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Quality and antioxidant property of buckwheat enhanced wheat bread

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ABSTRACT

Common buckwheat (*Fagopyrium esculentum* Moench) was used to substitute 15% of wheat flour to make buckwheat enhanced wheat breads. Proximate composition, physical quality, functional components and antioxidant properties of buckwheat enhanced wheat breads were analysed and compared with those of white bread. Specific volumes of three breads were 6.10–6.75 cm^3/g. Buckwheat enhanced wheat bread showed lower lightness and whiteness index values and higher redness and yellowness values. On a seven-point hedonic scale, all sensory results were 5.33–5.91, indicating that three breads were moderately acceptable. No differences were found in appearance, colour and overall sensory attributes for three breads, whereas both buckwheat enhanced wheat breads were rated higher in flavour and mouth feel. Buckwheat enhanced wheat bread contained more rutin and quercetin as expected. Buckwheat enhanced wheat bread was good in antioxidant activity, reducing power and 1,1-diphenyl-2-picrylhydrazyl radical scavenging ability with unhusked buckwheat enhanced wheat bread being the most effective. Overall, buckwheat enhanced wheat bread could be developed as a food with more effective antioxidant properties.

1. Introduction

Common buckwheat (*Fagopyrium esculentum* Moench) is recognised as an important functional food in some countries such as China, Japan and Taiwan and most popularly is ground to make buckwheat noodles. Unlike other cereals, buckwheat is an alternative crop that belongs to the Polygonaceae family and can be used to replace rice or potatoes in the regular meal. Phenolic compounds in buckwheat have been shown to possess antioxidant activity (Halosava et al., 2002; Sensoy, Rosen, Ho, & Karwe, 2006; Sun & Ho, 2005). Four flavonol glycosides including rutin, quercetin, kaemferol-3-rutinoside and a trace amount of a flavanol triglycoside were found in the methanol extract of buckwheat (Tian, Li, & Patil, 2002). Compared to most fruits, vegetables and grain crops, buckwheat contains more rutin, which is a quercetin-3-rutinoside with antioxidant, anti-inflammatory and anticarcinogenic effects, and can also reduce the fragility of blood vessels related to haemorrhagic disease and hypertension in humans (Baumgertel, Grimm, Eisenbeiß, & Kreis, 2003; Oomah & Mazza, 1996).

In addition, buckwheat was found to be a prebiotic food because it could increase lactic acid bacteria in rat intestine (Prestamo, Pedrazuela, Penas, Lasuncion, & Arroyo, 2003). Kim et al. (2003) claimed that buckwheat grain extract could be used in the treatment of allergic inflammation. Buckwheat has been used to reduce the serum glucose level in rats due to its high content of D-*chiro*-inositol, a component of an insulin mediator (Kawa, Taylor, & Przybylski, 2003).

Natural antioxidants may inhibit lipid peroxidation in food and improve food quality and safety. Buckwheat seed contains antioxidants such as rutin and can be stored for a long time without apparent chemical changes (Dietrych-Szostak & Oleszek, 1999). Buckwheat, which is added to food as a supplement, can provide beneficial health effects and prevent food from oxidation during processing. Bread is mainly made of wheat flour, salt and yeast and it is consumed all over the world. Many food ingredients, other than those mentioned above, have been included in bread formulation to increase its diversity, nutrition and product appeal. The objectives of this research were to make buckwheat enhanced wheat bread, to evaluate the influence of buckwheat flour on bread quality and contents of functional component as a result of supplementation. The antioxidant properties of buckwheat enhanced wheat bread were also determined.

2. Materials and methods

2.1. Materials

The ingredients used in the formula of bread were high gluten wheat flour (Uni-President Enterprises Corp., Tainan, Taiwan), milk

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Table 1
The formulations of breads

