Effects of Whole Buckwheat Flour on Physical, Chemical, and Sensory Properties of Flat Bread, Lavaş

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Abstract

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The whole buckwheat flour (WBF) was used in Turkish flat bread, lavaş, up to 30% level without gluten, and up to 40% level with gluten and sodium stearoyl-2-lactylate (SSL) additions. Some physical, chemical, and sensory properties of lavaş bread samples were determined. While ash, crude fiber, phytic acid (PA), Fe, K, Mg, and P contents of lavaş breads increased with WBF addition, gluten supplementation caused an increase especially in protein and Ca contents. Leavening process decreased PA contents in the breads compared to raw material, but WBF substitution increased PA contents up to 729 mg/100 g. As a result, the utilisation of WBF in lavaş bread improved the nutrients contents of the bread except PA. The dark colour and slight bitter taste of the WBF affected the sensory score of lavaş bread negatively at 40% substitution level, but the overall acceptability values did not change significantly ($P < 0.05$) compared to control sample.

Keywords: pseudo-cereals; phytic acid; mineral; sensory

Buckwheat (BW) is a traditional crop in Central and Eastern Europe and Asia. BW belongs to the Polygonaceae family and is taxonomically different from the Gramineae family to which belong cereals such as wheat, maize, and rice. However, BW seed has chemical, structural, and utilisation characteristics similar to those of cereal grains, and thus is usually classified as a cereal (Campell 1997; Ikeda 2002). BW, a pseudo-cereal, is commonly used as an important functional food. BW grains contain many valuable compounds and they are rich in vitamins (B_1, B_2, B_6, and E) and minerals (P, Fe, Zn, K, and Mg) (Wijngaard & Arendt 2006). BW proteins have a high biological value, although their digestibility is relatively low. The amino acids in BW protein are well balanced and rich in lysine, which is generally the first limiting amino acid in other plant proteins, and arginine (Pomeranz & Robbins 1972). Besides them, the contents of rutin, catechins, and polyphenols as well as their potential antioxidant activity are also of great significance (Fabjan *et al.* 2003).

The chemical composition of BW groat has been reported by a number of authors (Steadman *et al.* 2001; Bonaffacia *et al.* 2003; Wei *et al.* 2003; Krkošková & Mrázová 2005). Kim *et al.* (1994) reported the contents of crude protein, crude lipids, and ash in the range of 16.2 to 20.4%, 2.2 to 2.9%, and 2.8 to 4.3%, respectively. Shim *et al.* (1998) reported the average contents of crude protein, crude lipids, and ash to be 13.0 ± 0.28%, 2.9 ± 0.1% and 2.7 ± 0.13%, respectively. BW does not contain gluten, so it may be used for patients with coeliac disease. On the other hand, resistant starch content of BW has an important role for the preparation of low glycemic index food (Wojcicki *et al.* 1995; Fabjan *et al.* 2003). Some early studies also reported the use of BW flours and bran in different bakery products, pasta-noodle, cookie, cake, crepe, breakfast cereal and soap formulations (Bonafaccia & Kreft 1994; Kim *et al.* 1999; Lin *et al.* 2009; Bojňanská *et al.* 2009; Bilgiçli 2009a,b).

Lavaş is a kind of flat bread which is widely consumed in Turkey. Lavaş is prepared from wheat flour, salt, water, and compressed yeast + baking soda by 1.5 h fermentation. Dough is sheeted to 3 mm thickness and baked on iron plate (sac) or stone ovens (Coskuner & Karababa 2005). In the bread formula, the utilisation of BW flour causes some quality loss due to gluten free composition. WBF has a detrimental effect on the bread making quality in terms of colour and volume because of the natural dark colour and absence of gluten. Some researchers recommended vital gluten, milk, non fat dry milk, whey, ascorbic acid, gum, and emulsifier additions to the bread formula to overcome the quality losses (Haber 1980; Callejo *et al.* 1999). There are a number of studies in the literature on the improving effect of vital gluten on the quality of bread prepared with pseudo-cereal, legume, or gluten free cereal flours. The gluten proteins play an important role in subsequent stages of the bread making process and in the structure and volume of the final product (Callejo *et al.* 1999). Emulsifiers influence rheological properties of bread by interacting with proteins and carbohydrates thus resulting in a better quality of dough. SSL is an anionic oil-in-water emulsifier commonly used in bakery industry, and is also called dough strengthener and dough improver (Ribotta *et al.* 2010).

