



## Buckwheat flour fortified bread

S. Mohajan<sup>1</sup>, M. M. Munna<sup>2</sup>, T. N. Orchy<sup>1</sup>, M. M. Hoque<sup>2</sup> and T. Farzana<sup>1\*</sup>

<sup>1</sup>Institute of Food Science and Technology (IFST), BCSIR Dhaka, Bangladesh

<sup>2</sup>Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

### Abstract

This study was conducted to explore the possibility of substitution of wheat flour with 10%, 20%, 30%, 35% and 40% buckwheat (*Fagopyrum esculentum*) flour and to formulate bread with improved nutritional value along with acceptable nutritional and sensory attributes, and to compare with locally available breads. The results showed that the ash (0.80-1.21%), protein (10.11-16.23%), fat (4.88-5.85%), fiber (0.07-0.19%), energy (301-322 kcal/100g) and mineral contents were increased with the increasing content of buckwheat flour in the bread preparation. Physical characteristics were decreased with the increasing content of buckwheat flour. On sensory evaluation, bread formulated with 30% buckwheat flour was found acceptable. In comparison with locally available breads, 30% buckwheat flour substituted bread was found significantly higher in ash, protein, fiber and energy content. Based on these results, it can be concluded that bread prepared with 30% substitution of wheat flour with buckwheat flour is nutritionally superior over locally available breads.

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### Introduction

Buckwheat (*Fagopyrum esculentum*) is a pseudocereal, widely being used for production of gluten free bakery products (Wronkowska and Soral-Smietana, 2008) and as a potential functional foods. It is an excellent source of protein, fiber, vitamins (B1, B2, B6, and E) and minerals (Wijngaard and Arendt, 2006). Buckwheat proteins have well balanced amino acids composition that increased its biological value. Buckwheat protein is rich in lysine that is limiting amino acids in many plant proteins. It also contains many health promoting components like rutin, quercetin, isovitexin, isoorientin, vitexin, orientin, phenols etc. (Fabjan *et al.* 2003; Dietrych-Szostak and Oleszek, 1999) that makes it an ideal choice of natural sources of antioxidant (Sun and Ho, 2005) butylated hydroxytoluene (BHT). Buckwheat has many health benefits like reduction of plasma cholesterol level, improvement of hypertension conditions, anti-inflammatory, neuro-protection, anticancer and antidiabetic effects (Quettier-Deleu *et al.*, 2000). These nutritional and health benefits make buckwheat a greater choice for the formulation of different bakeries, crepes,

pasta-noodles, cookies, cakes, breads, breakfast cereal formulations etc. (Gokcen and Nermin, 2012; Lin *et al.*, 2009; Bonafaccia and Kreft, 1994).

It is almost accepted that diet-based therapy is one of the most effective and sustainable way to combat with various diseases. However, development of effective food-based strategy depends on various factors like target communities, knowledge of nutrient sources and choice of suitable vehicle to incorporate functional ingredients. Wheat based baked products are now getting more importance as an appropriate vehicle for the incorporation of functional ingredients (Martins *et al.*, 2017). These are not only popular in Bangladesh but also throughout the world to all ages of people because of its low price, palatability, ease of consumption and availability. Among the wheat based baked products, bread is a staple food in many countries around the world. In Bangladesh, the popularity of bread consumption is also increasing in both urban and sub-urban areas due to changing food habits, hectic life, increasing working people outside home and urban area (Begum *et al.*, 2014). It is consumed extensively in most homes, restaurants and hotels

\*Corresponding author e-mail: [triptiot@yahoo.com](mailto:triptiot@yahoo.com)

all over the country. Urban lifestyle is clearly a more market dependent for food with very limited capacity for home preparation. As a consequence the diet can be even more heavily biased towards pre-prepared and pre-cooked ready to eat food.

Considering the aforementioned nutritional and health benefits of buckwheat, and popularity and market size of bread, the present study was intended to explore the possibility of fortification of wheat flour with buckwheat flour (*Fagopyrum esculentum*) to formulate bread with improved nutritional value along with acceptable sensory properties.

### Materials and methods

The study was accomplished in the laboratory of Quality Control Research Section of Institute of Food Science & Technology, Bangladesh Council of Scientific & Industrial Research (BCSIR), Dr. Quadrat-i-Khuda Road, Dhanmondi, Dhaka, Bangladesh.

#### Sample and raw material collection

Raw materials (buckwheat flour, wheat flour, sugar, salt, dry yeast, egg) that were used for the preparation of buckwheat bread were collected from local market. Nine samples of wheat bread were collected from local market of Dhanmondi and Mirpur area for this study. All chemicals and materials were also purchased from local market.

#### Design of experiment

Experimental design was done to formulate high percentage of buckwheat fortified bread without affecting bread texture

significantly. Wheat flour was replaced with buckwheat flour as follows:

T0 = 100% wheat flour (WF)

T1 = 90% wheat flour (WF) + 10% buckwheat flour (BWF)

T2 = 80% wheat flour (WF) + 20% buckwheat flour (BWF)

T3 = 70% wheat flour (WF) + 30% buckwheat flour (BWF)

T4 = 65% wheat flour (WF) + 35% buckwheat flour (BWF)

T5 = 60% wheat flour (WF) + 40% buckwheat flour (BWF)

Wheat flour without buckwheat flour was kept as control T0 (100% WF). The formulation of bread preparation is outlined in the Table I.