Ingredient (g or ml)	White bread	Husked buckwheat enhanced wheat bread	Unhusked buckwheat enhanced wheat bread
Wheat flour	100	85	85
Husked buckwheat flour	0	15	0
Unhusked buckwheat flour	0	0	15
Milk powder	4	4	4
Sugar	10	10	10
Salt	1	1	1
Egg	8	8	8
Yeast	1.3	1.3	1.3
Improver	1	1	1
Shortening	10	10	10
Water	55	54	56
Total	190.3	189.3	191.3

powder (KLIM, Nestle Taiwan Co., Taipei, Taiwan), sugar (Taiwan Sugar Corp., Tainan, Taiwan), salt (Taiyen Industrial Corp., Tainan, Taiwan), egg (local market, Taichung, Taiwan), yeast (Puratos Co., Buckingham, UK), bread improver (S-5000, Puratos) and shortening (refined oil blend, Uni-President). Both husked buckwheat (whole buckwheat with hull on) and unhusked buckwheat (polished buckwheat) were purchased from Shinn Cherng Co., Taipei, Taiwan and ground into a coarse powder (60 mesh) using a mill (Retsch ultracentrifugal mill and sieving machine, Haan, Germany). The raw materials for bread-making were weighed according to the formula proportions listed in Table 1.

Methanol and ethanol were purchased from Mallinckrodt Baker, Inc. (New Jersey, USA). Linoleic acid, potassium ferricyanide, 1,1-diphenyl-2-picrylhydrazyl (DPPH), phosphoric acid, rutin and quercetin were purchased from Sigma Chemical Co. (St. Louis, MO). Trichloroacetic acid, ferric chloride and sodium phosphate were purchased from Wako Pure Chemical Industries, Ltd. (Tokyo, Japan).

2.2. Bread making

Dough was prepared using a straight dough method. First of all, yeast was dissolved in water at 28 °C and was mixed with dry ingredients to form a paste. Shortening was heated to melt and added into the paste. The paste was then mixed using a mixer (Dai Lih Machinery Factory, Taichung, Taiwan) at low speed for 2 min, followed by 6 min of mixing at high speed. After complete mixing of the dough, it was placed in the incubator (Yeong Soon Co., Taichung, Taiwan) at 28 °C and 75% RH for fermentation; the total duration of the fermentation was 125 min. Before bread sample making, the dough fermentation was studied for white bread, husked and unhusked buckwheat enhanced wheat breads and the dough volumes were measured from 30 min to 180 min at 30-min intervals.

After the first 60 min, the dough was taken out of the incubator, punched and placed back to the incubator again. A second punch took place after a further 15 min and then the dough was divided into dough pieces of equal weight (~560 g). Each piece was shaped and put into the incubator for the last 50 min under the same incubator conditions. Conventional baking was performed at 200 °C for 40 min in an oven (Yeong Soon). The oven was preheated to the set temperature before placing the dough into it. Afterwards, the baked bread was taken out of the oven, cooled to room temperature for 2 h and weighed. For each type of bread, three loaves were freeze-dried and ground into a coarse powder (60 mesh) for further analysis. The specific volume (cm^3/g) was the bread volume divided by the weight of bread. The bread volume of loaves was determined by the rapeseed displacement method AACC, 1988.

2.3. Proximate analysis

The proximate composition of flours and breads, including moisture, crude ash, crude fat, crude fibre and crude protein, were determined according to the methods of AOAC 14.091, 14.103, 14.093, 14.111 and 14.108, respectively (AOAC, 1990). The nitrogen conversion factor used for crude protein calculation was 5.70. The carbohydrate content (%) was calculated by subtracting the contents of crude ash, fat, fibre and protein from 100% of dry matter.

2.4. Colour measurement

The reflective surface colour of breads was measured on crumb using a Σ80 Colour Measuring System (Nippon Denshoku Inc., Tokyo, Japan) and L, a and b values were recorded. A standard white plate ($X = 91.98$, $Y = 93.97$ and $Z = 110.41$) was used to standardise the instrument. Each sample was individually measured in triplicate. Whiteness index (WI) was calculated based on the following equation (Hsu, Chen, Weng, & Tseng, 2003):

$$WI = 100 - [(100 - L)^2 + a^2 + b^2]^{1/2}$$

2.5. Sensory evaluation

The sensory evaluation was carried out on the bread samples within 3–6 h of baking. The samples served were sliced (1.5 cm thick) and evaluated in the Wellcome Supermarket of Miaoli City, Taiwan. Totally, 48 consumers with the age ranged from 25 to 45 years old completed the questionnaire. Sensory attributes of bread, including appearance, colour, flavour, mouth feel and overall acceptability were measured using a seven-point hedonic scale with 1, 4 and 7 representing extremely dislike, neither like not dislike and extremely like, respectively.

