude protein (12.36%), crude fat (1.46%) and phytic acid content (1.62%). The phytic acid content was reduced during chapatti making process. Anjum *et al.* (2001) and Khan *et al.* (2005) also indicated that phytic acid reduced during baking of chapattis.

3.5 Phytic Acid Conent and Mineral Estimation of Chapattis

There was an increase in mineral content of chapatti samples were observed as given in Table 8. The statistical results revealed that there is a significant difference among treatments regarding mineral content. The minerals were found to be highest in chapattis prepared from 20% supplemented four (T_4) iron (62.17 ppm), potassium (1716.1 ppm) and phosphorus (2118.4 pm) while the zinc content is found to be highest in whole wheat flour T_0 which is 32.92 ppm. Khan *et al.,* (2004) reported that mineral content of wheat flour supplemented chapattis increased with supplementation, which is in line with our present study. The maximum and minimum value of phytic acid was found to be in range of 1.62 to 1.03% in supplemented fkour chapattis.

3.6 Sensory Evaluation of Chapattis

The sensory characteristics of chapattis made from different supplemented flours have been presented in Table 9 showed significant differences. The overall acceptability scores assigned to chapattis for color, flavor, taste, texture, breakability and foldability were 8.00, 7.14, 7.08, 5.55 and 5.04 for T_0, T_1, T_2, T_3 and T_4 respectively. The results indicated that the chapattis prepared from whole wheat flour (T_0) were ranked at the top followed by chapattis prepared from 5% supplemented flour (T_1), 10% supplemented flour (T_2), 15% supplemented flour (T_3) and 20% supplemented flour (T_4). There was a non significant difference in T_1 and T_2 for many sensory attributes of the chapattis made from the buckwheat supplemented flours. Increasing concentration of buckwheat flour decreased the all sensory attributes. The color of chapattis was affected due to darken color of buckwheat flour. A gradual decrease in color of bread was also studied by Giammi (2004) who supplemented pumpkin seed protein concentrations in wheat flour. In a similar study Oluwamukomi *et al.* (2010) studied the decrease in color of biscuits when supplemented with soy flour. Olatidoye and Sobowale (2011) studied the similar pattern on supplementation of full-fat soy bean flour with cassava flour. In another study Sharif *et al.* (2009) reported the decrease in flavor of cookies prepare with defatted rice bran. Atuonwu and Akobundu (2010) also reported the decrease in flavor of cookies when supplemented with pumkin seed flour. The decreasing trend of flavor scores of cookies with the increase in supplementation level of rice bran was studied by Amna *et al.* 2011. The lowering trend of taste scores of cookies with the increase in supplementation level of rice bran was studied by Amna *et al.* 2011.

Olatidoye and Sobowale (2011) studied the similar trend in supplementation of full-fat soy bean flour with cassava flour. In a study Atuonwu and Akobundu (2010) reported the decrease in texture of cookies when supplemented with pumpkin seed flour. The lowering trend of texture scores of cookies with the increase in supplementation. In present study the decrease in breakability scores is due to the increased hardness of chapattis because of high protein content in Tartary buckwheat flour except gluten. In a study decreasing quality score for foldability in chapattis was earlier studied by khan *et al.* (2005) when supplemented with soy hull. The lowering trend of overall acceptability scores of cookies with the increase in supplementation level of rice bran was studied by Amna *et al.* 2011. In another similar study Oluwamukomi *et al.* (2010) studied the decrease in overall acceptability of biscuits when supplemented with soy flour. Olatidoye and Sobowale (2011) studied the similar pattern in on supplementation of full-fat soy bean flour with cassava flour

4. Conclusion

The current study indicated that concentration of crude fiber, crude protein, crude fat, iron, potassium and phosphorus were higher in buckwheat flour as compared to whole wheat flour and therefore, it must be used in daily diet to overcome nutritional imbalance and mineral deficiency. It is recommended to use 5 to 10% buckwheat flour with whole wheat flour to produce more nutritious and acceptable chapattis.