#### Preparation of buckwheat fortified breads

The whole process of bread preparation is outlined in the Figure 1. Firstly, sugar (15g) and salt (1g) were dissolved in water (30ml). Then flours (wheat flour, buckwheat flour as mentioned in the design of experiment) and yeast (1.25g) were added, and mixed well. Egg (1 piece) and oil (5 ml) were added to the mixture and mixed well to make dough. Dough was kept for 2 hrs at 40 $\pm$ 2 $^{\circ}$ C. Dough was given shape of loaf. Then, dough was kept for final puffing at 40 $\pm$ 2 $^{\circ}$ C for 60 min. Finally baking was done by placing the puffed dough in baking oven at 170 $\pm$ 5 $^{\circ}$ C for 25 $\pm$ 2 min followed by cooling at room temp and kept at 4 $^{\circ}$ C for further analysis.

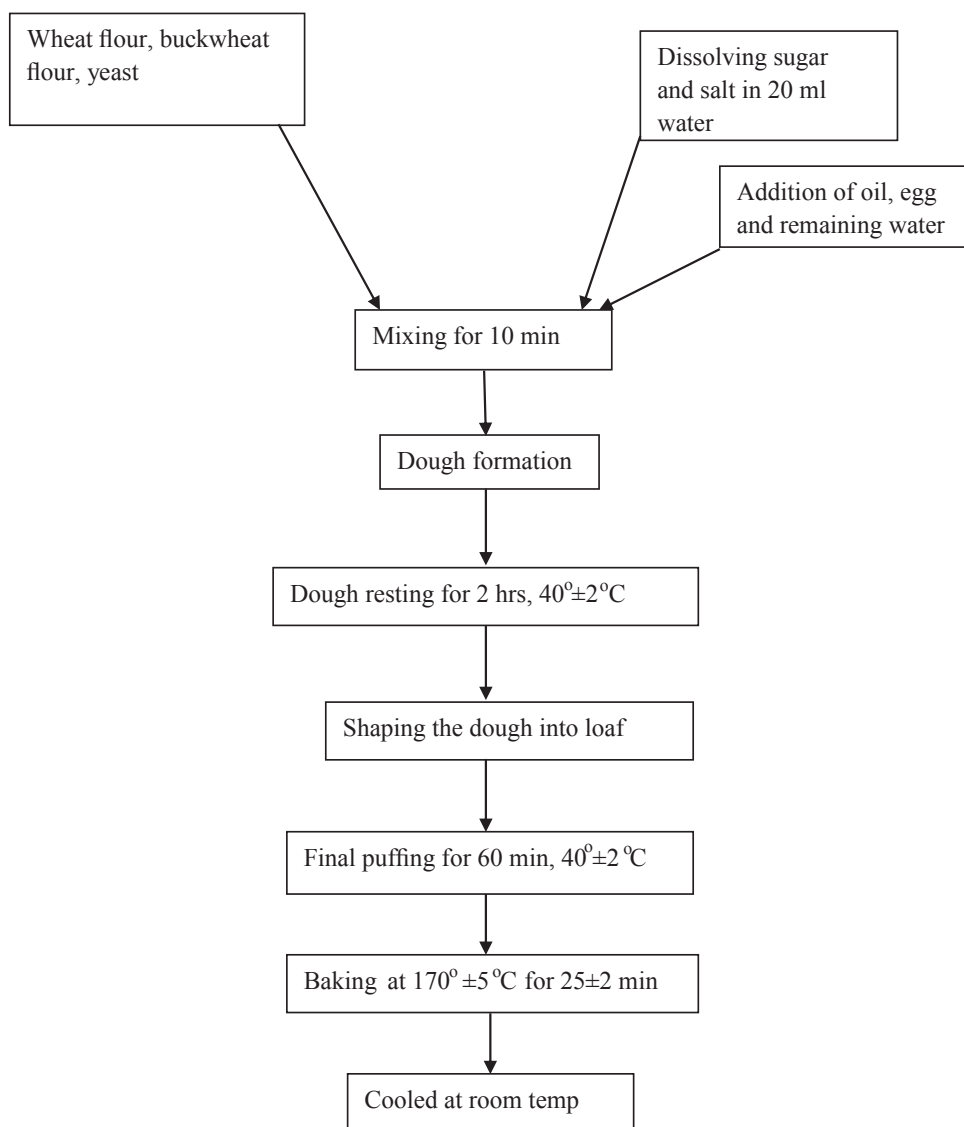
#### Proximate analysis of wheat flour, buckwheat flour, buckwheat fortified breads and locally available breads

The nutrition content (i.e., moisture, ash, protein, fat, fiber) of the newly developed buckwheat bread and locally available wheat breads were estimated according to the standard

