

# Development and analysis of composite flour bread

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**Abstract** The study elucidates the effect of utilizing cereal-pulse-fruit seed composite flour in the development and quality analysis of leavened bread. The composite flour was prepared using refined wheat flour (WF), high protein soy flour (SF), sprouted mung bean flour (MF) and mango kernel flour (MKF). Three variations were formulated such as V-I (WF: SF: MF: MKF=85:5:5:5), V-II (WF: SF: MF: MKF=70:10:10:10), and V-III (WF: SF: MF: MKF=60:14:13:13). Pertinent functional, physico-chemical and organoleptic attributes were studied in composite flour variations and their bread preparations. Physical characteristics of the bread variations revealed a percentage decrease in loaf height (14 %) and volume (25 %) and 20 % increase in loaf weight with increased substitution of composite flour. The sensory evaluation of experimental breads on a nine-point hedonic scale revealed that V-I score was 5 % higher than the standard bread. Hence, the present study highlighted the nutrient enrichment of bread on incorporation of a potential waste material mango kernel, soy and sprouted legume. Relevant statistical tests were done to analyze the significance of means for all tested parameters.

**Keywords** Composite flour · Leavened bread · Mango kernel · Germinated mung bean · Full-fat soy

## Introduction

Bread is one of the most widely consumed food product in the world and bread making technology is probably one of the oldest technology known (Selomulyo and Zhou 2007). The major ingredients in bread making are wheat flour, water and yeast (Akobundu et al. 1988). Due to the high cost, geographical scarcity and high demand of wheat flour, strong initiatives are taken toward the provision of alternative source of flour. It is therefore of economic advantage if wheat import can be reduced by substitution with other nutrient dense materials. This led to the whole idea of composite flour (Oyeku et al. 2008).

Composite flour has been defined in numerous researches as a combination of wheat and non-wheat flours for the production of leavened breads, other baked products, and pastas; or wholly non wheat flour prepared from mixtures of flours from cereals, roots, tubers, legumes, or other raw materials, to be used for traditional or novel products (Dendy 1992). Composite flours have been used extensively in preparation of baked products to primarily identify the functional roles of flour components and test its organoleptic acceptability. Each component of composite flours is carefully selected in the present study to play a considerable role in contributing towards the nutritional or functional attribute of the product developed.

Since bread is an important food that is generally accepted, they could be an excellent and convenient food item for protein and other nutrient dense fruit seed fortification to improve the nutritional well being/health of the people which will enhance reduction in protein malnutrition that is prevalent in developing countries. Keeping this idea in mind, the present

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study was undertaken to formulate leavened bread by partial substitution with full-fat soy flour, sprouted mung flour and mango kernel flour, as a composite blend.

The study analyzes the feasibility of utilizing the above mentioned composite blend in composite flour bread preparation. The study also highlighted the prospect of utilizing a potential agro-waste, mango kernel, as a good source of phenolic compounds and also as a partial fat replacer.

## Materials and methods

### Materials

Refined wheat (*Triticum aestivum L.*) flour, full-fat soy (*Glycine max*) flour and fresh mung bean (*Vigna radiata*) were sourced from a local market. The fresh mung bean was then germinated and made into flour by using standard procedure. Mango (*Mangifera indica*) seeds of *Totapuri* variety were obtained from a mango juice processing industry located in Chennai. Mango kernel flour was prepared from these mangoes after required processing.

### Preparation of mango kernel flour

The seeds were collected and rinsed immediately. The kernels were manually removed from the seeds and washed to get remove of any adhering material. It was blanched for 2 min and mechanically dried at 60–65 °C for 2 days. The dried material was ground in a hammer mill into a powder form and passed through 30 mesh standard sieve. The flour stored in air-tight Poly ethylene (PE) bags until further analysis and kept in a dry and dark storage shelf, away from sunlight (Ashoush and Gadallah 2011).

### Preparation of sprouted mung flour

The germination of mung beans was carried out by soaking the seeds in distilled water (1:3 w/v) for 12 h at room temperature (~25 °C). A pre-weighed quantity of sample was placed in a cotton cloth and allowed to sprout in the dark for 36 h. The seeds were moistened with distilled water every 12 h throughout germination period. The sprouted mung beans were dried at 65 °C for 9 h followed by cooling to ambient temperature. The dry seeds are then pulverized and passed through 30 mesh standard sieve. The flour stored in air-tight Poly ethylene (PE) bags until further analysis (Blessing and Gregory 2010).