2.6. Determination of rutin and quercetin

Rutin and quercetin was analysed according to the methods of Ohara, Ohinata, and Muramatsu (1989) and Fuleki (1999). Each bread powder (100 mg) was extracted with 20 ml methanol at 35 °C for 24 h and filtered through Whatman No. 1 filter paper. The extract was then filtered through a syringe-driven filter unit (13 mm, Millipore, Billerica, MA) using a 0.45-μm PVDF non-sterile filter paper. The filtrate was injected onto a high performance liquid chromatograph (HPLC).

The HPLC system consisted of a Hitachi L-6000 pump, a Rheodyne 7161 injector, a 20-μl sample loop, a Hitachi D-2500 chromato-integrator, Hitachi L-4200 UV detector and a Mightysil RT-18 GP250 column (4.6 × 250 mm, 2.5 μm, Kanto Chem. Co., Tokyo, Japan). The mobile phase was run at a flow rate of 1 ml/min and UV detection at 350 nm. Solvent A consisted of phosphoric acid (85.5%) in water, and solvent B was a mixture of methanol and solvent A (80:20). The solvent gradient was as follows: B increased from 0% to 12% in the first 2 min; then from 12% to 100% from 2 to 35 min; the concentration of B remained at 100% from 35 to 45 min, and then decreased to 12% in the next 10 min (Fuleki, 1999). Content of rutin and quercetin was calculated on the basis of the calibration curve of authentic rutin and quercetin and expressed as mg/100 g of dry matter.

2.7. Preparation of ethanol extracts

For ethanolic extraction, each bread powder (10 g) was extracted by stirring with 100 ml of ethanol at 25 °C at 20g for 24 h and filtering through Whatman No. 1 filter paper. The residue

was then extracted with two additional 100 ml portions of ethanol as described above. The combined ethanolic extracts were then rotary evaporated at 40 °C to dryness. The yield of extracts were determined and expressed as percentages of dry matter.

2.8. Antioxidant activity

The antioxidant activity was determined by the conjugated diene method (Lingnert, Vallentin, & Eriksson, 1979). Each extract (0.5–20 mg/ml) in ethanol (100 μl) was mixed with 2 ml of 10 mM linoleic acid emulsion in 0.2 M sodium phosphate buffer (pH 6.6) in test tubes and placed in darkness at 37 °C to accelerate oxidation. After incubation for 15 h, 0.1 ml of each tube was mixed with 7 ml of 80% methanol in deionized water, and the absorbance of the mixture was measured at 234 nm against a blank in a Hitachi U-2001 spectrophotometer. A control consisted of ethanol and the reagent solution without ethanolic extracts added and the procedure was carried out as described above. The antioxidant activity was calculated as follows: antioxidant activity (%) = $[(\Delta A_{234}$ of control $- \Delta A_{234}$ of sample$)/\Delta A_{234}$ of control$] \times 100$. A value of 100% indicates the strongest antioxidant activity. EC_{50} value (mg/ml) is the effective concentration at which the antioxidant activity was 50% and was obtained by interpolation from linear regression analysis.

2.9. Reducing power

The reducing power was determined according to the method of Oyaizu (1986). Each extract (0.5–20 mg/ml) in ethanol (2.5 ml) was mixed with 2.5 ml of 200 mM sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide, and the mixture was incubated at 50 °C for 20 min. After 2.5 ml of 10% trichloroacetic acid were added, the mixture was centrifuged at 200*g* for 10 min. The upper layer (5 ml) was mixed with 5 ml of deionized water and 1 ml of 0.1% ferric chloride, and the absorbance was measured at 700 nm against a blank. A higher absorbance indicates a higher reducing power. EC_{50} value (mg/ml) is the effective concentration at which the absorbance was 0.5 for reducing power.

2.10. Scavenging ability on 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals

Each extract (0.5–20 mg/ml) in ethanol (4 ml) was mixed with 1 ml of methanolic solution containing DPPH radicals, resulting in a final concentration of 0.2 mM DPPH. The mixture was shaken vigorously and left to stand for 30 min in the dark, and the absorbance was then measured at 517 nm against a blank (Shimada, Fujikawa, Yahara, & Nakamura, 1992). A control consisted of ethanol and the reagent solution without ethanolic extracts added and the procedure was carried out as described above. The scavenging ability was calculated as follows: scavenging ability (%) = $[(\Delta A_{517}$ of control $- \Delta A_{517}$ of sample$)/\Delta A_{517}$ of control$] \times 100$. EC_{50} value (mg/ml) is the effective concentration at which DPPH radicals were scavenged by 50%.