**Table I. Formulation of bread preparation fortified with buckwheat flours**

Sample name	Ingredients								
	Wheat flour (%)	Buckwheat flour (%)	Sugar (%)	Salt (%)	Yeast (%)	Bread improver (%)	Milk flavor (%)	Egg piece	Water (ml)
Control (T0)	100	0	15	1	1.25	0.3	0.1	1	30
T1	90	10	15	1	1.25	0.3	0.1	1	30
T2	80	20	15	1	1.25	0.3	0.1	1	30
T3	70	30	15	1	1.25	0.3	0.1	1	30
T4	65	35	15	1	1.25	0.3	0.1	1	30
T5	60	40	15	1	1.25	0.3	0.1	1	30

Control (T0) =0% BWF; T1= 10% BWF; T2= 20% BWF; T3=30% BWF; T4=35% BWF, T5=40% BWF



**Fig. 1. Flow chart for the preparation of Buckwheat fortified bread**

analytical methods (AOAC, 2005). The carbohydrate content and energy value was determined following the methods of Farzana and Mohajan (2015) and Eneche (1999).

#### *Mineral analysis of wheat flour, buckwheat flour and buckwheat fortified breads*

Flame photometric method was used for the determination of sodium and potassium content (Jahan *et al.*, 2011; Mutalik *et al.*, 2011). Flame Atomic Absorption Spectrometric method was used for the determination of iron, copper, manganese

and zinc (AOAC, 2005; Kirk and Sawyer, 1991).

#### *Sensory analysis*

Sensory analysis of the developed buckwheat fortified bread was done using nine-point hedonic-scale scorecard (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like or dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely) (Lim, 2011). A sensory panel consists of 10 trained members, selected from the staff members of IFST,

BCSIR, participated in the evaluation of sensory attributes such as color and appearance, texture, flavor, evenness of bake, taste and overall acceptability.

#### Statistical analysis

Data analysis was done using SPSS (Statistical Package for the Social Sciences) software, version 15.0, SPSS Inc. Chicago, Illinois, USA. Values were expressed as percentage and mean  $\pm$  SD. The significance/non-significance of the mean difference was determined using one way ANOVA and Duncan test. Means were separated using t - test.

**Table II. Proximate and mineral content of wheat and buckwheat flour (on dry basis)**

Parameters	Wheat Flour	Buckwheat Flour
Moisture (%)	12.73 $\pm$ 0.01 <sup>a</sup>	5.47 $\pm$ 0.02 <sup>b</sup>
Ash (%)	0.52 $\pm$ 0.02 <sup>b</sup>	1.68 $\pm$ 0.01 <sup>a</sup>
Protein (%)	12.24 $\pm$ 0.03 <sup>b</sup>	16.66 $\pm$ 0.02 <sup>a</sup>
Fat (%)	2.46 $\pm$ 0.01 <sup>b</sup>	3.42 $\pm$ 0.03 <sup>a</sup>
Fibre (%)	0.07 $\pm$ 0.01 <sup>b</sup>	0.58 $\pm$ 0.01 <sup>a</sup>
Carbohydrate (%)	71.98 $\pm$ 0.07 <sup>b</sup>	72.19 $\pm$ 0.09 <sup>a</sup>
Sodium (mg/100g)	14.78 $\pm$ 0.15 <sup>a</sup>	20.59 $\pm$ 0.09 <sup>b</sup>
Potassium (mg/100g)	116.87 $\pm$ 0.03 <sup>a</sup>	360.89 $\pm$ 0.18 <sup>b</sup>
Copper (mg/100g)	0.15 $\pm$ 0.01 <sup>a</sup>	1.12 $\pm$ 0.02 <sup>b</sup>
Zinc (mg/100g)	1.61 $\pm$ 0.03 <sup>a</sup>	5.19 $\pm$ 0.04 <sup>b</sup>
Iron (mg/100g)	2.36 $\pm$ 0.05 <sup>a</sup>	4.95 $\pm$ 0.07 <sup>b</sup>
Manganese (mg/100g)	0.67 $\pm$ 0.01 <sup>a</sup>	1.23 $\pm$ 0.02 <sup>b</sup>

Values are mean of triplicates  $\pm$  standard deviation. Values with the same superscript in a column are not significantly different ( $p > 0.05$ )

## Results and discussion

#### Proximate compositions of wheat flour and buckwheat flour (on dry basis)

A comparative study of nutritional analysis of wheat flour and buckwheat flour has been shown in the Table II (on dry basis). In the study, in case of wheat flour, the moisture, protein, fat, ash, crude fiber and carbohydrate content was found to be 12.73%, 12.24%, 2.46%, 0.52%, 0.07% and

71.98% respectively. While in buckwheat flour, the moisture, protein, fat, ash, crude fiber and carbohydrate content were found to be 5.47%, 16.66%, 3.42%, 1.68%, 0.58% and 72.19%. The protein, crude fiber, ash and fat content were significantly higher and moisture content is also significantly lower as compared to the wheat flour (Table II), supported by other studies (Selimovic *et al.*, 2014; Bhavsar *et al.*, 2013)

In case of mineral contents, buckwheat flour has significantly higher sodium (20.59 mg/100g), potassium (360.89mg/100g), copper (1.12mg/100g), zinc (5.19mg/100g), iron (4.95mg/ 100g) and manganese (1.23mg/100g) content than that of the wheat flour (sodium-14.78mg/100g, potassium-116.81mg/ 100g, copper-0.15mg/100g, zinc-1.61mg/100g, iron-2.36mg/100g, manganese-0. 67mg/100g) (Table II), supported by the study of Bhavsar *et al.*(2013).

