Studies on Physico-Chemical Characteristics of Buckwheat and Its Exploration in Bread as Functional Food

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Abstract

Aim of this work is to study the physic-chemical characteristics of buckwheat and its exploration in bread as functional food. Buckwheat flour addition into bread formulation had considerable effects on physico chemical and sensory properties of bread. It can be finally concluded that the addition of buckwheat flour in refined wheat flour up to a level of 10 per cent in bread yielded a good quality product improving their physical characteristics, nutritional and mineral composition as compared to control bread with slight reduction in sensory attributes but found to be overall acceptable. Hence, development and utilization of such functional foods will not only improve the nutritional status of the population but also helps those suffering from degenerative diseases. More studies should be conducted to investigate the possibility of using BWF as an ingredient in other food products in order to increase applications of such value-added food ingredient.

1. Introduction

Buckwheat refers to a variety of plants in the dicot family Polygonaceae. The crop plant, common buckwheat, is Fagopyrum esculentum. Within Fagopyrum, the cultivated species are in the cymosum group, with F. cymosum L. (perennial buckwheat), F. giganteum and F. Homotropicum (Sharma and Jana, 2002).

Buckwheat is confusing to many as it seems to convey relationship to wheat which is not true. The name is probably a modification of "beech-wheat" (German Buckweizen) from the resemblance of its - grains with beechnuts, Fagus grandi/oUa (Singh and Atal 1982).Buckwheat is categorized as a pseudocerealin that it shows both differences and similarities with cereals (Aufhammer 2000).Some researchers have proposed that the word may be a translation of Middle Dutch boecweite : boec, beech + weite, wheat.

Buckwheat originates from the middle Asia and was transferred by nomadic people to Central and Eastern Europe. Within the thirteenth century, buckwheat reached some importance in Germany, Australia and Italy, which was however lost due to cultivation of other cereals.

Buckwheat seeds mainly contain starch 70–91% in of flour. Starch is 25% amylose and 75% amylopectin and 7–37% of resistant starch (Skrabanja et al., 2004). Proteins content is around 18% with biological values above 90%. This can be explained by a high concentration of all essential amino acids, especially lysine, threonine, tryptophan, and the sulphur-containing amino acids (Bonafaccia et al., 2003).

It has been established that diet-based therapies are among the most effective and sustainable ways to overcome various maladies. However, development of successful food-based strategy requires knowledge of nutrients dense sources, target communities and indeed selection of suitable vehicle (Fiedler et al., 2008; Steyn et al., 2008). Functional foods are important components in such interventions aiming to provide health benefits beyond their basic nutrition (Gidding et al., 2005; Barta et al., 2006) Wheat based baked products are considered suitable vehicles for incorporation of functional ingredients that can easily be accessible to masses especially in countries like India where wheat is staple diet (Jacob and Leelavathi, 2007) In the view of the importance of buckwheat as a functional food with respect to its high medicinal and nutritional value, the present investigation entitled "Studies on Physico-Chemical Characteristics of Buckwheat (Fagopyrum esculentum Moench) and its Exploration in Bakery Products as Functional Food" estimate the energy value of buckwheat fortified cereal based baked.

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2. MATERIALS AND METHODS

2.1. Procurement of raw materials.

Buckwheat is a seasonal crop and comes in the local market in the month of November. The Buckwheat grains were procured from the local market of Patiala, Punjab, India and stored in airtight container in the departmental laboratory. Maida was collected from DattaKrupa flour mill, MIDC, Parbhani and the other ingredients viz. sugar, salt, GMS, Skim Milk Powder, calcium propionate, Sodium bicarbonate, and Ammonium bicarbonate were procured from the local Market of Parbhani. Compressed yeast (SAF Yeast, Mumbai) and Vanaspati (Dalda) was also purchased from the Local Market of Parbhani. (MS) India.

