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Enrichment of Ginger Nut Biscuits with Wholegrain Buckwheat and Rye Flour

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ABSTRACT

To broaden the use of common buckwheat in human nutrition, an attempt was made to use wholegrain buckwheat flour in ginger nut biscuit formulations. The aim of the study was to develop a ginger nut biscuit formulation in which wheat flour is partially substituted with buckwheat flour in such doses to obtain nutritionally improved and acceptable product. Buckwheat flour was tested at doses 30, 40, 50% (flour weight basis). Proximate composition (basic chemical composition, fibers, micro elements), physical (height, width, spread, density, color) and textural attributes (hardness, fracturability) of buckwheat enriched ginger nut biscuits were analyzed and compared to those made with wheat flour solely. Since buckwheat tends to increase hardness of the products due to the peculiar gelling properties of buckwheat starch, inclusion of rye flour at 10 and 20% dose was also investigated. The dimension of ginger nut biscuits decreased but since the biscuit height was more affected by the rising doses of buckwheat, the spread increased in the composite biscuits (significant difference was noted at 40 and 50% levels of replacement). This could be attributed to the coarse granularity of buckwheat flour. Hardness and fracturability of ginger nut biscuits increased significantly with the addition of 50% buckwheat. The enriched biscuits were nutritionally improved as they contained more fibers, minerals and proteins (percent increase ranges depending on the replacement level were: for fibers 41.8-141.4%, for Fe 132.3-189.2%, for Zn 115.4-223.1%, for Mn 43.9-72.7%, for Cu 212.5-262.5%, for proteins 6.6-17.1%). Yellow tone decreased in all buckwheat containing biscuits at all substitution levels. All composite biscuits over 40% buckwheat substitution level showed an increased red tone. The majority of composite biscuits did not differ significantly from the control regarding darkness.

Keywords: carbohydrate, dietary fibers, fat, mineral content, physical attributes, texture

INTRODUCTION

Food produced from major industrial crops has been found to lack some functional compounds which are today recognized as vital for the human health and well-being. This has led to an increase in consumers' concern for health and placed the food industry before a challenging task: to produce food with improved nutritional quality, functionality and acceptable palatability. Among many newly discovered food ingredients, some underutilized traditional crops that used to be important basic food sources in the past like amaranth, quinoa, spelt, kamut have also gained renewed interest because of their exceptional nutritional quality.

Buckwheat is one such rediscovered traditional crops, due to its superior nutritional quality and physiological effects (Przybylski and Gruczyñska 2009; Bojñanská *et al.* 2009; Wronkowska *et al.* 2010; Léder *et al.* 2010). Buckwheat is utilized for human consumption mostly in the form of flour for noodles, pastas, pancakes and bread (Min *et al.* 2010) or groats and grits in a variety of national dishes (Kreft 1983). Experimental results have shown that bread supplemented with 15% of buckwheat (flour basis) had more effective antioxidant properties than common wheat bread (Lin *et al*. 2009). Vogrinčić *et al.* (2010) discovered that the baking process decreases antioxidant activity in buckwheat breads; despite this, breads enhanced with tartary buckwheat retained higher antioxidant activity than their 100% wheat counterpart. Şensoy *et al.* (2006) suggested that, by optimization of processing conditions during roasting and extrusion, the functionality of active components in buckwheat contained products can be retained. However, buckwheat has still not been exploited in the food industry. Since easy-to-eat products with health benefits are an emerging trend in the industry, using buckwheat in biscuit (cookie) production is worthy of consideration.

Ginger nut biscuits are a popular type of biscuit containing honey and spices. Consumers consider ginger nut biscuits as healthier than other biscuit types due to their low fat content and the presence of honey which is generally perceived as a value-adding all-natural ingredient to products (LaGrange *et al.* 1991). Formulations of ginger nut biscuits typically include 35-50% honey, 28-32% sugar, 0-5% fat on a flour weight basis (Gavrilović 2003) whereas the levels of major ingredients in common sweet biscuits are 30-75% sugar and 30-60% fat (Pyler 1988). In industrial and artisan practice, wheat flour is frequently substituted with rye flour in doses up to 20% (flour weight basis) which contributes to better moisture retention and prolonged freshness of the product.