2.11. Statistical analysis

Each bread-making and measurement was conducted in triplicate, except for the sensory evaluation ($n = 48$). The experimental data were subjected to an analysis of variance for a completely random design using a statistical analysis system (SAS Institute, Inc., Cary, NC, 2000). Duncan's multiple range tests were used to determine the difference amongst means at the level of 0.05.

3. Results and discussion

3.1. Proximate composition

Different proximate compositions were found amongst flours especially in carbohydrate and fibre contents (Table 2). Carbohydrate contents were found in the descending order of wheat flour > unhusked buckwheat flour > husked buckwheat flour whereas fibre contents were in the reversed order because buckwheat was high in fibre (Bonafaccia, Marocchini, & Kreft, 2003). Since 15% of wheat flour in the bread formula was substituted with buckwheat flour, the proximate composition, especially carbohydrate and fibre contents would be affected expectedly.

Moisture contents were in the order of unhusked buckwheat enhanced wheat bread > white bread > husked buckwheat enhanced wheat bread. The varied moisture contents were consistent with different water amounts used for different breads. Interestingly, carbohydrate content was higher in unhusked buckwheat enhanced wheat bread. However, only husked buckwheat enhanced wheat bread was high in fibre content as expected. Husked buckwheat contained higher amount of insoluble β-glucan in its hull, which was known to be an immunostimulating polysaccharide (Hozová, Kuniak, Moravčíková, & Gajdošová, 2007). Therefore, more insoluble β-glucan in husked buckwheat enhanced wheat bread would be beneficial and provide consumers with the alleged immunostimulating effect. Besides, contents of other proximate components were not varied remarkably.

3.2. Physical quality

The dough volume increase for white bread was higher than those for other buckwheat enhanced wheat breads throughout the fermentation course of 120 min (data not shown). At the end of fermentation course (180 min), the dough volume increases were similar for three breads. At 120–150 min, the dough volume increased slowly and the dough was ready for baking. Therefore, the total duration of the fermentation used afterwards was 125 min. Specific volumes of three breads (volume/weight) were 6.75 ± 0.38, 6.10 ± 0.18 and 6.32 ± 0.09 cm^3/g for white bread,

Table 2
Proximate composition of flours and breads

Component[a] (%)	Wheat flour	Husked buckwheat flour	Unhusked buckwheat flour	White bread	Husked buckwheat enhanced wheat bread	Unhusked buckwheat enhanced wheat bread
Moisture	12.68 ± 0.02E[b]	13.29 ± 0.12D	13.32 ± 0.13D	33.06 ± 0.06B	31.69 ± 0.03C	34.26 ± 0.07A
Dry matter	87.32 ± 0.02A	86.71 ± 0.12B	86.68 ± 0.13B	66.94 ± 0.06D	68.31 ± 0.03C	65.74 ± 0.07E
Carbohydrate	83.50 ± 0.38A	61.57 ± 0.60E	77.02 ± 0.74D	79.82 ± 0.48C	79.58 ± 0.35C	81.79 ± 0.50B
Crude ash	1.22 ± 0.44B	1.71 ± 0.10A	1.56 ± 0.01A	1.63 ± 0.18A	1.22 ± 0.10B	1.11 ± 0.04B
Crude fat	2.63 ± 0.88B	2.22 ± 0.11B	2.15 ± 0.79B	4.56 ± 0.41A	3.94 ± 0.23A	4.13 ± 0.08A
Crude fibre	2.03 ± 0.45D	23.81 ± 0.75A	10.31 ± 0.73B	1.81 ± 0.86D	3.02 ± 0.81C	1.10 ± 0.43D
Crude protein	10.62 ± 0.51B	10.69 ± 0.51B	8.96 ± 0.14C	12.18 ± 0.33A	12.24 ± 0.71A	11.87 ± 0.15[a]

[a] Moisture and dry matter of flours and breads were presented based on air-dried weight and fresh bread weight, respectively; others were presented on dry weight.
[b] Each value is expressed as mean ± SE ($n = 3$). Means with different letters within a row are significantly different ($P < 0.05$).