The specific objective of this study was to investigate the effects of WBF and some additives on the flat bread lavaş quality in an effort to increase the nutritional value of these breads made with WBF.

MATERIAL AND METHODS

Materials. Commercial white wheat flour contain 0.47% ash and 11.6% protein. BW groats were ground in a hammer mill (Falling Number-3100, Laboratuvary Mill.; Perten Instruments AB, Huddinge, Sweden) equipped with 0.5 mm opening screen. WBF with 100% extraction ratio was used in bread production. Vital gluten (Meelunie B.V., Amsterdam, The Netherlands) and SSL (Palsgaard A/S, Juelsminde, Denmark) were used in some bread formulae.

Experimental design and statistical analyses. Lavaş breads were prepared with up to 30% WBF without vital gluten and SSL additions, and up to 40% WBF with gluten and SSL additions. Gluten addition was made according to the diluted gluten content in the flour blend. For 20, 30, and 40% WBF substituted flours, 1.85, 2.78, and 3.71% vital gluten was used, respectively. SSL was added as an emulsifier to these three flour blends at a ratio of 0.5%.

Lavaş preparation. For the preparation of the lavaş samples, the method was used given by Coskuner and Karababa (2005). To prepare lavaş samples, doughs comprising flour (200 g, 14% moisture basis), salt (3 g), compressed yeast (2 g), baking soda (0.5 g), and water (adjusted by adding 2 points over the farinograph absorption) at 30°C were mixed in a mixer Hobart N50 (Hobart Canada Inc., North York, Canada) for a period of 45 s at maximum speed (to obtain optimum dough consistency). In WBF enriched lavaş samples, wheat flour was replaced with 10, 15, 20, 25, and 30% (w/w) WBF and at 3 different replacement ratios (20, 30 and 40% w/w) with gluten and SSL additions. Control samples were made with wheat flour. After mixing, the doughs were allowed to ferment at 30°C and 85% relative humidity for 1.5 h in a fermentation cabin. The doughs were divided into 4 pieces, and then they were rounded into a ball shape and dusted with flour of the same blend to aid sheeting. The dough balls were rolled to the final thickness of 3 mm and diameter of 20 cm. Baking was performed at 280 ± 5°C on a pre-heated (50–300°C) iron plate (*sac* or *sadj*) (Otm, San Ltd. Şti, Konya, Turkey) for 2.0 minute. After baking, the lavaş samples were cooled to room temperature (approximately 1 h) after which the thickness of the breads was measured with a digital micrometer (0.001 mm, Mitutoyo; Minoto-Ku, Tokyo, Japan) while the diameters were measured with an ordinary ruler.

Laboratory analyses. The AACC methods were used for the determination of moisture (method 44-19), protein (method 46-12), and crude fiber (method 32-10) contents in the raw material and bread samples (AACC 1990). Ash contents in the samples were estimated according to ICC method 104-1 (ICC 2002).

The mineral (Ca, Mg, P, Fe, and K) contents of the samples were determined by inductively-coupled plasma spectroscopy, ICP-AES (Vista series; Varian International AG, Zug, Switzerland). Dry samples were digested using closed vessel microwave digestion oven (Mars 5; CEM Corporation, Mathews, USA) with concentrated nitric acid and sulphuric acid. The concentrations were determined by ICP-AES.

Phytic acid (PA) was measured by a colorimetric method according to Haugh and Lantzsch (1983). PA in the sample was extracted with a solution of HCl (0.2N) and precipitated with a solution of ammonium iron(III) sulfate ($NH_4Fe(SO_4)_2 \cdot 12\,H_2O$).

The colour of the samples was determined by measuring the L^* (100 = white; 0 = black), a^* (+ red; – green) and b^* (+ yellow; – blue) values using a Minolta CR-400 (Minolta Camera Co., Ltd., Osaka, Japan) with illuminant D65 as reference. The means were determined using three samples.