References

AACC, (2000). Approved Method of American Association of Cereal Chemists, 10th ed: Arlington, USA: American Association of Cereal Chemists.

Agri. Stat. (2007). Northern areas agricultural statistics survey report, Fruit Production in Northern Areas. Deptt. Agri. Northern Areas Pakistan. p. 53-69.

Akhtar, S., Anjum, F. M., Rehman, S. U., Sheikh, A. M. and Kalsoom, F. (2008). Effect of fortification on physic-chemical and microbiological stability of whole wheat flour, Food Chem., 110, 113-119.

Amna, Y., Bhatti, M. S., Ahmed, A. and Randhawa, M. A. (2011). Effect of rice bran supplementation on cookie baking quality. Pak. J. Agri. Sci., 48(2):133-138.

Anjum, F.M., Butt, M. S., Ahmad, N. and Ahmad, I. (2001). 'Phytate and mineral content in different milling fractions of some Pakistani spring wheats'', International J. Food Sci. and Tech., 37,13-7.

Bilgicli, N. (2009). Effect of buckwheat flour on chemical and functional properties of tarhana. Food Sci. Technol., 42,514-518.

Bonafaccia, G. and Fabjan, N. (2003). Nutritional comparison of tartary buckwheat with common buckwheat and minor cereals Zb. Bioteh. Fak. Univ. Ljublj. Kmet. 81(2):349-355.

Bonafaccia, G., Marocchini, M. and Kreft, I. (2003). Composition and technological properties of the flour and bran from common and tartary buckwheat. Food Chem., 83(1):1-5.

Bonafaccia, L., Gambelli, N., Fabjan and Kreft, I. (2003a). Trace elements in flour and bran from common and tartary buckwheat. Food Chem., 83 (1):1-5.

Brennan, C. H. (2005). Dietary fiber, glycaemic response and diabetes. Mol. Nutri. Food Res., 49,560-570.

Butt, M. S., Sharif, K.., Nasir, M., Iftikhar, M. and Rehman, K.. (2004). Preparation and quality evaluation of cookies containing sweet potato flour. Indus. J. Plant Sci., 3,69-76.

Fabjan, N., Rode, J., Kosir, I. J., Zhang, Z. and Kreft, I. (2003). Tartary buckwheat as a source of dietary rutin and quercetin. J. Agri. Food Chem., 51,6452-6455.

FAOSTAT. (2013).http://faostat3.org/home/index.htlm#DOWNLOAD

Fessas, D., Signorelli, M., Pagaai, A., Mariotti, M., Jametti, S. and Schirald, A. (2008). Guidelines for Buckwheat Enriched Bread: Thermal Analysis Approach. J. Therm. Anal. Cal., 91:9-10.

Francischi, M. L. P., Salgado, J. M. and Leitao, R. F. F. (1994). Chemical, nutritional and technological characteristics of buckwheat and non-prolamine buckwheat flours in comparison of wheat flour. Pl. Foods Hum. Nutr., 46,323-329.

Giami, S. Y. (2005). Dough rheologhy and quality of wheat bread supplemented with fluted pumpkin seed protein concentrate. Glob. J. Agric. Sce., 41:7-18.

Haridas, R. P., Leelavathi, K. and Shurpalekar, S. R. (1986). Test baking of a chapatti development of a method. Cereal Chem., 63(4):297-303.