The objective of this work was to evaluate the feasibility of partial replacement of wheat flour with wholegrain buckwheat flour and rye in ginger nut biscuit formulations by determining the chemical composition, physical and textural attributes of such products after baking and 30-day storage.

MATERIALS AND METHODS

Ingredients and ginger nut biscuit making

Wheat flour (WF) type 850 (ash content 0.81% on dry matter (DM) basis, moisture content 12.53%), milled wholegrain buckwheat flour (ash 2.20% (DM), moisture content 12.31%), wholegrain rye flour (ash 1.61% (DM), moisture content 9.37%), honey, vegetable fat, sugar, $NaHCO_3$, lecithin and spice (cinnamon) were

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Table 1 Ginger nut biscuit formulas.

Ingredients (g)	Control	Composite ginger nut biscuits										
	100WH[a]	0BWH-10R	0BWH-20R	30BWH-0R	30BWH-10R	30BWH-20R	40BWH-0R	40BW-10R	40BWH-20R	50BWH-0R	50BWH-10R	50BWH-20R
Wheat flour	100	90	80	70	60	50	60	50	40	50	40	30
Buckwheat flour	0	0	0	30	30	30	40	40	40	50	50	50
Rye flour	0	10	20	0	10	20	0	10	20	0	10	20
Honey						50						
Sugar						10						
Vegetable fat						10						
$NaHCO_3$						2.1						
Cinnamon						2						
Lecithin						1						
Water	12	13	14	9	10	11	8	9	10	7	8	9

[a] WH-wheat substitution level in the the biscuit formulation (% flour basis)
BWH- buckwheat substitution level in the biscuit formulation (% flour basis)
R- rye substitution level in the biscuit formulation (% flour basis)

purchased locally. Ginger nut biscuits with various proportions of buckwheat and/or rye were prepared according to the formula presented in **Table 1**.

To prepare the ginger nut biscuit dough, a mixture of honey, sugar and water was first warmed to 65°C. After cooling to 40°C, other ingredients were mixed using a kitchen mixer with a spiral hook (approximately for 8 min). Dough consistency was checked subjectively by an experienced baker to obtain dough with good handling ability. The dough was left to rest overnight at room temperature. Following the rest time, the dough was sheeted to a final thickness of 10 mm on a pastry break. Dough pieces with a diameter of 60 mm were cut and baked for 12 min in a deck oven at 170°C. After cooling to room temperature, the biscuits were placed in polyethylene bags and stored for 30 days at ambient temperature until further examination.

Determination of chemical composition

Standard procedures (AOAC 2000) were used to evaluate all samples in duplicate for moisture (Method No. 926.5), protein (Method No. 950.36), fat (Method No. 935.38), reducing sugar (Method No. 975.14) and total dietary fiber (Method No. 958.29). Starch content was determined by hydrochloric acid dissolution according to the ICC Standard (ICC Standard No. 123/1, 1994). Mineral composition was analyzed by atomic absorption spectrometry (AAS) on a Varian SpectrAA-10 (Varian Iberica S.L., Madrid, Spain) atomic absorption spectrophotometer equipped with a background correction (D2-lamp). A dry ashing procedure was used to prepare the samples for AAS.

Physical tests

Physical parameters (diameter, height, weight) were determined on 12 replicates and mean values were recorded. Biscuit diameters and heights were measured by vernier calipers and weights on a digital top loading balance. Spread was calculated from the ratio of width and height. Biscuit density (D) was derived by calculation dividing biscuit weight by its volume (volume was calculated directly as it approximated a cylinder volume) using a formula as follows:

$$D = m / (r^2 * \pi * h)$$

where m = biscuit weight, r = biscuit radius, h = biscuit height.