Sensory analyses. Sensory analyses were conducted on gluten and SSL added lavaş bread samples due to their superior physical and chemical properties when compared with bread without additives. Sensory analyses were made by 10 panelists (age range of 30 to 60) from the Food Engineering Department at Selçuk University, all being experienced in the sensory evaluation of breads. The breads were coded and presented to the panelists at room temperature in plastic plates under daylight room conditions. The samples were randomly ordered, and each panelist received the samples in the same order. The bread characteristics were rated on a 1 to 5 scale, 5 being the most desirable. In sensory analyses, lavaş samples were evaluated in terms of the crust colour, elasticity, chewiness, taste-odour, and overall acceptability.

Statistical analyses. TARIST (Version 4.0; İzmir, Turkey) software was used to conduct the statistical analyses. The data were compared using standard Analyses of Variance (ANOVA) (significance level of $P < 0.05$). Duncan's Multiple Range Test was performed to compare the means between the treatments.

RESULT AND DISCUSSION

Raw material properties

Chemical composition and colour values of wheat flour and WBF are given in Table 1. As the WBF is produced from the whole groat, the ash, crude fiber, and mineral contents are higher compared to those in wheat flour ($P < 0.05$). These results are in agreement with those reported by Steadman *et al*. (2001) and Marshall and Pomeranz (1982) and Wijngaard and Arendt (2006). The higher PA (1480 mg/100 g) content in WBF than that in wheat flour (240 mg/100 g) is important in terms of the negative effect on mineral bioavailability. Egli *et al.* (2003) found the PA values of WBF as 1000 mg/100 g. WBF had low L^* (77.96) and high a^* (3.55) and b^* (17.19) colour values than wheat flour with L^* (95.51), a^* (–0.77) and b^* (9.89). WBF produced from the whole groat resulted in a dark colour. Bilgiçli (2009a) reported that L^*, a^* and b* values of WBF were 77.36, 3.41, and 16.22, respectively.

Table 1. Some chemical properties and color values of wheat and WBF[1,2]

	Wheat flour	WBF
Moisture (%)	10.7 ± 0.57^a	11.1 ± 0.28^a
Ash (%)	0.47 ± 0.01^b	1.73 ± 0.04^a
Protein (%)[3]	11.6 ± 0.14^a	12.10 ± 0.14^a
Crude fiber (%)	0.50 ± 0.00^b	1.20 ± 0.14^a
Phytic acid (mg/100 g)	240 ± 2.83^b	1480 ± 4.24^a
Minerals (mg/100 g)		
Ca	21 ± 1.41^a	22 ± 1.41^a
Fe	0.9 ± 0.01^b	2.8 ± 0.14^a
K	145 ± 2.83^b	433 ± 2.83^a
Mg	35 ± 1.41^b	235 ± 2.83^a
P	127 ± 2.83^b	455 ± 2.83^a
Colour values		
L^*	95.51 ± 0.72^a	77.96 ± 1.36^b
a^*	-0.77 ± 0.10^b	3.55 ± 0.14^a
b^*	9.89 ± 0.11^b	17.19 ± 0.27^a

[1]means with same letter within row are not significantly different ($P < 0.05$); [2]based on dry matter; [3]N × 5.70 for wheat flour; N × 6.25 for WBF

Chemical properties of lavaş bread

Chemical properties of lavaş breads are presented in Table 2. Generally, as the WBF substitution ratio of the breads without additives increased, moisture contents of the breads increased as well due to the higher water absorption capacity of WBF (Atalay 2009). Mean ash content found for lavaş breads was 1.56% (Table 2). Rich ash content of WBF compared to that in wheat flour increased the ash content of bread, as expected. Some investigators reported an increase in the ash content of different cereal products with the addition of BW milling products (Atalay 2009; Bilgiçli 2009a,b; Bojňanská *et al.* 2009). Gluten addition in lavaş formulae increased the protein content up to 15.48%. The higher crude fiber content of WBF, like its ash content, directly affected the end product crude fiber content.