2.2. Bread recipe used in bread production

Sr. no.	Ingredients	Weight (g)
1	Flour	100.0
2	Water	60 .0
3	Sugar	2.0
4	Shortening	2.0
5	Salt	1.5
6	Yeast	2.0
7	Skim Milk Powder (SMP)	1.0
8	Glycerol Mono Stearate (GMS)	0.2
9	Calcium propionate	0.15

Table-1: Different levels of buckwheat flour used in bread production

Sample	Buckwheat flour (BWF) (g/100g flour)
Control	0.00
A	5.00 (5%)
B	10.00 (10%)
C	15.00 (15%)
D	20.00 (20%)

Control=0% BWF; A= 5% BWF; B= 10% BWF; C=15% BWF; D=20% BWF

2.2. Flow sheet for bread preparation by addition of Buckwheat Flour

Sieving and Mixing of ingredients along with Buckwheat flour
↓
Fermentation (at 21-260C)
↓
Knock back
↓
Dividing
↓
Intermediate Proofing (15 min)
↓
Molding and panning
↓
Pan Proofing (45-60 min)
↓
Baking (2400C for 25 min)
↓
Cooling (2 hrs)
↓
Slicing
↓
Wrapping

2.3. Physical properties of Buckwheat seed

2.3.1. True Density

25 g of grains were filled into the measuring cylinder and volume occupied by them was measured. It was then calculated by following formula and represented in g/ml

$$\textbf{True Density} = \frac{\textbf{Weight of grains}}{\textbf{Volume occupied}}$$

2.3.2. Bulk Density

25 g of sound grains were weighed on the digital weighing balance and filled into the measuring cylinder earlier filled with reference solution of kerosene or toluene. The increase in the level of liquid was measured after adding the grains. It is bulk density represented in g/L.

$$\textbf{Bulk Density} = \frac{\textbf{Weight of grains}}{\textbf{Volume displayed}}$$

2.3.3. Porosity

Porosity is the per cent of the volume of inter grain space to the total volume of grain space. It is represented as per cent porosity.

2.3.4. Angle of Repose

It is the steepest angle between the base and slope of cone formed on a free vertical fall of grain mass to a horizontal plane when material is free falling or sliding. It was determined by making a circular pile of the grains freely falling. The height of the pile was taken (h) and its radius (r) is also taken. Angle of repose was then calculated by following formula.

Angle of Repose = tan (h/r)

2.4. Preparation of Buckwheat flour

The buckwheat flour (BWF) was prepared in Krupa Mill and was sieved and used for preparation of product.

2.4.1. Proximate composition of Buckwheat, Wheat

2.4.1.1. Moisture

It was worked out by weighing 5g sample accurately and subjecting to oven drying at 110oC for 4-6hrs. Oven dried samples were cooled in desiccator and weighed. The drying was repeated until the constant weights were obtained. The resultant loss in weight was calculated as per cent moisture content. (A.O.A.C., 2005)

2.4.1.2. Crude Fat

Sample (5g) was weighed accurately in thimble and defatted with n-hexane (boiling point 68-720C) in soxhlet apparatus for 8hrs. The resultant extract was evaporated and crude fat content was calculated as per A.O.A.C. (2005) method.

2.4.1.3. Crude protein

Protein was estimated by Microkjeldhal method using 0.5g of moisture free defatted sample by digestion with concentrated sulphuric acid and digestion mixture at 130-140˚C. Then it was distilled with 40 per cent sodium hydroxide and liberated ammonia was trapped in 4 per cent boric acid, using mixed indicator (methyl red : Bromoceresol green 1: 5). It was then titrated with 0.1N hydrochloric acid; the per cent nitrogen was estimated. Protein content was calculated by multiplying per cent nitrogen by a factor of 6.25 (A.O.A.C., 2005).

2.4.1.4. Total ash

Total ash was determined according to A.O.A.C. (2005). Sample (5g) was weighed into a crucible and burnt completely at low flame till all the material became smokeless. Then it was kept in muffle furnace for 6 hrs at 600oC then cooled in desiccators and weighed. The sample was again put in muffle furnace till two consecutive weights were constant and per cent ash was calculated.