Texture measurements

Biscuit penetration force was measured on eight samples using a TA.HDplus Texture Analyzer (Stable Micro Systems, England, UK) with a 5 kg load capacity. The apparatus settings were: pre-test speed = 1.0 mm/s, test speed = 0.5 mm/s, post-test speed = 10.0 mm/s, travelling distance = 24 mm, 2 mm cylinder probe. Ginger nut biscuit hardness was calculated as the area under the curve and biscuit fracturability was the linear distance.

Color determinations

Color determinations were conducted on all samples in duplicate using a tristimulus photocolorimeter MOM-Color 100 (Magyar Optikai Művek, Budapest, Hungary). The CIE $L^*a^*b^*$ values were recorded. The CIE $L^*a^*b^*$ is a uniform colour scale in which L^*, a^* and b^* are coordinates; L^* ranges from 0 (black) to 100 (white), a^* and b^* have no numerical limits (positive a^* denotes red tone, negative a^* is green, positive b^* is yellow, negative b^* is blue). Standard values of a white standard tile were L = 92.25, a = -1.34 and b = 0.69.

Statistical analysis

A two-factor completely randomized design was used to analyze metric data (parameters of chemical composition, biscuit dimensions, density, texture parameters (hardness, fracturability), color parameters) using the Statistica 7.1 statistical software package (StatSoft Inc., Tulsa, Oklahoma). Tukey's *post-hoc* test was used to compare the means at a 95% confidence interval. Correlation analysis was conducted using Spearman's rank correlation coefficient applied to mean values for each biscuit. If otherwise not stated, 3 samples of each biscuit type were analyzed in parallels.

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of ginger nut biscuits is presented in **Tables 2A** and **2B**. The results demonstrated that increased substitution of wheat flour with buckwheat and rye flour significantly increased the content of zinc, manganese, fibers and proteins in the biscuits ($P < 0.05$). From formulation 30BWH-10R and those with higher substitution levels with buckwheat and/or rye, there was a significant increase in the iron and copper content. Reducing sugars significantly declined in the samples 30BWH-20R and those with a higher substitution level. The content of starch showed a declining trend but significant difference in the starch content as compared to the control was observed for sample 50BWH-20R. The fat content gradually increased from 8.08% d.b. (control) to 9.26% d.b. (50BWH-20R). This could be due to higher fat content in buckwheat flour (2.20% DM) compared to wheat flour (1.15% DM). A similar increasing tendency in the fat content was observed in common biscuits supplemented with 40% (flour basis) buckwheat by Baljeet *et al.* (2010), explained to be a consequence of higher oil retention ability of buckwheat flour.

Moisture content of biscuits was significantly affected by substituting wheat flour with buckwheat and rye: buckwheat tended to decrease it whereas rye increased the moisture content (**Fig. 1**). As a result, composite biscuits with 40 and 50% of buckwheat were significantly lower in moisture (8.00-9.00%) than the control. Other formulations had higher moisture contents with the highest registered in biscuits made with 10 and 20% rye (10.08 and 10.11%, respec-

Table 2a Proximate chemical composition of composite ginger nut biscuits.

Components	100WH	0BWH:10R^{f}	0BWH:20R	30BWH:0R	30BWH:10R	30BWH:20R
Nutritional value (g/100 g DM)						
Moisture	10.02^{d}	10.08^{d}	10.11^{d}	9.58^{c,d}	9.92^{d}	9.98^{d}
Starch	45.40^{b,c}	45.44^{c}	45.19^{b,c}	43.82^{a,b,c}	42.26^{a,b,c}	41.64^{a,b,c}
Reducing sugars	29.68^{c,d,e}	29.88^{d,e}	30.39^{e}	26.68^{b,c}	26.79^{b,c}	26.20^{a,b}
Dietary fibers	4.42^{a}	4.81^{a}	5.31^{a,b}	6.27^{b}	6.60^{c,d}	7.10^{c,d,e}
Fat	8.08^{a}	8.14^{a}	8.27^{a}	8.54^{a,b}	8.62^{a,b}	8.64^{a,b}
Protein	7.30^{a,b}	7.18^{a}	7.20^{a}	7.69^{b,c}	7.78^{c}	7.92^{c,d}
Mineral content (mg/100 g DM)						
Fe	0.65^{a}	0.98^{a,b}	1.05^{a,b}	1.44^{a,b,c}	1.51^{b,c}	1.72^{b,c}
Zn	0.39^{a}	0.43^{a}	0.47^{a}	0.84^{b}	1.06^{b,c}	0.96^{b,c}
Mn	0.66^{a}	0.72^{a}	0.78^{a,b}	0.95^{c,d}	0.88^{b,c}	1.00^{c,d,e}
Cu	0.08^{a}	0.09^{a}	0.10^{a}	0.17^{a,b}	0.25^{b}	0.23^{b}