#### Proximate composition and mineral analysis of buckwheat fortified breads (on dry basis)

Breads with different levels of buckwheat flour were prepared and subsequently their proximate and mineral analysis was carried out. These results were shown in the Table III (on dry basis).

In the present study, the moisture (29.91 to 25.41%) and carbohydrate (54.23 to 51.11%) contents were decreased with the increasing level of buckwheat flour, while the ash (0.80 to 1.21%), protein (10.11 to 16.23%), fat (4.88 to 5.85%), fiber (0.07 to 0.19 %) and energy (301 to 322 kcal/100g) contents were linearly increased with the increasing percentage of buckwheat flour in the bread preparation (Table III). These trends of increase are in agreement with the study of Selimovic *et al.* (2014) The highest moisture content was found for control, T0 (29.91%) while least for treatment T5 (25.41%). The moisture content for other treatments, T1, T2, T3 and T4 was found to be 28.95%, 27.86%, 26.50%, and 26.01% respectively. Decreased water content of finished bread may be a consequence of depleted water absorption capacity of dough due to addition of buckwheat flour, supported by the study of Baljeet *et al.* (2010).

The highest ash content was found for treatment, T5 (1.21%) while least for control, T0 (0.80%). The ash content for other treatments, T1, T2, T3 and T4 was found 0.92%, 0.97%, 1.06%, and 1.11% respectively. The highest protein content was found for treatment, T5 (16.23%) while least for control, T0 (10.11%). The protein content for other treatments, T1, T2, T3 and T4 was found 11.01%, 12.52%, 14.07%, and 15.04% respectively. The highest fat content was found for treatment, T5 (5.85%) while least for control, T0 (4.88%). The fat

**Table III. Proximate and mineral content of buckwheat flour (BWF) fortified breads (on dry basis)**

Sample name	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (Kcal/100g)	Na (mg/100g)	K (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Fe (mg/100g)	Mn (mg/100g)
T0	29.91±0.02 <sup>a</sup>	0.80±0.01 <sup>f</sup>	10.11±0.03 <sup>f</sup>	4.88±0.04 <sup>f</sup>	0.07±0.01 <sup>a</sup>	54.23±0.11 <sup>a</sup>	301±1.0 <sup>f</sup>	177.42±0.04 <sup>f</sup>	71.16±0.03 <sup>f</sup>	0.03±0.01 <sup>d</sup>	0.21±0.02 <sup>f</sup>	1.66±0.03 <sup>f</sup>	0.37±0.02 <sup>e</sup>
T1	28.95±0.03 <sup>b</sup>	0.92±0.02 <sup>e</sup>	11.01±0.04 <sup>e</sup>	5.06±0.01 <sup>e</sup>	0.11±0.02 <sup>e</sup>	53.95±0.12 <sup>b</sup>	305±1.0 <sup>e</sup>	190.52±0.09 <sup>e</sup>	76.26±0.05 <sup>e</sup>	0.06±0.01 <sup>cd</sup>	0.35±0.03 <sup>e</sup>	1.79±0.06 <sup>e</sup>	0.40±0.01 <sup>de</sup>
T2	27.86±0.01 <sup>c</sup>	0.97±0.04 <sup>d</sup>	12.52±0.01 <sup>d</sup>	5.28±0.02 <sup>d</sup>	0.13±0.01 <sup>bc</sup>	53.24±0.09 <sup>c</sup>	311±1.0 <sup>d</sup>	202.35±0.05 <sup>d</sup>	84.01±0.06 <sup>d</sup>	0.08±0.01 <sup>c</sup>	0.58±0.01 <sup>d</sup>	1.96±0.03 <sup>d</sup>	0.42±0.02 <sup>cd</sup>
T3	26.50±0.04 <sup>d</sup>	1.06±0.03 <sup>c</sup>	14.07±0.02 <sup>c</sup>	5.48±0.05 <sup>c</sup>	0.16±0.03 <sup>ab</sup>	52.73±0.17 <sup>d</sup>	317±1.0 <sup>c</sup>	222.35±0.08 <sup>c</sup>	90.05±0.05 <sup>c</sup>	0.12±0.02 <sup>b</sup>	0.69±0.02 <sup>c</sup>	2.10±0.01 <sup>c</sup>	0.45±0.03 <sup>bc</sup>
T4	26.01±0.01 <sup>e</sup>	1.11±0.02 <sup>b</sup>	15.04±0.03 <sup>b</sup>	5.62±0.04 <sup>b</sup>	0.18±0.02 <sup>a</sup>	52.04±0.12 <sup>e</sup>	319±1.0 <sup>b</sup>	231.94±0.15 <sup>b</sup>	95.87±0.09 <sup>b</sup>	0.15±0.03 <sup>b</sup>	0.88±0.01 <sup>b</sup>	2.18±0.07 <sup>b</sup>	0.46±0.02 <sup>b</sup>
T5	25.41±0.02 <sup>f</sup>	1.21±0.01 <sup>a</sup>	16.23±0.05 <sup>a</sup>	5.85±0.03 <sup>a</sup>	0.19±0.01 <sup>a</sup>	51.11±0.12 <sup>f</sup>	322±1.0 <sup>a</sup>	238.91±0.04 <sup>a</sup>	99.31±0.10 <sup>a</sup>	0.22±0.02 <sup>a</sup>	1.05±0.04 <sup>a</sup>	2.29±0.04 <sup>a</sup>	0.50±0.01 <sup>a</sup>