2.4.1.5. Total carbohydrate

Total carbohydrate was determined by standard procedure using phenol and sulphuric acid. Sample (500 mg) was taken in test tube in an ice bath; 2 ml of 72 per cent H2SO4 was added to avoid the burning of sample. Then the volume of solution was made to 23 ml with distilled water. The sample was refluxed in water bath at 90 + 5oC for 3 hr. It was then filtered through a Whatman No. 1 filter paper and volume of the filtrate was made to 50 ml with distilled water. 1ml aliquot was taken for analysis; to this 2ml H2SO4 and 0.5ml phenol were added. The standard curve was prepared from serial dilution of standard glucose solution corresponding to 0.2, 0.4, 0.6, 0.8 and 1 □g of glucose. The intensity of colour was measured at 480 nm by spectrophotometers. From the standard curve, the concentration of total sugar was calculated.

2.4.1.6. Mineral content of Buckwheat seed

The minerals such as iron, zinc, manganese and copper were estimated according to the respective method as described in AOAC (2005) using Atomic Absorption Spectrophotometer (Varian, AA240, Victoria, Australia). 0.5 g sample was digested separately by using wet digestion method. The sample was first digested with 10 ml HNO3 at a temperature of 60-70°C for 20 min and then digested with HCl at a temperature of 190°C till the solution become clear. The digested sample was transferred to 250 ml volumetric flask and volume was made with distilled water and then filtered. The solution was loaded into Atomic Absorption Spectrophotometer apparatus. The standard curve was prepared by running samples of known strength through atomic absorption spectrophotometer. The mineral contents of unknown samples were estimated by using the respective standard curve prepared for each mineral.

2.4.2. Functional properties of flours

The functionality of flours of cereals grains which depends on extent of starch and protein content of flours, contribute in a lot to the formulation and properties of the final product Therefore, flours were analyzed for their physicochemical and functional properties. Particularly, the functional properties are required for the formulation of value added composite bakery products.

2.4.2.1. Water and oil absorption capacity

The water and oil absorption capacities were determined by the method of Sosulski et al. (1976). The sample (1.0 g) was mixed with 10 ml distilled water or refined soybean oil, kept at ambient temperature for 30 min and centrifuged for 10 min at 2000×g. Water or oil absorption capacity was expressed as percent water or oil bound per gram of the sample.

2.4.2.2. Bulk density

Bulk density of buckwheat flour was determined according to the method described by Okaka and Potter (1977). The sample (50 g) was put into a 100 ml graduated cylinder and tapped 20-30 times. The bulk density was calculated as weight per unit volume of sample.

2.4.2.3. Swelling capacity

The method of Okaka and Potter (1977) with some modifications was used for determining the swelling capacity. The sample filled up to 10 ml mark in a 100 ml graduated cylinder was added with water to adjust total volume to 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and allowed to stand for further 30 min. The volume occupied by the sample was taken after 30 min.

2.4.2.4. Foaming capacity and foaming stability

Foaming capacity and foaming stability were determined as described by Narayana and Narasinga Rao (1982) with slight modifications. Sample (1.0 g) was added to 50 ml distilled water at 30±20C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam after whipping for 30 sec was expressed as foaming capacity. Where, AW: After whipping, BW: Before whipping the volume of foam was recorded 1h after whipping to determine foaming stability as percent of the initial foam volume.

$$FC = \frac{\text{Volume of foam (AW)} - \text{Volume of foam (BW)} \times 100}{\text{Volume of foam (BW)}}$$

2.5. Formulation and Preparation of Bread

The bread was prepared in the Bakery Plant of the College of Food Technology, Marathwada Krishi Vidyapeeth, Parbhani, using straight dough method (A.A.C.C., 2000). The recipe was used for preparation of bread mentioned below and buckwheat flour was used in standard recipe in different concentration as mentioned in table-1.

2.5.1. Physico-chemical analysis of product

2.5.1.1. Loaf volume

The loaf volumes after cooling for 15 min were measured using the rapeseed displacement method. Each loaf was put in a container and covered with rapeseed to totally fill the container. Then the loaf was removed and the volume of the rapeseed was recorded by the method given in AACC (2000).

2.5.1.2. Specific volume

Bread crumb from centre portion of loaf was cut into 1cm x 1 cm size and it is accurately weighed.

2.5.1.3. Crumb firmness

Crumb firmness was measured according to AACC (2000) method 74.09.