$^{a-e}$ Mean values within raws followed by the same letter are not different (p>0.05).
^{f} WH-wheat substitution level in the the biscuit formulation (% flour basis)
BWH- buckwheat substitution level in the biscuit formulation (% flour basis)
R- rye substitution level in the biscuit formulation (% flour basis)

Table 2b Proximate chemical composition of composite ginger nut biscuits.

Components	40BWH:0R^{f}	40BWH:10R	40BWH:20R	50BWH:0R	50BWH:10R	50BWH:20R
Nutritional value (g/100 g DM)						
Moisture	8.48^{a}	9.19^{b,c}	9.28^{c}	8.43^{a}	8.60^{a}	8.67^{a,b}
Starch	43.57^{a,b,c}	43.23^{a,b,c}	41.58^{a,b,c}	42.89^{a-d}	41.38^{a,b}	40.72^{a}
Reducing sugars	26.04^{a,b}	24.32^{a,b}	27.00^{b,c,d}	26.36^{a,b}	25.57^{a,b}	23.4^{a}
Dietary fibers	7.07^{c,d,e}	7.64^{d,e}	8.82^{f,g}	7.85^{e,f}	9.31^{g}	10.67^{h}
Fat	8.55^{a,b}	8.67^{a,b,c}	8.46^{a,b}	8.59^{a,b}	9.02^{b,c}	9.26^{c}
Protein	7.91^{c,d}	8.35^{e}	8.54^{e}	8.20^{d,e}	8.24^{d,e}	8.55^{e}
Mineral content (mg/100 g DM)						
Fe	1.70^{b,c}	1.51^{b,c}	1.87^{c}	1.76^{b,c}	1.78^{b,c}	1.88^{c}
Zn	1.15^{b,c}	1.10^{b,c}	1.16^{c}	1.18^{c}	1.20^{c}	1.26^{c}
Mn	0.97^{c,d,e}	0.98^{c,d,e}	1.09^{e,f}	1.02^{d,e}	1.04^{c,d,f}	1.14^{f}
Cu	0.19^{a,b}	0.27^{b}	0.29^{b}	0.23^{b}	0.26^{b}	0.28^{b}

$^{a-e}$ Mean values within raws followed by the same letter are not different (p>0.05).
^{f} BWH- buckwheat substitution level in the biscuit formulation (% flour basis)
R- rye substitution level in the biscuit formulation (% flour basis)

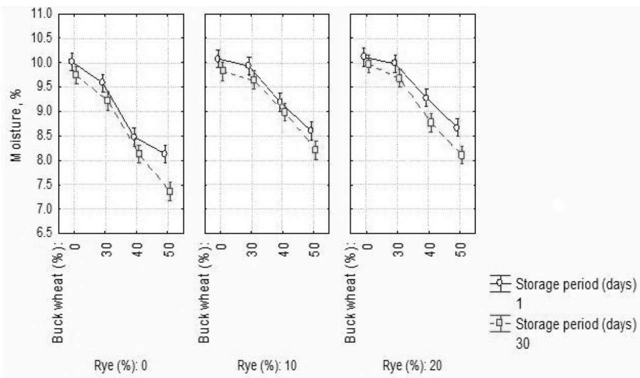
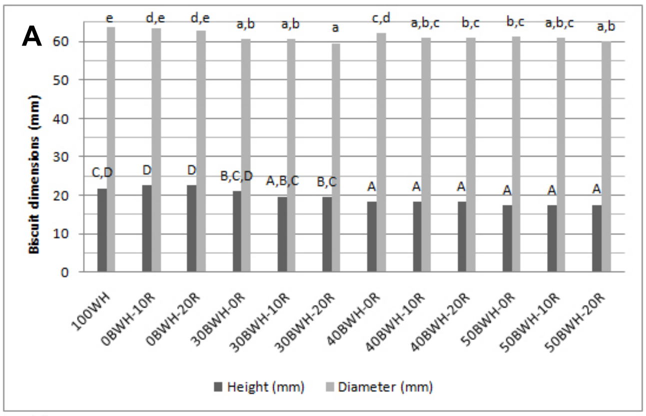