PA (myo-initisol hexaphosphate) is considered to be an antinutrient due to its ability to bind minerals and proteins, either directly or indirectly, and thus change their solubility, functionality, absorption and digestibility (Rickard & Thompson 1997). Most PA-mineral complexes are insoluble at physiological pH level, which is the main cause of the poor bioavailability of the mineral complexes (Harland & Harland 1980). In our study, mean PA content of lavaş samples changed between 192 mg/100 g and 729 mg/100 g. As the WBF addition ratio increased in lavaş formulae, PA content increased and the highest PA content was obtained with 40% addition levels. The high PA content (1480 mg/100 g) of WBF (Table 1) directly affected the PA content of the bread samples. Fermentation is one of the most effective processes known to reduce PA (Harland & Harland 1980; Ozkaya *et al.* 2002; Bilgiçli 2009a). At the end of the fermentation period, PA was degraded in bread doughs by phytase enzyme from compressed yeast.

Ca, Fe, K, Mg, and P contents of the breads are shown in Table 2. In lavaş bread, as the ratio of WBF in formula increased, K, Mg, and P contents of the breads increased significantly ($P < 0.05$). On the other hand, Ca content was affected with gluten and SSL additions. The increase in mineral contents was 1.20 and 1.81 times in Fe, 1.19 and 1.71 times in K, 1.54 and 2.84 times in Mg, and 1.18 and 2.07 times in P with the minimum and maximum WBF substitution levels, respectively (Table 2). Steadman *et al.* (2001) and Wijngaard and Arendt (2006) as well reported that the levels

Table 2. Some chemical properties and mineral contents of lavaş breads[1,2]

Flour blend	Moisture (%)	Ash(%)	Protein[3] (%)	Crude fiber (%)	PA (mg/100g)	Ca (mg/100g)	Fe (mg/100g)	K (mg/100g)	Mg (mg/100g)	P (mg/100g)
0[4]	23.6 ± 0.14^{e}	1.31 ± 0.02^{g}	11.61 ± 0.07^{g}	0.53 ± 0.03^{d}	192 ± 1.70^{i}	25.4 ± 0.00^{c}	0.93 ± 0.04^{g}	152.5 ± 1.98^{g}	35.9 ± 0.44^{g}	126.2 ± 2.69^{i}
10	24.1 ± 0.11^{d}	1.42 ± 0.03^{f}	11.74 ± 0.01^{f}	0.59 ± 0.04^{cd}	303 ± 2.12^{h}	25.5 ± 0.14^{c}	1.12 ± 0.04^{f}	181.3 ± 2.97^{f}	55.2 ± 1.27^{f}	149.3 ± 1.56^{h}
15	25.7 ± 0.28^{c}	1.47 ± 0.04^{ef}	11.80 ± 0.03^{f}	0.62 ± 0.02^{bc}	361 ± 3.96^{g}	25.5 ± 0.14^{c}	1.24 ± 0.06^{ef}	204.1 ± 1.56^{e}	66.0 ± 1.27^{e}	162.6 ± 1.27^{g}
20	26.4 ± 0.21^{b}	1.53 ± 0.06^{de}	11.86 ± 0.06^{ef}	0.65 ± 0.04^{abc}	431 ± 2.12^{f}	25.7 ± 0.42^{c}	1.31 ± 0.07^{de}	210.7 ± 2.83^{d}	74.2 ± 0.28^{d}	173.5 ± 2.83^{f}
25	27.4 ± 0.14^{a}	1.58 ± 0.04^{bcd}	11.93 ± 0.04^{d}	0.68 ± 0.02^{ab}	492 ± 2.83^{d}	25.7 ± 0.28^{c}	1.43 ± 0.08^{bcd}	220.6 ± 1.98^{c}	83.7 ± 1.56^{c}	189.1 ± 1.27^{d}
30	27.3 ± 0.21^{a}	1.65 ± 0.06^{bc}	11.94 ± 0.04^{d}	0.71 ± 0.03^{a}	544 ± 3.68^{c}	25.7 ± 0.28^{c}	1.51 ± 0.08^{abc}	237.4 ± 2.12^{b}	91.5 ± 0.28^{b}	210.7 ± 1.84^{c}
G 20[5]	22.4 ± 0.11^{f}	1.55 ± 0.04^{cde}	13.64 ± 0.06^{c}	0.63 ± 0.02^{bc}	457 ± 3.82^{e}	27.6 ± 0.42^{b}	1.34 ± 0.04^{cde}	218.9 ± 2.12^{c}	75.2 ± 0.95^{d}	188.8 ± 0.57^{e}
G 30	22.2 ± 0.20^{f}	1.69 ± 0.03^{ab}	14.54 ± 0.04^{b}	0.68 ± 0.03^{ab}	581 ± 2.40^{b}	28.1 ± 0.14^{ab}	1.53 ± 0.08^{ab}	243.2 ± 1.27^{b}	91.1 ± 1.13^{b}	225.3 ± 1.70^{b}
G 40	24.4 ± 0.21^{d}	1.84 ± 0.04^{a}	15.48 ± 0.06^{a}	0.73 ± 0.05^{a}	729 ± 1.98^{a}	28.7 ± 0.28^{a}	1.69 ± 0.08^{a}	261.5 ± 1.56^{a}	102.0 ± 1.84^{a}	260.7 ± 0.99^{a}
Mean	24.82 ± 1.90	1.56 ± 0.15	12.73 ± 1.41	0.65 ± 0.07	454.40 ± 154.1	26.40 ± 1.29	1.34 ± 0.60	2214.50 ± 78.8	75.10 ± 19.94	187.40 ± 39.67