### Preparation of composite flours and bread variations

The experimental variations of the composite flour were formulated using refined wheat flour (WF), sprouted mung flour

(MF), full fat soy flour (SF) and mango kernel flour (MKF) for the preparation of bread. Table 1 depicts the proportions of composite flour in the three experimental variations such as: V-I (WF: SF: MF: MKF=85:5:5:5), V-II (WF: SF: MF: MKF=70:10:10:10), V-III (WF: SF: MF: MKF=60:14:13:13). Bread prepared from refined wheat flour served as standard bread for the study. The composition of the experimental and standard breads has been given in Table 2. The process of preparing standard and experimental bread variations has been described in Fig. 1. The yield of a single fresh dough loaf after mixing was about 450 g (Akobundu et al. 1988).

### Preparation of sample extract for total phenolic content

Pre-weighted quantity (0.5 g) of MKF and V-I, V-II and V-III composite flour bread samples was mixed in 20 ml of methanol: water mixture (60:40 v/v). This was centrifuged and the supernatant was adjusted to 25 ml. An aliquot of these extracts were used for the quantification of total phenolic content (Bloor 2001).

### Functional properties of composite flour blends

All composite flour blends and refined wheat flour were tested for functional properties such as bulk density (Okaka and Potter 1977), water holding capacity, water absorption capacity (Gould et al. 1989), oil absorption capacity (Sosulski et al. 1976), swelling index (Lin et al. 1974), foam capacity and foam stability (Narayana and Rao 1982).

### Physico-chemical properties of breads

Loaf weight and loaf height of the standard and composite flour breads were determined by a method of See et al. (2007). Loaf volume and specific loaf volume were determined using standard AACC (2000) procedures.

### Baking loss analysis

Baking losses were analyzed in terms of moisture loss. Loss was also calculated by the baking yield. Dough baking yield was determined by comparing the fresh dough weight ( $W_1$ ) before placing in the oven and with the final bread weight ( $W_2$ ). The loaves were weighed 1 h after removal from the oven ( $W_2$ ). This baking loss was a measure of loss of moisture of the bread during baking and expressed in terms of percentage (Puhr et al. 1992).

### Proximate composition of composite flour breads

The moisture, crude protein, fat, crude fibre and total ash content were determined by AOAC 2000. The total phenolic

**Table 1** Preparation of composite flour blend

Variations	Refined wheat flour (%)	Soy flour (%)	Mung flour (%)	Mango kernel flour (%)
Standard flour	100			
V-I	85	5	5	5
V-II	70	10	10	10
V-III	60	14	13	13

content of the bread was analysed as Gallic Acid Equivalents (GAE) by a spectrophotometric method (Singleton et al. 1999).

#### Organoleptic evaluation

The bread samples were cooled for 1–2 h to room temperature. The bread was then cut into small slices using a bread knife. Sensory evaluation was performed on a nine-point hedonic scale using 10 semi trained panelists. Samples were randomly assigned to the panelist. The panelists were asked to evaluate each loaf on given sensory score sheet for the attributes such as crumb and crust colour, aroma, texture, mouthfeel, taste, overall acceptability. The nine-point hedonic scale was represented as: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = extremely dislike (See et al. 2007).

#### Processing and analysis of data

All determinations were performed in triplicates ( $n=3$ ). All data were expressed as mean values  $\pm$  Standard Deviation (SD). Depending upon the experimental design, the inferential statistical analyses were conducted as follows:

- One-way analysis of variance (ANOVA) was done to analyze the significance in the variation of means between the standard and the experimental samples as well as to

analyze the significance in the variation of mean values within the experimental samples. Statistical differences in samples were tested at  $p<0.01$ .

- Duncan's multiple-range test (DMRT) was used to differentiate between the mean values. All the analyses were done using SPSS statistics (17.0) software.

## Results and discussion

### Functional properties of standard and composite flours

Functional properties are the intrinsic physicochemical characteristics which may affect the behavior of food systems during processing and storage. Adequate knowledge of these properties indicate the usefulness and acceptability of a product. Bulk density, Water holding capacity, Water absorption capacity, Oil holding capacity, Swelling index and Foaming capacity of the standard and composite flour blends were analysed to understand their role in the developed product.