2.5.1.4. Crumb to crust ratio

It is determined by separating crust and crumb using razor blade and weighing each component as described by Barett et al. (2005).

2.5.2. Proximate and mineral analysis of the product

The prepared bread was analyzed for proximate composition; moisture, ash, protein, fat, fiber according to their respective methods AOAC (2005). The minerals such as iron, zinc, manganese and copper were estimated according to the respective method as described in AOAC (2005) using Atomic Absorption Spectrophotometer.

2.5.3. Sensory evaluation of Buckwheat bread

Freshly prepared bread was evaluated for sensory characteristics like color and appearance, taste, flavor, evenness of bake, texture, and overall acceptability according to the method of Amerine et al. (1965) at room temperature by a panel of ten semi trained judges, comprised of postgraduate students and academic staff members of the faculty on 9-point Hedonic Scale. Judges were asked to rate the product on 9 point Hedonic scale with corresponding descriptive terms ranging from 9 'like extremely' to 1 'dislike extremely'. The used score card and hedonic scale is given in appendix.

2.6. Estimation of Theoretical Energy Value of the product

Theoretical energy value of the prepared buckwheat bread were calculated on the basis of proximate chemical composition taking conversion values for protein, fat and carbohydrate are 4, 9 and 4 Kcal respectively.

2.7. Techno-economical feasibility of the buckwheat bread

The cost of production of most acceptable buckwheat bread were calculated by considering the raw materials cost, processing cost, packaging cost and miscellaneous cost.

3. RESULTS AND DISCUSSION

During the present investigation entitled "Studies on Physico-Chemical Characteristics of Buckwheat (Fagopyrum esculentum Moench) and its Exploration in Bakery Products as Functional Food", attempts were made to use buckwheat as a functional ingredient in formulation of bakery products (bread and cookies). The study was focused on standardizing the concentration of buckwheat flour (BWF) in bakery products up to a level of acceptable quality. Quality characteristics of bread and cookies were reaffirmed by means of its physicochemical analysis followed by sensorial evaluation. The results were discussed in the view of relevant available scientific literature. The obtained results are presented and discussed in the following suitable headings:

3.1 Physical properties of buckwheat

The knowledge of physical properties of seeds helps in development of processing technology (Fellows, 2000). Theories used to predict the pressure and loads on storage structures (Janssen, 1895 and Lvin, 1970) require the knowledge of bulk density, angle of repose against bin wall materials. Also the design of grain hoppers for processing machinery requires data on bulk density and angle of repose. In order to characterize buckwheat, different physical parameters viz. colour, shape, 1000 kernel weight, density, etc. were investigated and data on these physical properties are presented in Table-1.

Table-1: Physical attributes of buckwheat seeds

Physical Attribute	Mean value*
Colour	Dark grey
Shape	Triangular with sharp edges
1000 Kernel Wt. (g)	20.70
1000 Kernel Vol. (ml)	15.60
True Density (g/ml)	1.19
Bulk Density (g/ml)	0.69
Porosity (%)	41.37
Angle of Repose (Degrees)	$24^{0}.52'$

The seed colour of buckwheat was dark found to be dark gray while the shape of seeds was triangular with sharp edges. Shape of seed is a distinguishing characteristic of buckwheat. Colour of buckwheat has been reported to vary from dark brown to dark grey depending upon cultivar and geographical conditions (Byoung et al., 2004a). Average density of seeds was found to be 1.19g/ml, while the average bulk density was 0.69 g/ml. The higher values of true and bulk densities may be regarded as a consequence of volumes and shape of grain (Lawton, 1980). This factor is important because it determines the capacity of storage, packaging and transport systems (James, 2005).

Weight and volume of 1000 kernel were found to be 20.70g and 15.60ml respectively which are comparable with the findings of Byoung et al., (2004). The per cent porosity of sample was found to be higher (i.e. 41.37 per cent). Porosity is a factor dependent on size, shape and boldness of seeds. It must be noted that porosity of the mass of seeds determines the resistance to airflow during aeration and drying procedures.Angle of repose represents the smoothness of seed surface and has marked effect on transportation of seeds. During present investigation, 24o 52′ was observed value for angle of repose of buckwheat. Angle of repose is also an indicator of free flowing nature of seeds and is important for designing of processing equipments (Barbosa et al., 2006). These results are in good agreement with the observations of present investigation.