[1]Duncan's multiple range test. Means with same letter within column are not significantly different ($P < 0.05$); Values are the average of triplicate measurements on the duplicate sample ± standard deviation;; [2]based on dry matter; [3]N × 5.70 for wheat flour; N × 6.25 for WBF; [4]WBF substitution ratio; [5]WBF substitution ratio with gluten and SSL addition

of Mg, Zn, K, P, and Cu in BW were high compared to those in wheat and other cereals.

Spread ratio and colour values of bread samples

Spread ratio and colour values of the lavaş samples are presented in Table 3. Spread ratio was calculated by dividing the diameter (cm) of flat bread by thickness (cm). The mean value of the spread ratio for lavaş samples was 40.90, while WBF addition increased the spread ratios. Additives (gluten and SSL) increased the thickness and decreased the diameter of lavaş bread compared to the samples without additives (data not given), but these changes did not affect the spread ratio of the bread statistically ($P > 0.05$).

Lightness (L^*) values of the breads prepared without gluten and SSL decreased with the increase in WBF addition. As mentioned before, WBF as a raw material has a darker and more yellowish colour intensity compared to that of wheat flour (Table 1). As expected, raw material colour intensity affected the colour of the end product, bread. An other reason for lower L^* values of lavaş breads containing WBF might be easy degradation of BW starch to reducing sugar, which could play an important role in the browning reactions (Marshall & Pomeranz 1982; Bilgiçli 2009a). Maillard reaction also caused an increase in redness (a^*) intensity as the WBF substitution ratio increased. The highest yellowish (b^*) colour in lavaş breads was observed with a high substitution of WBF with gluten and SSL additions.

Sensory properties of lavaş bread

Sensory properties of lavaş breads with additives are presented in Figure 1. As a result of the pre-assessment, lavaş samples with additives were preferred in sensory evaluation due to being more flexible and thicker than lavaş without additives (data not given). Flexibility of lavaş bread in terms of traditional consumption function is the most important parameter. In addition, it was not able to reach to 40% WBF ratio without additives. Additives are commonly used in the baking industry to improve the quality of the bakery products. The use of these additives in the bakery products is increasing all over the world because of the advantages they offer. The addition of WBF as a non-gluten flour diluted the gluten content and weakened the structure of the lavaş samples. In the literature, the addition of the vital gluten has been reported to improve the processing properties of the dough and the quality of the end product (Gan *et al.* 1989; Rao & Rao 1991; Ozkaya & Ozkaya 1992; Kim *et al.* 2000; Flander *et al.* 2007). Shakuntala *et al.* (2010) reported that the use of SSL surfactant softens the texture of loaves with better physical characteristics.