Holasova, M., Fiedlerova, V., Smricinova, H., Orsak, M., Lachman, J. and Vavreinova, S. (2002). Buckwheat

the source of antioxidant activity in functional foods. Food Res. Inter., 35,207-211.
Hussian, S. (2004). Biochemical and technological properties of flaxseed supplemented wheat flour. M.Sc. Thesis. Nat. Inst. Food Sci. Tech, Univ. Agriculture.
Ihsnullah, M. J,. Qureshi, T. N., Khattak and Akhtar, T. (2002). Determination of Iron in different types of wheat flours. Int. J. Agric. Biol., 2,297-299.
Ikeda, S., Yamashita, Y. and Kreft, I. (2000). Essential mineral composition of buckwheat flour fractions. Fagopyrum., 17,57-61.
Khan, M. I., Anjum, F. M., Hussain, S. and Tariq, T. M. (2005). Effect of soy flour supplementation on mineral and phytate content of unleavened flate bread (Chapatis). Nutri. Food Sci. 35(3):163-168.
Khetarpaul, N. and Rajni, G. (2009). Effect of composite flour fortification to wheat flour on the quality characteristics on unleavened bread. British Food J., 11(6):554-564.
Kreft, I. and Mateja, G. (2008). Organically grown buckwheat as a healthy food and a source of natural antioxidants. Pregledni znanstveni clanak. 397-406.
Krkoskova, B. and Mrazova, Z. (2005). Prophylactic components of buckwheat. Food Res. Int., 38(5):561-568.
Krkoskova, B. and Mrazova, Z. (2005). Prophylactic components of buckwheat. Food Res. Int., 38(5):561-568.
Land, D. and Shepherd. (1998). Scaling and Ranking Methods. J. R. Piggot. Elsevier Applied Sci. London., pp: 1545-1585.
Li, A. S. and Zhang, Q. H. (2001). Advances in development of functional foods from buckwheat. Food Sci. Nutri., 46(6):451-464.
Li, A. S. and Zhang, Q. H. (2001). Advances in development of functional foods from buckwheat. Food Sci. Nutri., 46(6):451-464.
Liu, Z., Ishikawa, W., Huang, X., Tomotake, H., Kayashita, J., Watanabe, H., Nakajoh, M. and Kato, N. (2001). A buckwheat protein product suppresses 1,2-dimethylhydrazine-induced colon carcinogenesis in rats by reducing cells proliferation. J. Nutri., 131,1850-1875.
Olatidoye, O. P. and Sobowale, S. S. (2011). Effect of full-fat soy-bean flour on the nutritional, physicochemical properties and acceptability of cassava flour. EJEAFChe. 10(3):1994-1999.
Przybylski, R. and Gruczyńska, E. (2009). A Review of Nutritional and Nutraceutical Components of Buckwheat. Euro. J. plant Scie. Biotech., pp. 10-22.
Randhawa, M. A., Anjum, F. M. and Butt, M. S. (2002). Physicochemical and milling properties of new spring wheats grown in Punjab and Sindh for the production of pizza. Int. J. Agric. Biol., 4,482-484.
Rehman, S. (2006). Flavour in sourdough breads: a review. Trends Food Sci. Tech., 17,557-566.
Said, W. (2001). Effect of Calcium fortification on the overall quality of whole wheat flour leavened and unleavened bread. A Post doctoral report. College of Biosystem Engineering and Food Science. ZJU. China.
Sandstead, H. H. (2000). Causes of iron and zinc deficiencies and their effects on brain. J. Nutr. 130,347-349.
Shalini, K. G. and Laxmi, A. (2007). Influence of additives on rheological characteristics of whole-wheat dough and quality of Chapatti (Indian unleavened flat bread). Part I: hydrocolloids. Food Hydrocoll., 21,110-117.
Sharif, M. K., Butt, M. S., Anjum, F. M. and Nawaz, H. (2009). Preparation of Fiber and Mineral Enriched Defatted Rice Bran Supplemented Cookies. Pak. J. Nutri., 8(5):571-577.
Skrabanja, V., Kreft, I., Golob, T., Modic, M., Ikeda, S., Ikeda, K., Kreft, S., Bonafaccia, G., Knapp, M. and Kosmelj, K.. (2004). Nutrient content in buckwheat milling fractions. Cereal Chem., 81 (2):172-176.
Skrabanja, V., Nygaard, L. H. and Kreft, I. (2000). Protein–polyphenol interactions and in vivo digestibility of buckwheat groat proteins. Pflugers Archiv, 440,129-131.
Steel, G. R. and Torrie, J. H. (1980). Principles and Procedure of Statistics. McGraw Hill Book Co., N. Y. USA. p: 134-145.
Stibilj, V., Kreft, I., Smrkolj, P. and Osvald, J. (2004). Enhanced selenium content in buckwheat (Fagopyrum esculentum Moench) and pumpkin (Cucurbita pepo L.) seeds by foliar fertilisation. Eur. Food Res. Tech.., 219,142-144.
Temel, A., Akfiruat, F. S., Ertugrul, F., Yumurtaci, A., Aydin, Y., Talas-ogras, T., Gozukirizi, N., Bolat, N., Yorgancilar, O., Belen, S., Yildirim, M., Cakmak, M., Ozdemir, E., Cetin, N., Mert, Z., Sipani, H., Albustan, S., Akan, K., Dsuncell, F. and Uncuoglu, A. A. (2008). Yr10 gene polymorphism in bread wheat varieties. J. African Biotech., 7(14):2328-2332.
Wei, Y., Hu, M. X., Zhang, G. and Ouyang, S. (2003). Studies on the amino acid and mineral content of buckwheat protein fractions. Nahrung Food., 47,114-116.