Control (T0)=0% BWF; T1= 10% BWF; T2= 20% BWF; T3=30% BWF; T4=35% BWF, T5=40% BWF

Values are means of triplicates ± standard deviation. Values with the same superscript in a column are not significantly different (p >0.05).

content for other treatments, T1, T2, T3 and T4 was found 5.06%, 5.28%, 5.48%, and 5.62% respectively. The highest fiber content was found for treatment, T5 (0.19%) while least for control, T0 (0.07%). The fiber content for other treatments, T1, T2, T3 and T4 was found 0.11%, 0.13%, 0.16%, and 0.18% respectively. The highest carbohydrate content was found for control, T0 (54.23%) while least for treatment, T5 (51.11%). The carbohydrate content for other treatments, T1, T2, T3 and T4 was found 53.95%, 53.24%, 52.73%, and 52.04% respectively. The highest energy content was found for treatment, T5 (322kcal/100g) while least for control, T0 (301kcal/100g). The energy content for other treatments, T1, T2, T3 and T4 was found 305kcal/100g, 311kcal/100g, 317kcal/100g and 319kcal/100g respectively. The increase value of these parameters is due to incorporation of buckwheat flour as this flour contains higher amount of protein, fat, ash, fiber, carbohydrate and energy than wheat flour (Bhavsar *et al.*, 2013).

The mineral contents (sodium ranged from 177.42 to 238.91mg/100g, potassium ranged from 71.16 to 99.31mg/100g, copper ranged from 0.03 to 0.22mg/100g, zinc ranged from 0.21 to 1.05mg/100g, iron ranged from 1.66 to 2.29mg/100g and manganese ranged from 0.37 to 0.50mg/100g) were increased with the increasing content of buckwheat flour (Table III). Similar increasing trends were also observed in other studies (Bojnanska *et al.*, 2009; Wronkowska *et al.*, 2008).

The highest sodium (Na) content was found for treatment, T5 (238.91mg/100g) while least for control, T0 (177.42mg/100g). The sodium content for other treatments, T1, T2, T3 and T4 was found 190.52mg/100g, 202.35mg/100g, 222.35mg/100g and 231.94mg/100g respectively. The highest potassium (K) content was found for treatment, T5 (99.31mg/100g) while least for control, T0 (71.16mg/100g). The sodium

content for other treatments, T1, T2, T3 and T4 was found 76.26mg/100g, 84.01mg/100g, 90.05mg/100g and 95.87mg/100g respectively. The highest copper (Cu) content was found for treatment, T5 (0.22mg/100g) while least for control, T0 (0.03mg/100g). The copper content for other treatments, T1, T2, T3 and T4 was found 0.06mg/100g, 0.08mg/100g, 0.12mg/100g and 0.15mg/100g respectively. The highest zinc (Zn) content was found for treatment, T5 (1.05mg/100g) while least for control, T0 (0.21mg/100g). The zinc content for other treatments, T1, T2, T3 and T4 was found 0.35mg/100g, 0.58mg/100g, 0.69mg/100g and 0.88mg/100g respectively. The highest iron (Fe) content was found for treatment, T5 (2.29mg/100g) while least for control, T0 (1.66mg/100g). The iron content for other treatments, T1, T2, T3 and T4 was found 1.79mg/100g, 1.96mg/100g, 2.10mg/100g and 2.18mg/100g respectively. The highest manganese (Mn) content was found for treatment, T5 (0.50mg/100g) while least for control, T0 (0.37mg/100g). The sodium content for other treatments, T1, T2, T3 and T4 was found 0.40mg/100g, 0.42mg/100g, 0.45mg/100g and 0.46mg/100g respectively. These increases in the minerals content of the breads sample may be due to higher minerals content of buckwheat flour as compared to wheat flour.

#### *Physical properties of buckwheat flour fortified breads*

In order to assess the effect of incorporation of buckwheat flour on the physical properties of bread, different parameters such as loaf volume, loaf weight and specific volume were investigated and presented in the Table IV.