In the present study, the crust colour of the lavaş containing 40% WBF and additives was found lower ($P < 0.05$) than that of control bread due to the dark colour of the WBF (Figure 1). Other ad-

Table 3. Spread ratio and color values of lavaş breads[1]

Flour blend	Spread ratio (D/T)[2]	L^*	a^*	b^*
0[3]	30.20 ± 0.92[c]	88.32 ± 0.16[a]	0.73 ± 0.06[f]	14.19 ± 0.23[e]
10	37.15 ± 2.16[b]	84.40 ± 0.20[b]	2.08 ± 0.06[e]	15.22 ± 0.16[d]
15	38.26 ± 0.09[b]	83.48 ± 0.08[c]	2.15 ± 0.13[e]	15.46 ± 0.20[d]
20	39.02 ± 1.07[b]	82.02 ± 0.27[d]	2.66 ± 0.07[d]	15.55 ± 0.10[d]
25	45.56 ± 3.13[a]	79.53 ± 0.25[e]	3.37 ± 0.16[c]	16.53 ± 0.07[c]
30	47.95 ± 1.69[a]	78.58 ± 0.27[f]	3.63 ± 0.17[bc]	17.34 ± 0.16[a]
G 20[4]	37.88 ± 0.80[b]	81.92 ± 0.14[d]	2.57 ± 0.07[d]	16.69 ± 0.11[bc]
G 30	45.83 ± 2.30[a]	78.23 ± 0.40[f]	3.68 ± 0.10[b]	17.07 ± 0.07[ab]
G 40	46.22 ± 1.46[a]	76.57 ± 0.47[g]	4.14 ± 0.08[a]	17.21 ± 0.13[a]
Mean	40.90 ± 10.11	81.45 ± 3.55	2.78 ± 1.02	16.14 ± 1.06

[1]Duncan's multiple range test. Means with same letter within column are not significantly different ($P < 0.05$). Values are the average of triplicate measurements on the duplicate sample ± standard deviation; [2]D/T: diameter/thickness; [3]WBF substitution ratio; [4]WBF substitution ratio with gluten and SSL addition

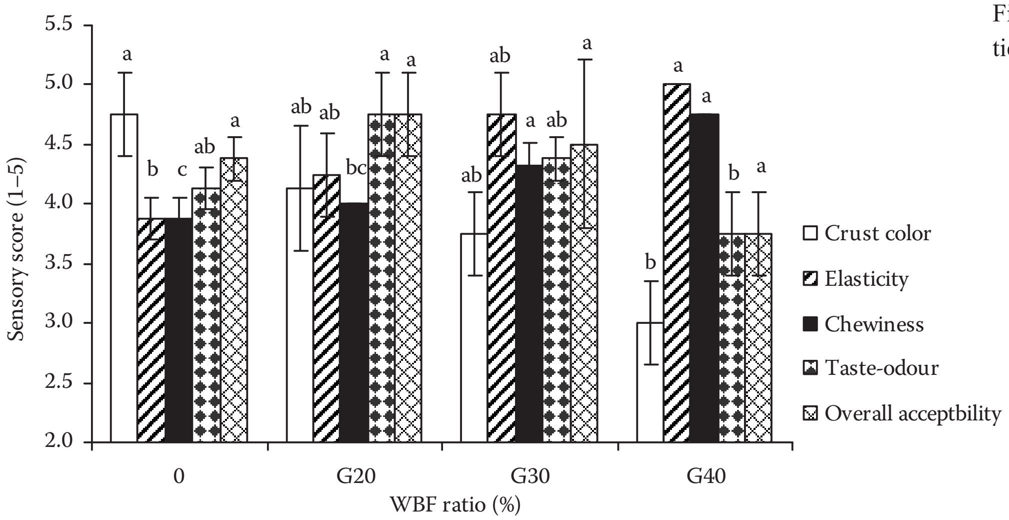

Figure 1. Sensory properties of lavaş breads

dition levels of the WBF also decreased the crust colour but the values are not different statistically ($P > 0.05$). Elasticity and chewiness of the lavaş were positively affected by the addition of WBF, and 40% WBF addition level gave higher elasticity and chewiness scores than control samples. But 40% WBF substitution level decreased the taste and odour scores of lavaş breads. Slightly bitter taste of WBF might have affected the taste-odour appreciation. All of the bread samples had similar overall acceptability scores.

CONCLUSION

WBF addition into flat bread formula improved the nutritional value of lavaş bread in terms of ash, crude fiber, and mineral (Fe, K, Mg and P) contents. WBF provided the breads darker crust as a result of natural pigmentation. WBF up to 30–40% proportion with gluten and SSL can be used in the lavaş bread formula to enrich the bread, taking the optimum physical and sensorial properties of breads into consideration.

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