Table 2. Proximate composition of whole wheat flour and buckwheat flour

Treatments	Moisture (%)	Ash (%)	Fiber (%)	Protein (%)	Fat (%)	NFE (%)	Phytic Acid (%)	Gluten dry (%)	Gluten wet (%)	Fe (ppm)	Zn (ppm)	K (ppm)	P (ppm)
Whole Wheat Flour	9.02	0.82	2.34	11.23	0.99	74.91	1.48	9.27	30.76	35.11	32.05	969.03	1241.66
Buckwheat Flour	13.45	1.79	8.65	13.93	2.99	59.3	4.84	---	---	147.50	27.05	3716	4273.33

Table 3. The proximate composition of tartary buckwheat supplemented flour samples

Treatment	Moisture (%)	Total Ash (%)	Crude Fiber (%)	Crude Protein (%)	Crude Fat (%)	NFE (%)
T_0	9.02±0.05e	0.82±0.03c	2.34±0.02e	11.23±0.07e	0.99±0.01e	74.91±0.69a
T_1	9.67±0.04d	0.85±0.03c	2.67±0.04d	11.50±0.02d	1.11±0.04d	74.17±0.05b
T_2	10.39±0.06c	1.02±0.05b	3.10±0.02c	11.76±0.03c	1.27±0.03c	72.44±0.06c
T_3	11.12±0.04b	1.11±0.02a	3.53±0.02b	12.10±0.01b	1.41±0.03b	70.72±0.02d
T_4	11.71±0.12a	1.17±0.02a	4.03±0.04a	12.47±0.05a	1.50±0.02a	69.11±0.23e

T_0 = 100% WWF T_1 = 95% WWF + 5% BWF
T_2 = 90% WWF + 10% BWF T_3 = 85%WWF + 15% BWF
T_4 = 80% WWF + 20% BWF
WWF = Whole Wheat Flour BWF = Buckwheat Flour
*All the values are means of three replications
*Means carrying same alphabets are non significant at p<0.05

Table 4. Phytic acid and gluten contents of supplemented flour samples

Treatment	Phytic Acid (%)	Gluten (Wet) (%)	Gluten (Dry) (%)
T_0	1.48±0.02e	30.76±0.07a	9.27±0.06a
T_1	1.70±0.01d	28.69±0.46b	8.84±0.11b
T_2	1.93±0.04c	26.83±0.49c	8.36±0.05c
T_3	2.19±0.02b	25.71±1.08c	7.65±0.06d
T_4	2.39±0.02a	23.89±0.80d	7.19±0.20e