Fig. 1 Effect of ginger nut biscuit formulation on biscuit moisture content measured after 24 h and 30 days. Vertical bars denote 0.95 confidence.

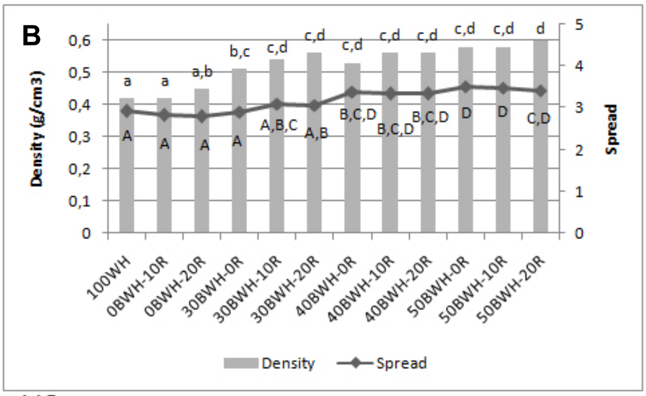
tively). Lower moisture content of composite biscuits was due to lower moisture absorption capacity of buckwheat flour and lower dough cohesiveness, which influenced its handling ability. These results are in agreement with the findings of Baljeet *et al.* (2010) who found significantly lower water absorption capacity in buckwheat flour (133.7%) in relation to refined wheat flour (151.0%) and consequently lower moisture content (2.43-3.00%) in biscuits enriched with buckwheat in doses above 20% (flour weight basis) compared to the wheat control sample (3.37%). All formulations containing rye had somewhat higher moisture contents than those that did not contain rye. Rye contains pentosans and secalins which exhibit high water absorption capacity and, furthermore, its finer granulation additionally contributed to a better capacity to absorb water (Auerman 1972). Minimal moisture content required for the retention of freshness in ginger nut biscuit is 7% (Gavrilović 2003). Moisture contents below this value render biscuits unacceptable due to the increased tendency to dry out. Readings taken after 30 days showed a gradual decrease in moisture content of all biscuits without dropping below the critical value.

Biscuit dimension, density and spread

The effect of various product formulations on biscuit dimensions and spread are shown in **Figs. 2A** and **2B**. The replacement of wheat flour with buckwheat flour significantly decreased ($P < 0.05$) the biscuit height except for formulations with 30% substitution level. Biscuit diameter significantly decreased ($P < 0.05$) in the combined formulations due to the addition of both buckwheat and rye. There was a significant positive correlation between height and diameter ($r = 0.56$). Although both dimensions became reduced within all composite biscuits relative to the control, the dimensions were not equally affected which caused an increased spread (diameter to height ratio) in biscuits at the 40 and 50% buckwheat substitution levels. Biscuit spread is controlled by dough viscosity during baking (Abboud *et al.* 1985; Hoseney *et al.* 1988; Hoseney and Rogers 1994) and as such by all factors that affect dough viscosity. According to Hoseney *et al.* (1988), dough viscosity is determined by the level of water in the dough formulation. A higher amount of water contributes to sugar dissolving, lower dough viscosity and increased spread. If the dough contains ingredients with high moisture absorption capacity then less water is available to act as a solvent, dough viscosity increases and consequently spread decreases. Increased spread in the biscuits substituted with higher buckwheat doses might have been due to coarse granulation of the buckwheat flour (50% of particles was larger than 350 μm). Coarsely granulated flours have been reported to contribute to greater spread in cookies as described by Manley (1991) and Singh Gurjal *et al.* (2003). Furthermore, some studies have confirmed that the addition of finely ground buck-