3.2 Comparative study of proximate composition of buckwheat (BWF) and refined wheat flour (WF)

Determination of proximate composition of flour is essential in assessing its nutritional value. During present investigation, efforts were made to compare the chemical composition of buckwheat and refined wheat flour (WF). Different chemical compositional parameters viz. moisture, total fat, crude protein, total carbohydrates and ash contents of buckwheat and refined wheat flour were compared in the table-2.

Table-2: Proximate composition of buckwheat and refined wheat flour

Chemical Parameter (%)	Buckwheat flour*	Refined Wheat flour*
Moisture	11.35	12.73
Fat	2.20	1.80
Protein	10.41	12.86
Carbohydrate	70.40	69.92
Crude fibre	1.68	0.67
Ash	2.67	1.38

*Each value is a mean of three determinations.

It could be observed from the table-2 that buckwheat flour contained 11.35 per cent of moisture, whereas refined wheat flours it was 12.73 per cent. The lower moisture content of buckwheat flour justifies the suitability for long term storage without deterioration (David and Persis, 2000). Significant differences were observed in ash, crude fibre, carbohydrate and protein content of buckwheat and refined wheat flour. Buckwheat flour showed lower protein content (10.41 per cent) and higher carbohydrates (70.40 per cent) and crude fibre content (1.68 per cent) in comparison to refined wheat flour which showed 12.86, 69.92 and 0.67 per cent protein, carbohydrates and crude fibre respectively. The high ash content of buckwheat flour as compared to refined wheat flour improved the nutritional value (mineral content) of prepared bread and cookies. The ash content of buckwheat flour (2.67%) observed in this study is comparable with that reported by Taira (1974).

The results of proximate composition of refined wheat flour and buckwheat flour are comparable with slight differences with the findings reported by Zeleny (1954) and Franchischi et al. (1994). Variations in the proximate composition of Buckwheat flour may be attributed to the variety, pesticides used, and fertilization (Fornal, 1999).

3.3. Micromineral composition of buckwheat and refined wheat flours

Various mineral elements are known to be essential in human nutrition (Suzuki and Wada, 1994). In addition to this, for the processing of many foods, mineral elements may have a profound influence on their palatability such as texture and taste (Ikeda et al., 1999). Efforts were made to analyze the essential microminerals content of buckwheat flour and the values are compared with that of refined wheat flour. Table 3 shows the composition of the essential microminerals, i.e., iron, zinc, copper, manganese in buckwheat and refined wheat flours.

Table-3: Microminerals content of buckwheat flour compared with that of refined wheat flour

Mineral Element (mg/100g)	Mean Value	
	Buckwheat flour*	Wheat flour*
Iron	**2.67**	**0.78**
Zinc	**2.53**	**0.79**
Manganese	**1.52**	**0.46**
Copper	**0.49**	**0.18**

*Each value is a mean of three determinations.

It is evident from the table-3 that there were variations in the essential mineral composition between the flour samples. Buckwheat flour was shown to have significant higher levels of Iron, zinc, manganese and copper as compared with those of the refined wheat flour. The values for Iron, Zinc, Manganese and copper contents of buckwheat flour were recorded to be 2.67, 2.53, 1.52 and 0.49 mg/100g flour respectively. Whereas refined wheat flour showed Iron, Zinc, Manganese and copper contents to be 0.78, 0.79, 0.46 and 0.18 mg/100g flour respectively. These finding showed that buckwheat flour can be comparatively good source of these essential minerals. Results of mineral content of buckwheat flour in the present investigation are well in line with the values reported by Taira (1974).

3.4 Functional properties of buckwheat flour and refined wheat flour:

The functional properties of flours play important role in the manufacturing of bakery products. The buckwheat flour (BWF) and refined wheat flour (WF) were analyzed for their functional properties. Table-4 summarizes the results pertaining to the functional characteristics of buckwheat flour and refined wheat flour being studied during present investigation viz. water absorption capacity (WAC), oil absorption capacity (OAC), swelling capacity (SC), foaming capacity (FC) and foaming stability (FS).