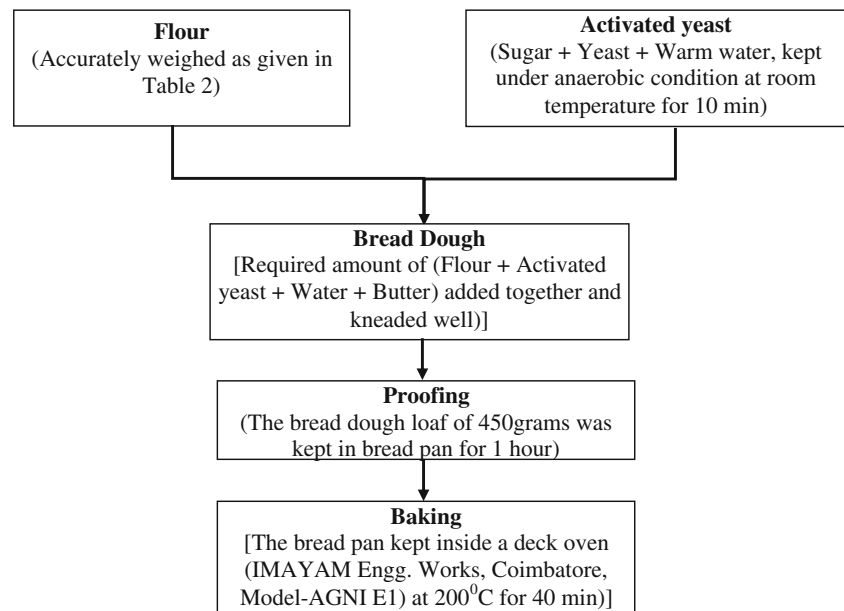
### Bulk density

Bulk density is generally affected by the particle size and density of the flour and it is very important in determining

**Table 2** Ingredient composition of standard and experimental breads

Ingredients	Standard bread	V-I bread	V-II bread	V-III bread
Refined wheat flour (g)	250	212.5	175	150
Sprouted mung flour (g)		12.5	25	35
Mango kernel flour (g)		12.5	25	32.5
Soya flour (g)		12.5	25	32.5
Refined sugar (g)	25	25	25	25
Dried yeast (g)	10	10	10	10
Salted butter (g)	4	3	2	–
Salt (g)	3	3	3	3
Distilled water (ml)	150	155	165	175

**Fig. 1** Preparation process of standard and composite flour bread variations



the packaging requirement, material handling and application in wet processing in the food industry (Karuna et al. 1996). In the present study, the bulk density of the standard refined wheat flour was 0.9259 g/ml which was the lowest amongst all variations. The bulk density of the three experimental variations were significantly higher ( $p < 0.01$ ) than the standard refined wheat flour.

The higher bulk density may be due to the presence of more crude fibre in composite flour samples which is in accordance with the observations made by Singh et al. (1996). Contrary to Peleg and Hollenbach (1983), emphasis of density variation of particulates was only on moisture content & particle size, it could be inferred that there are some other parameters affecting the bulk density of flours. The individual flour components used in composite flour blends had higher bulk density than refined wheat flour, thus causing increase in overall bulk density.

### Water holding capacity

The ability of dietary fibre to hold water may be expressed in different ways. The expression “Water holding capacity” describes the quantity of water that can be bound in fibre without the application of external force. The Water Holding Capacity (WHC) was lowest in standard refined wheat flour 1.01gH<sub>2</sub>O/g ( $\pm 0.01$ ). The composite flour variation, V-I was reported to have a water holding capacity of 1.2gH<sub>2</sub>O/g ( $\pm 0.02$ ). The WHC of V-II and V-III was found to be 1.3gH<sub>2</sub>O/g ( $\pm 0.3$ ) and 1.42gH<sub>2</sub>O/g ( $\pm 0.02$ ) respectively. Thus, according to the results obtained, it can be stated that the increase in water

holding capacity for experimental variations were directly proportional to the incorporation of high starch mango kernel flour. The ability of flour to bind and hold more water was reported to have a significant correlation with its starch content (Mbofung et al. 2006). According to Hodge and Osman (1976), flours with high WHC contain more hydrophilic constituents, such as polysaccharides which holds true for the present study due to the high polysaccharide content of mango kernel flour.