a-e; A-D Mean values above bars followed by the same letter of the same case are not different (p>0.05).
WH - wheat substitution level in the the biscuit formulation (% flour basis).
BWH - buckwheat substitution level in the biscuit formulation (% flour basis).
R - rye substitution level in the biscuit formulation (% flour basis).



a-d; A-D Mean values above bars followed by the same letter of the same case are not different (p>0.05).
WH - wheat substitution level in the the biscuit formulation (% flour basis).
BWH - buckwheat substitution level in the biscuit formulation (% flour basis).
R - rye substitution level in the biscuit formulation (% flour basis).

Fig. 2 Effect of ginger nut biscuit formulation on biscuit physical properties. (**A**) Height and diameter. (**B**) Spread and density.

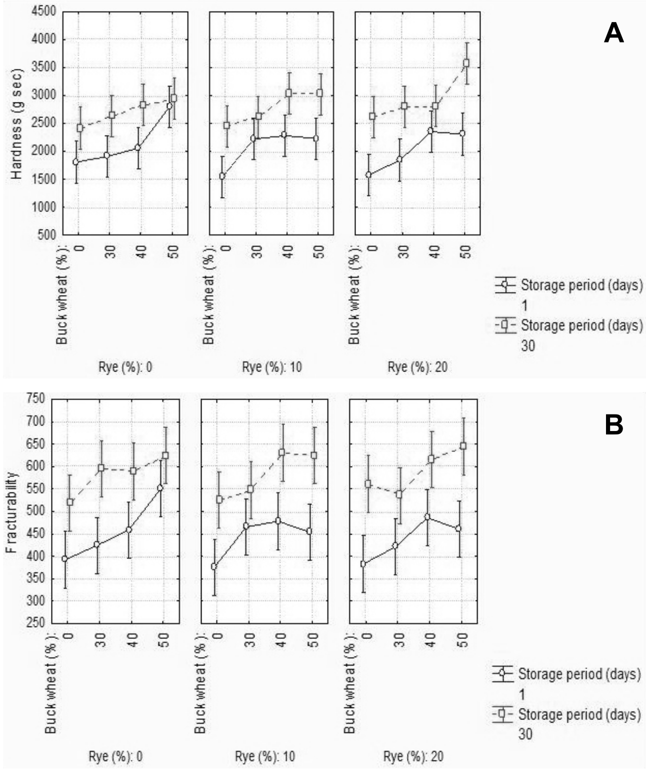


Fig. 3 Effect of ginger nut biscuit formulation on biscuit textural properties measured after 24 h and 30 days. (**A**) Hardness. (**B**) Fracturability. Vertical bars denote 0.95 confidence.

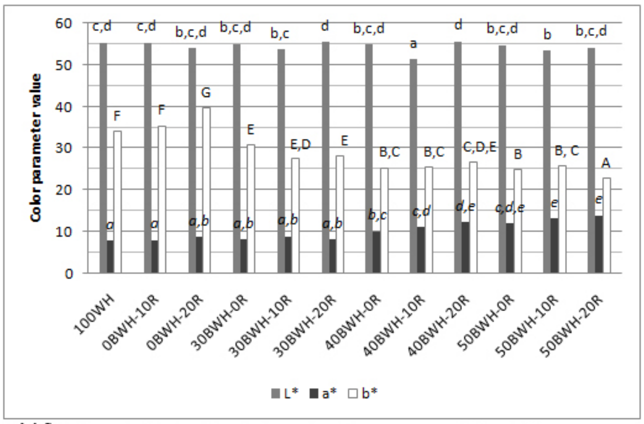
wheat flour (granulation size 100-150 µm) in sugar-snap cookie formulations lowered cookie spread (Maeda *et al.* 2004; Baljeet *et al.* 2010). Generally, higher biscuit spread is beneficial in biscuit making (Pareyt and Delcour 2008) but this might not be true in ginger nut biscuit making since a well developed crumb is essential for a high quality product (Gavrilović 2003), therefore greater thickness is preferable.