Table-4: Functional properties of buckwheat flour compared with that of refined wheat flour

Parameters	Buckwheat flour	Refined Wheat flour
Water Absorption Capacity (%)	137.89	154.23
Oil Absorption Capacity (%)	186.56	167.91
Swelling Capacity (ml)	15.84	16.49
Bulk Density of flour (g/ml)	0.86	0.74
Foaming Capacity (%)	14.89	12.54
Foaming Stability (%)	92.89	95.60

Note: Each value is a mean of three determinations.

It is evident from the table-4 that the water absorption capacity (WAC) of buckwheat flour (i.e. 137.89) was significantly lower than that of wheat flour (i.e. 154.23 per cent). The lower WAC of buckwheat flour could be attributed to the presence of lower amount of hydrophilic constituents in BWF (Akubor and Badifu 2001). The oil absorption capacity (OAC) of BWF was significantly higher than that of refined WF. The oil absorption capacity (OAC) of flour is equally important as it improves the mouth feel and retains the flavor. The higher OAC suggested the presence of polar amino acids in the BWF (Taira, 1974).The swelling capacities of BWF and refined WF were 15.84 and 16.49 ml respectively. The foaming capacity of BWF was higher than that of refined WF. Foaming capacity is assumed to be dependent on the configuration of protein molecules. Flexible proteins have good foaming capacity but highly ordered globular molecule gives low foam ability (Graham and Philips, 1976). The foam expansion and foam stability have been correlated with water-dispersible nitrogen (Yasumatsu et al., 1972). Food ingredients with good foaming capacity and stability can be used in bakery products (Akubor et al., 2000). The bulk density of BWF was 0.86 g/ml, significantly higher than that of the refined WF (0.74 g/ml).

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

Bread is liked by all segments of population and could serve as a carrier for delivering novel functional ingredients. In present investigation, efforts were made to utilize buckwheat flour in bread to evaluate the influence of buckwheat flour on bread quality and contents of functional components as a result of supplementation.

The consumer acceptability of bread may be assessed with the help of sensorial evaluation of the products. Sensorial quality characteristics of bread play a pivotal role to attract consumers to purchase the product. Breads are judged by consumers on the basi of its sensorial quality parameters such as color and appearance, taste, flavor evenness of bake, texture etc. During present investigation, efforts were made to study the effect of different levels of buckwheat on sensorial quality characteristics of breads on 9 point Hedonic scale (Amerine et al., 1965). The obtained results for sensorial characteristics of bread are summarized in table 5.

Table-5: Sensory evaluation of bread fortified with buckwheat flour

Sample	Colour and Appear ance	Tast e	Flav or	evennes s of bake	Texture	Overal l accept ability
Control	8.52	8.81	8.34	8.34	8.75	8.12
A	7.38	7.46	7.52	7.34	7.30	7.43
B	7.49	7.86	7.72	7.64	7.60	7.76
C	6.10	6.60	6.15	6.04	6.26	6.10
D	5.03	4.91	5.31	4.90	4.53	4.08
SE±	0.20	0.21	0.18	0.20	0.24	0.24
CD at 5%	0.60	0.65	0.55	0.61	0.74	0.73

Control=0%BWF; A= 5% BWF; B= 10%BWF; C=15%BWF; D=20%BWF

Each value is a mean of ten determinations.

It is evident from the table that buckwheat bread sample B having 10 per cent flour secured highest scores for sensory parameters like colour and appearance, taste, flavour and texture amongst all the treated samples.