Table 5. Mineral contents of supplemented flour samples

Treatment	Iron (ppm)	Zinc (ppm)	Potassium (ppm)	Phosphorus (ppm)
T_0	35.11±0.12e	32.05±0.08a	969.0±1.75e	1241.7±1.52e
T_1	42.99±0.03d	30.32±0.05b	1151.3±2.00d	1448.4±0.61d
T_2	50.75±0.25c	29.27±0.06c	1330.2±1.20c	1652.9±1.61c
T_3	57.13±0.12b	28.07±0.08d	1551.5±1.67b	1921.3±1.91b
T_4	63.45±0.67a	26.74±0.02e	1720.1±1.12a	2123.4±1.45a

Table 6. Water absorption and rheological properties of supplemented flour samples

Treatments	WA	DDT	DS	AT	DT
T_0	71.00a	3.5b	3.7b	1.90b	5.70
T_1	70.50ab	5.0ab	4.2b	3.30ab	7.80
T_2	70.30ab	5.2ab	4.5b	3.10ab	7.20
T_3	69.50ab	6.7a	6.6a	3.80a	10.20
T_4	68.90b	6.8a	6.6a	3.80a	10.20

Means carrying same alphabets are non significant at p<0.05
WA = Water Absorption DDT = Dough Development Time
DS = Dough Stability AT = Arrival Time
DT = Departure Time

Table 7. The proximate composition of supplemented flour chapattis

Treatment	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Total Ash (%)	Crude Fiber (%)	NFE (%)
T_0	29.10±0.03d	11.16±0.03e	0.94±0.04e	1.06±0.05e	2.22±0.03e	55.51±0.08a
T_1	29.50±0.03c	11.34±0.02d	1.07±0.02d	1.15±0.02d	2.79±0.02d	53.86±0.36b
T_2	29.78±0.03b	11.65±0.02c	1.21±0.02c	1.23±0.04c	3.10±0.02c	53.01±0.04c
T_3	29.78±0.03b	12.05±0.05b	1.38±0.01b	1.37±0.02b	3.40±0.02b	51.69±0.08d
T_4	30.32±0.03a	12.36±0.02a	1.46±0.01a	1.47±0.02a	3.93±0.04a	50.44±0.05e

Table 8. Phytic acid and mineral contents of supplemented flour chapattis

Treatment	Phytic Acid (%)	Iron (ppm)	Zinc (ppm)	Potassium (ppm)	Phosphorus (ppm)
T_0	1.03±0.04e	34.71±0.04e	32.92±0.015a	961.4±1.82e	1233.7±2.51e
T_1	1.15±0.015d	42.57±0.58d	30.42±0.015b	1149.0±1.74d	1440.5±0.97d
T_2	1.30±0.015c	49.05±0.08c	29.96±0.015c	1357.0±1.64c	1647.6±2.16c
T_3	1.49±0.015b	54.92±1.66b	28.31±0.045d	1545.5±1.83b	1916.0±1.73b
T_4	1.62±0.025a	62.17±0.03a	26.93±0.040e	1716.0±1.19a	2118.4±1.11a

Table 9. Sensory attributes of chapatti samples supplemented with tartary buckwheat

Treatment	Color	Flavor	Taste	Texture	Breakability	Foldability	Overall Acceptability
T_0	8.03±0.03a	8.05±0.02a	8.00±0.02a	7.89±0.01a	8.06±0.02a	7.99±0.01a	8.08±0.02a
T_1	7.66±0.02b	7.21±0.02b	7.04±0.02b	6.94±0.01b	6.98±0.02b	7.01±0.04b	7.07±0.02b
T_2	7.61±0.01b	7.16±0.01b	7.04±0.05b	6.87±0.02c	6.85±0.05c	6.98±0.03b	7.04±0.02b
T_3	5.30±0.03c	6.02±0.03b	5.10± 0.02c	5.21±0.02d	6.03±0.04d	5.31±0.02c	5.30±0.03c
T_4	5.25±0.01c	5.90±0.01d	4.88±0.01d	4.70± 0.01e	5.41±0.02e	4.11±0.02d	4.53±0.03d