### Water absorption capacity (WAC)

The water absorption percentage for dough development was determined. Variation in WAC of composite flours may be due to difference in concentration of protein, their degree of interaction with water and possibly their conformational characteristics. It has been reported earlier that the dough made from composite flour absorbed more water than dough made from wheat flour (Morita et al. 2002; Mbofung et al. 2006). This is in agreement with the finding of the present study where water absorption capacity was least in standard refined wheat flour 62.7 % ( $\pm 0.03$ ) and was highest i.e., 70.48 % ( $\pm 0.04$ ) in the composite flour variant V-III.

The incorporation of soy flour (SF) could increase the water absorption capacity due to the higher soluble protein content of SF that contributes to a greater hydration capacity and due to the high hydrophilicity of the soy proteins. This significant increase ( $p < 0.01$ ) in WAC might lead to the production of more moist and soft textured bread as well as it might also cause the increase in loaf weight as observed in this study.

## Oil absorption capacity

The mechanism of fat or oil absorption is attributed mainly to the physical entrapment of oil and the binding of fat/oil to the apolar chain of protein (Wang and Kinsella 1976). Absorption of oil by food products improves mouthfeel and flavor retention. The higher oil absorption capacity suggests the lipophilic nature of flour constituents (Ubbor and Akobundu 2009). In the present case, oil absorption capacity significantly decreased ( $p < 0.01$ ) in composite flour variants as compared to the standard flour. Oil absorption was highest (Table 3) for the standard flour 2.47gOil/g ( $\pm 0.036$ ) and lowest, i.e., 1.29gOil/g ( $\pm 0.02$ ) for the variation V-III.

The increase in oil absorption may also be attributed to the presence of more hydrophobic proteins which shows superior binding of lipids (Wang and Kinsella 1976). Thus, a larger proportion of hydrophilic groups or polar amino acids on the surface of protein molecules tend to cause a decrease in oil absorption capacity of flours (Sathe et al. 1982). Therefore, the lower oil absorption capacity of composite flours (V-I, V-II and V-III) might be due to the presence of high protein constituents such as legume flours and the hydrophilic nature of those flours. It was also noted that the increased ratio of high starch mango kernel flour in composite flour variations led to the decrease in oil absorption capacity. This result was in accordance with Legesse and Emire (2012) who has also reported that blending of mango kernel flour with wheat flour significantly reduces oil absorption capacity.

## Swelling index

Swelling index or swelling power is an indication of the water absorption index of the flour granules during heating (Loos et al. 1981). It is an evidence of non-covalent bonding between molecules within starch granules and also a factor of the ratio of  $\alpha$ -amylase and amylopectin ratios (Rasper 1969). Here the swelling index of the standard flour was reported as 4( $\pm 0.05$ ). The statistical analysis of variance (Table 3) revealed that the swelling index of experimental composite flour

variations were significantly different ( $p < 0.01$ ) from each other.

The composite flour with 15 % wheat flour substitution was reported to have a swelling index 3.8( $\pm 0.05$ ) which was significantly higher ( $p < 0.01$ ) than the other two composite flour variation having 30–40 % wheat flour substitution respectively. It was revealed that the decrease in swelling index for experimental flours was inversely proportional with the increased substitution of standard refined wheat flour by high starch and high protein composite blends.

Higher protein and fat content in flours have shown to reduce their swelling power owing to inhibition of the process of starch gelatinization. Composite flour blends used for the study are inherently high in protein, thus formation of a starch protein complex may be resultant of reduction in swelling power of the flour blends (Ikegwu et al. 2010). Since high swelling capacity was reported as part of the criteria for a good quality product (Achinewhu et al. 1998), thus, the decreased swelling index in the present study could probably cause the decrease in loaf volume and loaf height of the composite flour bread variants.

## Foaming capacity

Foam is a colloid of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films. Foam can be produced by whipping air into liquid as much and fast as possible (Sikorski 2002). Flours are capable of producing foams because of the proteins present in flours are surface active. Foaming capacity of the standard (100 %) refined wheat flour was found to be 8 %. The experimental flour, V-I, containing 85 % wheat flour and 15% composite blend was reported to have 5.6 % foaming capacity which was significantly higher ( $p < 0.01$ ) than the other two experimental flour variants. The experimental composite flour V-II and V-III with 30–40 % composite blend was found to have 3–2 % foaming capacity respectively.