The colour of bread is a function of reducing sugars as these reducing sugars during baking caramelized to produce dark brown colour of bread (Trierum, 2004). Hence, the colour and appearance of treated samples decreased linearly with the increased level of fortification. Symmetry and evenness of bread remained as a function of gluten strength and uniform vapor production during baking. It could be observed form the table that incorporation of buckwheat decreased the formation gluten network that failed to retain vapours produced and hence the symmetry and evenness of bread formed decreased linearly with increase in concentration of buckwheat. These findings are comparable with those reported by Li et al. (2009) who reported decreased colouring characteristic in baked loaf. The taste and flavour for all the treated samples linearly decreased as compared to control sample. The textural properties of all the samples were found to decrease with increase in level of fortification with buckwheat flour. Maximum textural scores were secured by control sample (i.e. 8.75) while the minimum values were observed in sample D (i.e. 4.53). SampleB appearing to be optimum in terms of textural properties having score of 7.60. Texture is actually the feel of the surface of the interior of the loaf when cut and sliced. The desirable texture obtained by sample B was soft. This was determined by pressing the fingers against and rubbing them across the cut surface of the loaf (Kihlberg, 2006). Similar findings have been reported by Angioloni and Collar (2010) in multigrain bread containing buckwheat as a functional ingredient.

The overall acceptability of buckwheat bread was recorded to be moderate till the fortification level of 10 per cent (i.e. Sample B which scored 7.76 for overall acceptability). The overall acceptability of bread was found to decrease linearly with increase in concentration of buckwheat and eventually resulting in rejection of sample D.

It can be concluded that control sample recorded higher sensory score as compare to all buckwheat flour based bread. However, among other bread, sample B having 10 per cent buckwheat flour was found to be statistically significant over sample C and D and was highly overall acceptable. It is also seen from results that sample A and B are found to be statistically at par with each other, where as sample D containing 20 per cent buck wheat flour was not liked by panel members and found to be unacceptable.

4.6 .Physical properties of bread prepared with different incorporation level of buckwheat flour

In order to understand the significance the effect of buckwheat flour on the physical properties of bread, different parameters like loaf volume, specific volume, crust to crumb ratio and crumb firmness were investigated and presented in this Table-6.

Table-6: Physical properties of bread prepared with different incorporation level of buckwheat flour

Sample	Loaf Volume (ml)	Specific Volume (cm^3/gm)	Crust to crumb ratio	Crumb firmness (g force)
Control	740	3.15	0.280	1.20
A	720	3.06	0.274	1.86
B	710	3.00	0.265	2.57
C	705	2.80	0.259	2.86
D	680	2.60	0.245	2.90
SE $\pm$	3.22	0.03	0.002	0.10
CD at 5%	9.60	0.09	0.006	0.32

Control=0%BWF; A= 5% BWF; B= 10% BWF; C=15% BWF; D=20% BWF

Each value is a mean of three determinations.

It is evident from table-6 that loaf volume showed significant variation as a result of treatments. Loaf volume of control sample was recorded to be 740ml. samples A showed maximum volume viz. 720ml amongst the treated samples, followed by D which produced minimum volume i.e. 680 ml. however samples B and C showed the slight differences in values for loaf volume as 710 ml and 705 ml respectively. These results in the present study are in line with the findings of Brunori et al. (2003).

Similarly, the specific volume of the bread samples was calculated sample A and B were found to possess almost similar value of around 3.06and 3.00 cm3/g respectively.Whereas, C sample was at bottom with specific volume 2.60cm3/g. The results pertaining to the specific volume of bread indicated that treatment resulted in breads with high density and decreased volume and hence, consumer preference decreased accordingly. The results obtained in present investigation are in close agreement with the findings of Ji-Young and Chang (1998).

Crust to crumb ratio was found to be in the range of 0.274 to 0.245 with control sample having 0.280 value for crust to crumb ratio, the highest value was obtained by sample A while sample D showed lowest value. The values obtained for crust to crumb ratio indicated that there was no much difference found in these values. Moreover, it was also seen from table that all the analysed values, physical properties of breads prepared with buckwheat flour are linearly decreased.

The crumb firmness increased with increased level of addition of buckwheat flour, with control scoring the minimum (i.e. 1.20) for crumb firmness. This score is found to increase linearly to reach maximum value of 2.90g (for sample D). The increased level of crumb firmness may be attributed to the decreased aeration and compact texture of buckwheat fortified bread; these findings are comparable with the work of Gabreila et al. (2011).