Density progressively increased as substitution levels of buckwheat and rye increased. Biscuit density was significantly inversely correlated to dimensions with r = -0.97 ($P < 0.01$) and -0.76 ($P < 0.05$) for height and diameter, respectively, confirming that higher density reduces biscuit development. Ragaee and Abdel-Aal (2006) observed that substitution of soft wheat with 30% of rye tended to decrease specific volume (i.e. increase density) in cake formulations but did not affect the diameter and height of cookie formulations.

Biscuit texture characteristics

Buckwheat and rye exerted mutually opposite influences on the hardness and fracturability of ginger nut biscuits: buckwheat tended to increase these parameters whereas rye decreased them. However, significant variability in these factors was due to the addition of buckwheat. Actually, statistically the highest difference was observed between sample 50B-0R (2799.2 g sec) and samples 0B-10R, OB-20R, control, 30B-20R, and 30B-0R (1542.8-1908.6 g sec), respectively (**Fig. 3A** and **3B**). Sample 50B-0R was statistically more fracturable than the control, 0B-10R and 0B-20R samples. Hardness and fracturability of the stored biscuits increased (**Fig. 3**).

According to Gavrilović (2003) hardness of ginger nut biscuits is affected by starch pasting properties. Kreft and Škrabanja (1998) reported that isolated buckwheat starch directly affected the texture of products by increasing their hardness. Ikeda *et al.* (1997) showed that incorporation of buckwheat starch into buckwheat flour significantly increased the hardness as well as other textural parameters of cooked dough (noodles). This is probably due to the ability of buckwheat starch to form gels of higher peak viscosity and setback values in comparison to other cereal starches (Li *et al.* 1997; Zheng *et al.* 1998; Qian and Kuhn 1999; Liu *et al.* 2006). On the other hand, some other studies (Qian *et al.* 1998; Chopin Applications Laboratory 2006; Banu *et al.* 2010) showed lower setback values of buckwheat starches and flour indicating lower retrogradation tendency, which is an advantage in food applications. Such behavior of buckwheat starch may be associated with increased hardness in ginger nut biscuits after baking and during storage but it is worth noting that biscuits, unlike noodles, are low-moisture systems in which starch gelatinization is impaired due to the lack of sufficient water. Besides the evident role of starch in the formation of texture in buckwheat products, some studies stress the importance of buckwheat proteins. Ikeda *et al.* (1997) concluded that buckwheat starch and protein contents are important factors that affect the texture profile of buckwheat-enhanced products and implied to the importance of protein and starch ratio on the product's palatability, which is a unique attribute of each buckwheat variety. In their later work, Ikeda *et al.* (1999) reported that protein in buckwheat flour was negatively correlated to texture attributes of cooked buckwheat dough. Inglett *et al.* (2009) found that buckwheat flours containing different ratios of endosperm, hull, aleurone layer and embryo showed different pasting and water-holding characteristics and proposed that high protein and low viscosity flour can be used for the production of breads and cookies. Mariotti *et al.* (2008) proposed that dehulled buckwheat flour can be used in breadmaking despite its higher retrogradation tendency. Fessas *et al.* (2008) pointed out that poor buckwheat protein quality in relation to network-forming ability limits the use of buckwheat flour in breadmaking but revealed that the ad-



a-d; A-G; *a-e* Mean values above bars followed by the same letter of the same case are not different ($p>0.05$).
WH - wheat substitution level in the the biscuit formulation (% flour basis).
BWH - buckwheat substitution level in the biscuit formulation (% flour basis).
R - rye substitution level in the biscuit formulation (% flour basis).