Table 3
The colour properties of breads

	L	*a*	*b*	WI[b]
White bread	76.75 ± 0.21A[a]	0.32 ± 0.01C	18.20 ± 0.11C	70.48 ± 0.21A
Husked buckwheat bread	67.98 ± 0.04C	2.83 ± 0.06B	20.50 ± 0.52B	61.88 ± 0.32B
Unhusked buckwheat bread	69.52 ± 0.74B	3.55 ± 0.10A	21.99 ± 0.41A	62.25 ± 0.84B

[a] Each value is expressed as mean ± SE ($n = 3$). Mean with different letters within a column are significantly different ($P < 0.05$).
[b] WI (whiteness index) = $100 - [(100 - L)^2 + a^2 + b^2]^{1/2}$.

husked and unhusked buckwheat enhanced wheat bread, respectively. The specific volume of standard bread should be 6 cm^3/g and should not be less than 3.5 cm^3/g (CGPRDI, 1983). It seems that all three breads met the passing level of specific volumes. Also, the results suggested that substituting 15% of wheat flour in the bread formula with buckwheat flour would not interfere with bread specific volume.

White bread showed the highest lightness and WI values (76.75 and 70.48) whereas the lightness value of unhusked buckwheat enhanced wheat bread was in turn higher than that of husked buckwheat enhanced wheat bread but the WI values of two buckwheat enhanced wheat breads were comparable (Table 3). With regard to *a* and *b* values, two buckwheat enhanced wheat breads showed higher redness and yellowness values, consistent with the fact that both buckwheat flours showed beige colour. Beneficially, the browner colour might be noticeable to attract consumer's attention on both buckwheat enhanced wheat breads. However, unhusked buckwheat enhanced wheat bread exhibited more intense red and yellow colour than husked buckwheat enhanced wheat bread did. It seems that unhusked buckwheat enhanced wheat bread might contain more phenolic compounds to inhibit the browning reaction during baking.

3.3. Sensory evaluation

On a seven-point hedonic scale, all sensory results were in the range of 5.33–5.91, indicating that three breads were moderately acceptable (Table 4). Generally, plain breads with scores of 5.33–5.91 were relatively acceptable since the starch-based food in Taiwan is rice instead of bread. No statistically significant differences evaluated by untrained consumers were found in appearance, colour and overall sensory attributes. Unfortunately, the remarkable colour difference measured by instrument was not recognised in sensory evaluation. However, with regard to the two flavour and mouth feel sensory attributes, both buckwheat enhanced wheat breads were rated higher than white bread. To study their better flavour and mouth feel, the flavour components including aroma and taste components and microscopic examination on their texture would be another area of investigation. Nevertheless, the results suggested that substituting 15% of wheat flour in the bread formula with buckwheat flour would not interfere with bread acceptability.

Table 4
Sensory evaluation of breads

	White bread	Husked buckwheat enhanced wheat bread	Unhusked buck wheat enhanced wheat bread
Appearance	5.44 ± 1.77A[a]	5.33 ± 1.19A	5.54 ± 1.15A
Colour	5.48 ± 1.11A	5.50 ± 1.09A	5.58 ± 1.03A
Flavour	5.42 ± 1.22B	5.91 ± 1.07A	5.79 ± 1.03A
Mouth feel	5.40 ± 1.22B	5.74 ± 1.18A	5.79 ± 1.20A
Overall	5.48 ± 1.15A	5.78 ± 1.13A	5.64 ± 1.11A

[a] Seven-point hedonic scale with 1, 4 and 7 representing extremely dislike, neither like nor dislike and extremely like, respectively. Each value is expressed as mean ± SE ($n = 48$). Means with different capital within a row are significantly different ($P < 0.05$).

3.4. Functional components

Two flavonoids rutin and quercetin were found in finished buckwheat enhanced wheat breads as expected (Table 5). Higher rutin content was found in husked buckwheat enhanced wheat bread than unhusked buckwheat enhanced wheat bread since husk contained more phenolic compounds (Oomah & Mazza, 1996; Quettier-Deleu et al., 2000). Kreft, Fabjan, and Yasumoto (2006) studied rutin content in buckwheat food materials and products and found that buckwheat with high rutin content could be used as a functional food. However, buckwheat enhanced wheat bread has not been studied. Since buckwheat is a good source of functional components rutin and quercetin, substituting 15% of wheat flour in the bread formula with buckwheat flour would be an alternative and successful buckwheat product. After baking, substantial amount of flavonoids remained in both buckwheat enhanced wheat breads would be beneficial and provide consumers with the alleged physiological properties.