Foaming capacity is assumed to be dependent on the configuration of protein molecules. Flexible proteins have good

**Table 3** Functional properties of standard and composite flours

Variations	Bulk density (g/ml)*	Water absorption capacity (%)*	Water holding capacity (g H <sub>2</sub> O/g flour)	Oil absorption capacity (g Oil/g flour)*	Swelling index*	Foam capacity (%)*
Standard	0.9259 $\pm$ 0.0004 <sup>a</sup>	62.7 $\pm$ 0.03 <sup>a</sup>	1.01 $\pm$ 0.01 <sup>a</sup>	2.47 $\pm$ 0.03 <sup>d</sup>	4 $\pm$ 0.05 <sup>d</sup>	8.0 $\pm$ 0.2 <sup>d</sup>
V-I	0.936 $\pm$ 0.0006 <sup>b</sup>	63.83 $\pm$ 0.05 <sup>b</sup>	1.2 $\pm$ 0.02 <sup>ab</sup>	1.59 $\pm$ 0.01 <sup>c</sup>	3.85 $\pm$ 0.05 <sup>c</sup>	5.6 $\pm$ 0.2 <sup>c</sup>
V-II	0.9468 $\pm$ 0.0003 <sup>c</sup>	66.9 $\pm$ 0.03 <sup>c</sup>	1.3 $\pm$ 0.30 <sup>ab</sup>	1.53 $\pm$ 0.03 <sup>b</sup>	3.75 $\pm$ 0.05 <sup>b</sup>	3.0 $\pm$ 0.2 <sup>b</sup>
V-III	0.9558 $\pm$ 0.0005 <sup>d</sup>	70.48 $\pm$ 0.04 <sup>d</sup>	1.42 $\pm$ 0.02 <sup>b</sup>	1.29 $\pm$ 0.02 <sup>a</sup>	3.64 $\pm$ 0.05 <sup>a</sup>	2.0 $\pm$ 0.2 <sup>a</sup>

V-I (WF: SF: MF: MKF=85:5:5:5), V-II (WF: SF: MF: MKF=70:10:10:10), V-III (WF: SF: MF: MKF=60:14:13:13, where, WF = (Refined) Wheat Flour, SF = Soy Flour, MF = Mung Flour (Sprouted), MKF = Mango Kernel Flour

\*Mean values bearing the same superscript do not differ significantly ( $p < 0.01$ )



foaming capacity but highly ordered globular molecule gives low foam ability (Graham and Philips 1976). Thus the reduction in foaming capacity for composite flour blends in the present study indicates the ordered globular nature of the proteins contained in it. Since foams in flours are able to retain more air in it, thus low foam capacity indicates lower ability to retain CO<sub>2</sub> in flour matrix. This could probably cause a decrease in loaf volume and specific volume of composite flour breads.

Physico-chemical properties of breads

### Loaf weight

Loaf weight is determined by quantity of dough baked and the amount of moisture and carbon dioxide diffused out of the loaf during baking. A reduction in carbon dioxide retention capacity in composite flour dough causes a subsequent increase in loaf weight. Approximately 450 g of dough (Fig. 1) was baked in a bread mould at 200 °C for 40 min and the resultant weight of the baked dough was considered as the loaf weight.

The loaf weight was lowest for the standard refined wheat flour bread 390 g ( $\pm 5$ ) as described in the following figure and increased gradually in composite flour bread variants but the increment was not statistically significant ( $p < 0.01$ ).

The loaf weight of V-I was found to be 392 g ( $\pm 5$ ) which was lower than the variations V-II and V-III composite bread. The highest value of loaf weight was observed for the experimental variation V-III. Thus it can probably be stated that the reduction of refined wheat flour content and incorporation of high starch mango kernel flour and protein rich soy and germinated mung flour contributed to the bulkness of the flour resulting in high loaf weight of the bread.

### Loaf height

Loaf height was highest for the standard bread 7.16 cm ( $\pm 0.15$ ) and decreased significantly ( $p < 0.01$ ) in composite flour bread variants V-I, 6.1 cm ( $\pm 0.1$ ); V-II, 5.5 cm ( $\pm 0.2$ ); and V-III, 4.5 cm ( $\pm 0.25$ ) respectively. The loaf height of the bread variations V-II and V-III were respectively 9.83–26 % lesser than that of the composite bread variation V-I. Since V-I was containing least proportion of refined wheat flour (85 %), thus the formation of gluten was maximum here which might led to the retention of more CO<sub>2</sub> gas resulting in higher loaf height.