Fig. 4 Color properties of ginger nut biscuits.

dition of water-soluble polysaccharides isolated from buckwheat husk ameliorates the inferior structure-related properties of buckwheat proteins making them more suitable for bread preparation.

Gavrilović (2003) related ginger nut biscuit fracturability to the presence of partially dehydrated gluten in the dough matrix. Higher fracturability of composite ginger nut biscuits could be due to a higher proportion of non-gluten ingredients (rye and buckwheat) that decreased the gluten content and simultaneously increased the discontinuity of the gluten network. The presence of a discontinuous phase in the gluten network was related to an increase in fracturability in flaky snacks (Charles *et al.* 2004).

The expected positive effect of rye flour on the textural properties of biscuits was not entirely confirmed in this study, especially not in those formulations that included buckwheat, as it did not reach statistical significance. This presumably might be due to a lack of sufficient amounts of water to hydrate rye components, which could contribute to freshness retention as ginger nut biscuit represents a low-moisture system and interfering ingredients like sugar and fat, which might have additionally impaired hydration.

Biscuit color characteristics

Surface color of the ginger nut biscuits was significantly affected by the addition of buckwheat and rye (**Fig. 4**). Increased redness was observed (a^*) with increasing buckwheat and rye doses at formulations with 40 and 50% buckwheat substitution in comparison to the control. Yellowness (b^*) declined with the addition of buckwheat in relation to the control but rye tended to increase the yellow color but this effect was found significant only in sample 0BWH-20R. Similar observations were reported by Oliete (2010) and Gómez (2008) in layer cakes that contained rye. According to Kruger *et al.* (1998), rye flour contains colored compounds such as flavonoids. When comparing different cultivars of tartary and common buckwheat, Qin *et al.* (2010) associated higher a^* and b^* values in tartary buckwheat to a higher content of flavonoids. The majority of biscuits did not differ significantly from the control regarding darkness although L^* values tended to decline. Maeda *et al.* (2004) examined the effect of light and dark buckwheat flour on the color properties of sugar snap cookies and found that light buckwheat flour increased lightness whereas dark flour decreased it. They also observed that, generally, buckwheat flours tended to decrease the reddish and yellowish tones of cookies. On the other hand, Lin *et al.* (2009) found that in buckwheat bread the values for a^* and b^* increased. The surface color basically depends on Maillard and caramelisation reactions occurring on the biscuit surface. Since the contents of sugar and honey in the formulations were constant, the differences in color parameters might be attributable to specific properties of added buckwheat and rye flour: presence of colored compounds, quality (quantity) of proteins and free amino acids (Oliete 2010).

CONCLUSION

The current results indicated that the addition of buckwheat decreased the dimension of ginger nut biscuits but the spread increased in the composite biscuits (significant difference was noted at 40 and 50% levels of replacement) since the biscuit height was more affected by the rising doses of buckwheat. This could be attributed to the coarse granularity of buckwheat flour. Hardness and fracturability of ginger nut biscuits increased significantly with the addition of 50% buckwheat. The rye flour was not confirmed to significantly improve the hardness or fracturability of buckwheat added biscuits. Hardness and fracturability of the stored biscuits increased.

Composite biscuits substituted with 40 and 50% buckwheat showed increased red tone and decreased yellow tone. The majority of composite biscuits did not significantly differ from the control regarding darkness.

Although buckwheat-supplemented ginger nut biscuits showed impaired textural and physical characteristics due to unique starch pasting properties of buckwheat, doses up to 40% level can be considered applicable in ginger nut biscuit making since significant variations were noticed only at 50% replacement level. It should be mentioned that the particular buckwheat aroma was almost completely masked in this type of product and the tested composite biscuits did not differ regarding taste. Thus, buckwheat should not be abandoned as a potential ingredient in ginger nut biscuit making, especially due to nutritional aspects. It would be worth to consider methods to reduce the viscoelastic properties of buckwheat flour and enhance water-holding capacities that could improve its suitability in ginger nut biscuit making at higher supplementation levels.

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