In the study, loaf volume and loaf specific volume were decreased with the increase of buckwheat flour. Highest loaf

volume was found for control, T0 (690 cc) whereas lowest in treatment T5 (414cc). The loaf volume for other treatments, T1, T2, T3 and T4 was found 614cc, 540cc, 476cc and 442cc respectively, supported by the study of (Wronkowska *et al.*, 2008). The loaf weight of the treatments, T0, T1, T2, T3, T4 and T5 was found 142.35g, 141.97g, 153.20g, 147.44g, 146.11g and 145.21g respectively. In case of loaf specific

*Effect of different levels of buckwheat flour on sensorial qualities of bread*

Sensory evaluation is an effective tools to judge whether the product will be acceptable or not among the consumers. In the present investigation, sensory qualities of breads prepared with the incorporation of different levels of

**Table IV. Physical characteristics of buckwheat flour (BWF) fortified breads**

Sample name	Loaf volume (cc)	Loaf weight (g)	Specific loaf volume (cc/g)
T0	690±2 <sup>a</sup>	142.35±0.5 <sup>d</sup>	4.85 ±0.2 <sup>a</sup>
T1	614±1 <sup>b</sup>	141.97±1.5 <sup>d</sup>	4.32 ±0.1 <sup>b</sup>
T2	540 ±3 <sup>c</sup>	153.20 ±1.0 <sup>a</sup>	3.52 ±0.09 <sup>c</sup>
T3	476±1 <sup>d</sup>	147.44±0.7 <sup>b</sup>	3.23±0.1 <sup>d</sup>
T4	442±3 <sup>e</sup>	146.11±0.9 <sup>b</sup>	3.02±0.1 <sup>e</sup>
T5	414±2 <sup>f</sup>	145.21±0.4 <sup>c</sup>	2.85 ±0.5 <sup>e</sup>

Control (T0) =0% BWF; T1= 10% BWF; T2= 20% BWF; T3=30% BWF; T4=35% BWF, T5=40% BWF

Values are means of triplicates ± standard deviation. Values with the same superscript in a column are not significantly different ( $p > 0.05$ ).

**Table V. Sensory attributes of developed breads prepared with different levels of buckwheat flour (BWF)**

Sample name	Color and appearance	Texture	Flavor	Evenness of bake	Taste	Overall acceptance
T0	8.80±0.04 <sup>a</sup>	8.83±0.05 <sup>a</sup>	7.84±0.04 <sup>e</sup>	8.74±0.03 <sup>a</sup>	8.09±0.05 <sup>d</sup>	8.33 ±0.05 <sup>a</sup>
T1	8.67±0.02 <sup>b</sup>	8.66±0.08 <sup>b</sup>	7.95±0.04 <sup>d</sup>	8.61±0.03 <sup>b</sup>	8.25±0.04 <sup>c</sup>	8.14±0.04 <sup>b</sup>
T2	8.58±0.03 <sup>c</sup>	8.45±0.05 <sup>c</sup>	8.05±0.03 <sup>c</sup>	8.50±0.08 <sup>c</sup>	8.34±0.05 <sup>b</sup>	8.06 ±0.05 <sup>b</sup>
T3	8.44±0.03 <sup>d</sup>	8.36±0.05 <sup>c</sup>	8.11±0.04 <sup>b</sup>	8.21±0.03 <sup>d</sup>	8.44±0.03 <sup>a</sup>	8.27 ±0.06 <sup>a</sup>
T4	8.25±0.05 <sup>e</sup>	8.09±0.08 <sup>d</sup>	8.17±0.02 <sup>a</sup>	7.97±0.03 <sup>e</sup>	8.0±0.04 <sup>e</sup>	7.95 ±0.04 <sup>c</sup>
T5	8.01 ±0.03 <sup>f</sup>	7.82±0.03 <sup>e</sup>	8.20±0.01 <sup>a</sup>	7.70±0.02 <sup>f</sup>	7.94±0.03 <sup>f</sup>	7.90 ±0.07 <sup>c</sup>

Control (T0) =0% BWF; T1= 10% BWF; T2= 20% BWF; T3=30% BWF; T4=35% BWF, T5=40% BWF

Values are expressed as means ± standard deviation. Values with the same superscript in a column are not significantly different ( $p > 0.05$ ).

volume, control, T0 showed highest (4.85cc/g) and treatment T5 lowest specific loaf volume (2.85cc/g). The specific loaf volume for other treatments, T1, T2, T3 and T4 was found 4.32cc/g, 3.52cc/g, 3.23cc/g and 3.02cc/g. These results in the present study are in line with the findings of other studies (Drobo *et al.*, 2014; Bhavsar *et al.*, 2013). The decrease in volume of breads may be due to decrease in gluten content and hence, decrease in air trapping capacity of the network that ultimately retards the increase in volume of breads.

buckwheat flour, 10% (T1), 20% (T2), 30% (T3), 35% (T4) and 40% (T5), showed that with regard to color and appearance, texture, flavor, evenness of bake, taste, and overall acceptance, 30% buckwheat fortified bread (T3) was found to be best among others. The effects of the incorporation of buckwheat flour (BWF) into sensory attributes of breads were shown in Table V.

The color and appearance is one of the most important sensory parameter that makes first impression in the consumers mind about the product. In the present study, the mean score for color and appearance was ranged from 8.0 to 8.8 and highest score was found in control, T0 while least in treatment T5. For other treatments, T1, T2, T3 and T4, it was found 8.67, 8.58, 8.44 and 8.25 respectively. The mean score for color and appearance was found decreasing as the increasing percentages of buckwheat flour due to the dark color of buckwheat flour (Gokcen and Nermin, 2012). Similar findings were also reported by Bhavsar *et al.* (2013).