4.7. Chemical composition of Bread fortified with buckwheat flour

In order to investigate the significance of addition of different levels of buckwheat flour on nutritional quality characteristics of bread, like moisture, protein, fat, carbohydrate, crude fiber, ash of bread sample. Table-7 summarizes the effects of different levels of buckwheat flour fortification on nutritional composition of bread.\

Table-7: Chemical composition of Bread prepared with different incorporation level of buckwheat flour

Sample	Moisture (%)	Fat (%)	Protein (%)	Carbohydrates (%)	Crude fibre (%)	Ash (%)
Control	31.35	2.34	11.62	51.27	1.98	1.42
A	30.19	2.59	10.79	52.50	2.27	1.64
B	29.03	2.78	9.96	53.72	2.58	1.91
C	27.83	2.94	9.11	55.07	2.89	2.18
D	26.63	3.10	8.24	56.04	3.16	2.45
SE ±	0.83	0.13	0.59	0.85	0.21	0.18
CD at 5%	0.28	0.04	0.20	0.28	0.07	0.061

Control=0%BWF; A= 5% BWF; B= 10% BWF; C=15% BWF; D=20% BWF

Each value is a mean of three determinations.

The results for moisture content of breads prepared from different level of buckwheat flour as given in Table-7 indicated that moisture content decreased linearly with the increase in addition of buckwheat flour. The results indicated that control bread sample showed the highest moisture content (31.35 per cent). Sample A possessed the highest moisture content (30.19 per cent) followed by B (29.03 per cent), C (27.83 per cent) and D (26.63 per cent). Decreased water content of finished bread may be a consequence of depleted water absorption capacity of dough due to addition of buckwheat flour, which weakens the gluten and starch network to retain less moisture (Petra et al., 2012). Results of present investigation are well in accordance with those reported by Angioloni and Collar (2010).

It is evident from the table that apart from moisture content, the macronutrient composition of buckwheat bread did not differ significantly between breads. The breads were a good source of protein (10.79 to 8.24 per cent), low in fat (2.59 to 3.10 per cent), ash content (1.64 to 2.45) and higher in the crude fiber (2.27 to 3.16 per cent). These findings conforms the earlier study of Li et al. (2009).

The ash content of buckwheat flour bread was found to be significantly increased as per cent addition of buckwheat flour increased. It is also interesting to note that the prepared buckwheat flour bread having higher ash and crude fibre content than control bread.

4.7. Theoretical Energy Values of value added products of buckwheat flour

Energy value of a product is important to assess its impact on human health especially if it is to marketed in health sensitive consumer group. Declaration of energy value of product has become mandatory on label in modern food regulations. Therefore efforts were made in present investigation to assess energy value of bread fortified with buckwheat flour on the basis of its proximate composition.

Table-a: Theoretical Energy Values of bread fortified with buckwheat flour

Sample code	Energy form (kcal)			Total energy (kcal)
	Protein	Carbohydrate	Fat	
Control	46.48	205.08	21.06	272.62
A	43.16	210.00	23.31	276.47
B	39.84	214.88	25.02	281.18
C	36.44	220.28	26.46	283.18
D	32.96	224.16	27.90	285.02

Control=0%BWF; A= 5% BWF; B= 10% BWF; C=15% BWF; D=20% BWF

It is evident from the table that energy value of bread increased more or less regularly as the level of fortification with buckwheat increased. The totalenergy value of control bread was recorded to be 272.62 Kcal which increased to 285.02 Kcal in sample D containing 20% buckwheat. Increased energy value of bread upon addition of buckwheat may be attributed to high carbohydrate content of buckwheat and comparatively more fat content of fortified bread.

4. CONCCLUSION

Buckwheat flour addition into bread formulation had considerable effects on physico chemical and sensory properties of bread. It can be finally concluded that the addition of buckwheat flour in refined wheat flour up to a level of 10 per cent in bread yielded a good quality product improving their physical characteristics, nutritional and mineral composition as compared to control bread with slight reduction in sensory attributes but found to be overall acceptable.
Hence, development and utilization of such functional foods will not only improve the nutritional status of the population but also helps those suffering from degenerative diseases. More studies should be conducted to investigate the possibility of using BWF as an ingredient in other food products in order to increase applications of such value-added food ingredient.

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