The results revealed that the increased proportion of composite flour generally affected the shape and height of breads resulting in more flat products. This is in accordance with the findings of Malomo et al. (2012) who had described similar trend on incorporation of breadfruit and breadnut during the

preparation of composite flour bread. The Pearson's correlation study also indicated a positive association of loaf height with swelling index and foaming capacity. Hence it can be stated that the decrease in swelling index and foaming capacity in experimental composite flour variations has caused the decrease in loaf height in composite flour bread variants.

### Loaf volume

Loaf volume was decreased significantly ( $p < 0.01$ ) in composite flour breads as compared to the standard bread having loaf volume of 1,244.66 cm<sup>3</sup> ( $\pm 2.51$ ). The loaf volume of V-I bread was 3.8 % higher than V-II, and 16 % higher than V-III respectively. Thus, it was observed that higher level of composite flour substitution had a negative effect on the volume of bread. This finding is in agreement with that reported by Aluko and Olugbemi (1990), who found lower volumes associated with composite flour in baked products as opposed to pure wheat flour products. This was in accordance with the report of Akobundu et al. (1988) that said the reduction in the wheat structure forming proteins and a lower ability of the dough to enclose air during proofing might have a volume depressing effect on bread.

### Specific volume

The specific volume, which is the ratio of the two properties, namely, loaf volume to loaf weight, has been generally adopted in the literature as a more reliable measure of loaf size (Shittu et al. 2007). The specific volume of the standard bread was 4.3 ml/g ( $\pm 0.6$ ) and the same for the experimental variation V-I was 2.37 ml/g ( $\pm 0.4$ ), V-II was 2.0 ml/g ( $\pm 0.4$ ), and V-III was 1.0 ml/g ( $\pm 0.4$ ). Since loaf volume and weight both got decreased in the present study, thus their ratio, i.e., the specific volume also decreased significantly ( $p < 0.01$ ) in composite flour breads when compared to the standard bread.

Pearson's correlation study also reported significant ( $p < 0.01$ ) positive association between specific volume and swelling index/foaming capacity. Thus the reduction in specific volume in the experimental composite flour breads could probably be attributed to the reduction in swelling index and/or foaming capacity. Abdel-Aal et al. (1993) also studied that loaf volume and specific volume of pan breads prepared from composite flours (fababean, cottonseed and sesame flour) were 25–60 % less than the standard bread.

### Moisture content

The moisture content of composite flour breads was significantly higher ( $p < 0.01$ ) when compared to the standard refined

wheat flour bread (Table 4). The moisture content of the standard bread was lowest 29.24 % ( $\pm 0.3$ ) amongst all variations and was highest for V-III bread, 39.39 % ( $\pm 0.36$ ). Thus it can be stated that the moisture content increased significantly ( $p < 0.01$ ) in experimental breads with increased proportion of legume and fruit-seed flour.

### Baking loss

The baking loss percentage decreased significantly ( $p < 0.01$ ) in composite flour breads as compared to the standard bread as observed from (Table 4). The baking loss of the standard bread was 31.81 % which was found to decrease significantly ( $p < 0.01$ ) in the composite bread variations.

Thus, it was observed that loss of moisture content on baking, which is called baking loss decreased with increased proportion of composite flour. This could be due to the compactness of crumb and increased starch content of the composite flour breads which led to greater water holding capacity. Berton et al. (2002) reported that flour hydration depended on starch damage during milling. The increased amount of damaged starch could be have resulted in a higher water holding capacity of composite flour samples compared to that of the standard (Lee et al. 2001).

### Proximate composition of composite flour breads

#### Protein content

The protein content of the standard bread was reported as 11.23 % (Table 5) which was observed to increase significantly ( $p < 0.01$ ) in composite flour breads (13.95–18.58 %). This increase in protein content in composite flour breads could be attributed to significantly higher protein content of individual flour components namely soya (Basman et al. 2003) and sprouted mung (Mubarak 2005) that were incorporated in composite flour formulation.