3.5. Antioxidant properties

Using ethanol as the extractant, the yields were in the descending order of unhusked buckwheat enhanced wheat bread (9.07 ± 0.21% dry matter) > husked buckwheat enhanced wheat bread (8.48 ± 0.11%) ~ white bread (8.50 ± 0.28%). The antioxidant properties assayed herein were summarised in Table 6 and the results were normalised and expressed as EC_{50} values (milligram dry weight of various extracts per milliliter) for comparison. Effectiveness of antioxidant properties inversely correlated with their EC_{50} values. It seems that unhusked buckwheat enhanced wheat bread

Table 5
Content of rutin and quercetin of breads

	Content (mg/100 g dry matter)	
	Rutin	Quercetin
White bread	nd[a]	nd
Husked buckwheat enhanced wheat bread	1.75 ± 0.21A[b]	0.03 ± 0.01A
Unhusked buckwheat enhanced wheat bread	0.90 ± 0.40B	0.04 ± 0.01A

[a] Not detected.
[b] Each value is expressed as mean ± SE ($n = 3$). Means with different letters within a row are significantly different ($P < 0.05$).

Table 6
EC_{50} values of ethanolic extracts from breads in antioxidant properties

	EC_{50} value[a](mg extract/ml)		
	White bread	Husked buckwheat enhanced wheat bread	Unhusked buckwheat enhanced wheat bread
Antioxidant activity	0.89 ± 0.03B[b]	1.06 ± 0.04A	0.44 ± 0.02C
Reducing power	37.14 ± 0.73A[c]	13.57 ± 0.29B	7.67 ± 0.17C
Scavenging ability DPPH radicals	37.07 ± 1.26A[c]	20.29 ± 0.86B[c]	9.75 ± 0.43C

[a] EC_{50} value: the effective concentration at which the antioxidant activity was inhibited by 50%; the absorbance was 0.5 for reducing power; and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals were scavenged by 50%, respectively. EC_{50} value was obtained by interpolation from linear regression analysis.
[b] Each value is expressed as mean ± SD ($n = 3$). Means with different letters within a row at a specific antioxidant attribute are significantly different ($P < 0.05$).
[c] Obtained by extrapolation from linear regression analysis.

was the most effective as evidenced by its lowest EC_{50} values. However, husked buckwheat enhanced wheat bread was more effective than white bread in reducing power and scavenging ability on DPPH radicals but less effective in antioxidant activity.

Overall, effectiveness in antioxidant properties was in the descending order: unhusked buckwheat enhanced wheat bread > husked buckwheat enhanced wheat bread > white bread. The results show that adding buckwheat flour, especially unhusked buckwheat enhanced wheat bread into bread greatly enhanced bread's antioxidant properties. The improved antioxidant properties of buckwheat enhanced wheat bread might be due to the incorporation of phenolic compounds, mainly rutin and quercetin, which had been shown to possess antioxidant activity (Halosava et al., 2002; Sun & Ho, 2005). Although BHA and α-tocopherol were good in antioxidant activity, reducing power and scavenging ability on DPPH radicals, they are additives and used or present in milligram levels in foods. However, buckwheat enhanced wheat bread could be consumed in gram levels as food. Therefore, buckwheat enhanced wheat bread could be developed as a functional food with more effective antioxidant properties.

4. Conclusion

Substituting 15% of wheat flour in the bread formula with buckwheat flour would not interfere with bread specific volume and score. Buckwheat enhanced wheat bread showed less lightness and WI values and higher redness and yellowness. However, the remarkable colour difference of buckwheat enhanced wheat bread was not recognised in sensory evaluation. No statistically significant differences were found in appearance, colour and overall sensory attributes for three breads whereas both buckwheat enhanced wheat breads were better in flavour and mouth feel sensory attributes. Buckwheat enhanced wheat bread contained more functional components rutin and quercetin as expected. Buckwheat enhanced wheat bread was good in antioxidant activity, reducing power and scavenging ability on DPPH radicals with unhusked buckwheat enhanced wheat bread being the most effective. Overall, buckwheat could be incorporated into bread and provide buckwheat enhanced wheat bread with more functional components and more effective antioxidant properties.

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