The texture is also an important sensory attribute to judge whether the food is soft or hard. In case of bread, it is the feel of interior part after it has been sliced off. In the study, the textural properties of all the bread samples were found decreasing with the increasing amount of buckwheat flour and highest score for textural properties was found for control, T0 (8.83) while least for T5(7.82). Similar results were also reported by other studies (Bhavsar *et al.*, 2013; Petra *et al.*, 2012). The mean score for texture of other treatments T1, T2, T3 and T4 were found to be 8.66, 8.45, 8.36 and 8.09 respectively.

The flavor of the bread samples varied significantly from 7.84 to 8.20. Highest mean score for flavor was reported for T5 while least for control, T0. The mean scores for other treatments, T1, T2, T3 and T4 were found to be 7.95, 8.05, 8.11 and 8.17 respectively. Similar findings were also reported by Bhattarai *et al.* (2012).

Another sensory attribute of bread is the symmetry and evenness which depends on the strength of gluten and homogeneous vapor production at the time of baking. Gluten forms a network that retains vapors during baking. Any decrease in gluten content also reduces network formation that ultimately decreases symmetry and evenness of bread. In the present study, the symmetry and evenness of all the bread samples were linearly decreased with the increase of buckwheat flour percentages due to lower gluten content in the breads. Highest score was observed for control, T0 (8.74) while least in T5 (7.70). The mean scores for evenness of other treatments T1, T2, T3 and T4 were found to be 8.61, 8.50, 8.21 and 7.97 respectively. This study is in agreement with Bhavsar *et al.* (2013).

Taste is also one of the most important parameters to assess the sensory quality of any foods because it determines the acceptability and market success of the foods concerned. In

the present investigation taste of all the bread samples varied significantly from each other's. The mean score for taste was found highest for treatment T3 (8.44) and lowest for treatment T5 (7.94). For other treatments, T0, T1, T2 and T4, the mean scores were found to be 8.09, 8.25, 8.34 and 8.0 respectively. In case of overall acceptability, control T0 (8.33) and treatment, T3 (8.27) showed significantly higher mean score as compared to others, T1 (8.14), T2 (8.06), T4 (7.95) and T5 (7.90). The overall acceptance for control and treatment T3 did not vary significantly. Based on all the sensory attributes, bread formulated with 30% (T3) buckwheat flour is acceptable in sensory quality (Fig. 2). Above this level of buckwheat flour fortification, bread received a lower sensory score.



**Fig. 2. 30% Buckwheat fortified bread**

*Comparison of buckwheat fortified bread (T3) with locally available breads*

The buckwheat flour fortified bread, T3 (30% buckwheat flour), was compared with locally available breads to assess its nutritional value over these bakery products and presented in the Table VI.

#### *Moisture*

Moisture content is one of the most important factors that maintaining food quality because increase in moisture content assists microbial growth and eventually deteriorates quality. In the present study, the moisture content of the composite bread T3 and locally available breads was found 26.50 to 34.12% (Table VI). Highest moisture content was for S3 whereas lowest in buckwheat flour fortified bread

**Table VI. Comparison of nutritional composition of developed buckwheat bread (T3) and locally available breads**

Sample name	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Crude Fiber (%)	Carbohydrate (%)	Energy (Kcal/100g)
S1	30.12 ±0.21 <sup>d</sup>	0.97 ±0.01 <sup>de</sup>	7.05 ±0.05 <sup>s</sup>	3.57 ±0.10 <sup>f</sup>	0.07 ±0.02 <sup>bc</sup>	58.22±0.39 <sup>b</sup>	293.21±0.46 <sup>f</sup>
S2	30.76 ±0.16 <sup>c</sup>	0.94 ±0.02 <sup>f</sup>	10.08 ±0.1b	4.89 ±0.12 <sup>c</sup>	0.05 ±0.01 <sup>c</sup>	53.28±0.40 <sup>f</sup>	297.45±0.24 <sup>d</sup>
S3	34.12±0.12 <sup>a</sup>	0.99 ±0.01 <sup>cd</sup>	7.92 ±0.06 <sup>f</sup>	3.55 ±0.08 <sup>f</sup>	0.05 ±0.01 <sup>c</sup>	53.37±0.26 <sup>ef</sup>	277.10±0.31 <sup>i</sup>
S4	30.76 ±0.21 <sup>c</sup>	0.95 ±0.01 <sup>ef</sup>	9.35 ±0.13 <sup>d</sup>	3.79 ±0.12 <sup>c</sup>	0.09 ±0.01 <sup>b</sup>	55.07±0.48 <sup>d</sup>	291.75±0.34 <sup>s</sup>
S5	28.78 ±0.22 <sup>e</sup>	0.98 ±0.02 <sup>d</sup>	7.85±0.13 <sup>f</sup>	3.01 ±0.14 <sup>s</sup>	0.07 ±0.01 <sup>bc</sup>	59.31±0.52 <sup>a</sup>	295.73±0.30 <sup>e</sup>
S6	28.98 ±0.14 <sup>e</sup>	0.93 ±0.02 <sup>f</sup>	7.21 ±0.10 <sup>s</sup>	5.69 ±0.11 <sup>a</sup>	0.07 ±0.02 <sup>bc</sup>	57.05±0.29 <sup>c</sup>	308.26±0.32 <sup>e</sup>
S7	33.01 ±0.16 <sup>b</sup>	1.02 ±0.01 <sup>b</sup>	8.86 ±0.10 <sup>c</sup>	3.05 ±0.12 <sup>s</sup>	0.06 ±0.01 <sup>bc</sup>	54.0±0.40 <sup>e</sup>	278.89±0.12 <sup>h</sup>
S8	27.45 ±0.18 <sup>f</sup>	1.01 ±0.01 <sup>bc</sup>	9.66 ±0.14 <sup>c</sup>	4.56 ±0.14 <sup>b</sup>	0.06 ±0.01 <sup>bc</sup>	57.26±0.47 <sup>c</sup>	308.72±0.10 <sup>b</sup>
S9	30.93 ±0.12 <sup>c</sup>	0.78 ±0.02 <sup>s</sup>	9.36 ±0.11 <sup>d</sup>	3.68 ±0.10 <sup>ef</sup>	0.05 ±0.01 <sup>c</sup>	55.20±0.36 <sup>d</sup>	291.36±0.1 <sup>s</sup>
T3	26.50 ±0.11 <sup>s</sup>	1.06 ±0.01 <sup>a</sup>	14.07±0.05 <sup>a</sup>	5.48 ±0.11 <sup>b</sup>	0.16 ±0.02 <sup>a</sup>	52.73±0.30 <sup>f</sup>	316.52±0.01 <sup>a</sup>

Values are means of triplicates ± standard deviation. Values with the same superscript in a column are not significantly different ( $p > 0.05$ )

T3. This may be explained as buckwheat flour contained greater amount of total dry solids. This study is in agreement with others (Baljeet *et al.*, 2010). Hence, the developed bread is suitable as compared to similar breads.

#### Ash

The ash content of all the bread samples was found 0.78 to 1.06% (Table VI). The ash content of buckwheat flour fortified bread (T3) was found highest among other samples and the difference is also significant. Highest ash content in the present study may be due to higher ash percentage in buckwheat flour than wheat flour (Baljeet *et al.*, 2010). This study further strengthens the suitability of the developed bread as a source of micronutrient.

#### Protein

In this study, the protein content of the breads analyzed from local market was significantly lower than the formulated buckwheat breads. The protein content of all the bread samples was ranged from 7.05 to 14.07% (Table VI). Highest protein content was found in the formulated buckwheat bread (T3) while least in sample S1. The increased protein content may be explained as buckwheat flour has higher protein as compared to wheat (Wronkowska and Soral, 2008). Higher protein content of buckwheat formulated bread will make it a greater choice to overcome the protein energy malnutrition problem of the country.

#### Fat

The fat content of all the bread samples was ranged from 3.01 to 5.69% (Table VI). The lowest fat content was found in locally available bread, S5 whereas highest in T6 (Table IV). The fat content of the buckwheat fortified bread (T3) is significantly higher than all the bread samples except sample S6 which has higher fat than buckwheat fortified bread (T3). The higher fat of T3 bread may be explained as buckwheat contains higher amount of fat than wheat, supported by the study of Alvarez-Jubete *et al.* (2009).

#### Fiber

Fiber is an important component of our regular diet. It has many health benefits like prevention of several diseases such as cardiovascular diseases, irritable colon, cancer, constipation, diabetes (Elleuch *et al.*, 2011; Slavin, 2005). In the present study, buckwheat flour fortified bread, T3 showed highest fiber content (0.16%) as compared to locally available breads, S1 to S9. The difference in fiber content is also significant. The least content was found in samples S2, S3, and S9 (0.05%) (Table VI). The higher fiber content of buckwheat flour fortified bread, T3 will increase its acceptability among consumers as a fiber source.

#### Carbohydrate

In this study, the carbohydrate content of the breads varied significantly. It ranged from 52.73 to 59.31%. The lowest



carbohydrate content was found in the buckwheat flour fortified bread, T3 (52.73%), whereas highest amount in locally available bread, S5 (59.31%) (Table VI). The lower carbohydrate content of the developed buckwheat bread (T3) makes it a good choice for health of adults and diabetes patients.

#### Energy value

Food energy is the amount of chemical energy derives from food through oxidation. An amount of 9 kcal/g and 4 kcal/g energy is obtained through the oxidation of fat, protein and carbohydrate present in the diet respectively. In this study, the energy value of the breads was ranged from 277 to 316.52 kcal/100 g. The highest content was found for buckwheat flour fortified bread (T3) whereas least in the locally available Bread, S3 (Table VI). The difference in energy content may be due to higher protein and fat content of the presently developed bread. This newly developed buckwheat flour fortified bread may be a good choice for energy deficient people.

#### Conclusion

From the above studies, it can be stated that incorporation of buckwheat flour in the bread formulation has significant effects on the nutritional, physical and sensory attributes of bread. Based on the biochemical, physical and sensory results, it can be concluded that bread prepared with 30% substitution of wheat flour with buckwheat flour is acceptable in quality and it is nutritionally superior over locally available breads. The findings of the present study will help in development and utilization of functional foods that will not only improve the nutritional status of the population but also help those suffering from degenerative diseases.

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#### Declarations of interest

No conflict of interest.

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