The difference in functional properties of composite flour blends when compared to the refined wheat flour could also be associated with this higher protein content of composite flour blends. The increase in non-wheat proteins in flour composites due to the presence of above mentioned ingredients could probably affect the gluten network and thereby the loaf volume, loaf height and the texture of the bread which could also be deduced from the negative correlation between loaf volume and/or loaf height with protein content. Thus, the increase in non-wheat protein in the present study could cause subsequent change in the bread textural characteristics. The utilization of soybeans flour (Gahlawat and Sehgal 1998), legume flour (Sadowska et al. 1996) as functional ingredients in breads, biscuits, *chapatis*, snacks and textured products has been successfully demonstrated to give extra protein and changes in texture of the product.

#### Fat content

The fat content of standard bread was 1.84 % and that of experimental composite flour breads V-I, V-II and V-III were 3.37, 4.75 and 5.64 % respectively (Table 5). The difference in numerical values of fat content of experimental composite bread variations were statistically significant ( $p < 0.01$ ) when compared to the standard bread.

It was observed from the results that the increase in fat content for the composite flour bread variations was directly correlated with the percentage incorporation of high fat mango kernel flour and soy flour. Thus, it could probably be stated that the increase in fat content for composite flour breads occurred due to the presence of mango kernel flour and full fat soy flour. Mango kernel flour had already been identified as a high fat source with crude fat content ranging from 8 to 16 % (Legesse and Emire 2012). The high fat nature of the composite flour formulations would explain the ability to prepare bread from V-III composite blend without the addition of any shortening. This feature also highlights the possibility

**Table 4** Physico-chemical properties of standard and experimental breads

Variations	Loaf weight (g)	Loaf height (cm)*	Loaf volume (cm <sup>3</sup> )*	Specific volume (ml/g)*	Moisture content (%)	Baking loss (%)
Standard	390 $\pm$ 5 <sup>a</sup>	7.16 $\pm$ 0.15 <sup>d</sup>	1,244.66 $\pm$ 2.51 <sup>d</sup>	4.3 $\pm$ 0.6 <sup>c</sup>	29.24 $\pm$ 0.3 <sup>a</sup>	31.81 $\pm$ 0.1 <sup>d</sup>
V-I	392 $\pm$ 5 <sup>a</sup>	6.1 $\pm$ 0.1 <sup>c</sup>	930.33 $\pm$ 3.21 <sup>c</sup>	2.4 $\pm$ 0.4 <sup>b</sup>	31.36 $\pm$ 0.08 <sup>b</sup>	28.42 $\pm$ 0.06 <sup>c</sup>
V-II	395 $\pm$ 5 <sup>a</sup>	5.5 $\pm$ 0.2 <sup>b</sup>	895 $\pm$ 2 <sup>b</sup>	2 $\pm$ 0.4 <sup>b</sup>	34.92 $\pm$ 0.07 <sup>c</sup>	24.32 $\pm$ 0.06 <sup>b</sup>
V-III	400 $\pm$ 5 <sup>a</sup>	4.5 $\pm$ 0.25 <sup>a</sup>	780 $\pm$ 3 <sup>a</sup>	1 $\pm$ 0.4 <sup>a</sup>	39.39 $\pm$ 0.36 <sup>d</sup>	20.58 $\pm$ 0.1 <sup>a</sup>

V-I (WF: SF: MF: MKF=85:5:5:5), V-II (WF: SF: MF: MKF=70:10:10:10), V-III (WF: SF: MF: MKF=60:14:13:13, where, WF = (Refined) Wheat Flour, SF = Soy Flour, MF = Mung Flour (Sprouted), MKF = Mango Kernel Flour

\*Mean values bearing the same superscript do not differ significantly ( $p < 0.01$ )

**Table 5** Proximate composition of standard and experimental breads

Variations	Protein content (%)	Fat content (%)	Crude fibre (%)	Total phenolic content (mg GAE/g)
Standard	11.23±0.11 <sup>a</sup>	1.84±0.04 <sup>a</sup>	1.9±0.5 <sup>a</sup>	–
V-I	13.95±0.05 <sup>b</sup>	3.37±0.05 <sup>b</sup>	2.1±0.9 <sup>a</sup>	3.83±0.09 <sup>b</sup>
V-II	16.66±0.06 <sup>c</sup>	4.75±0.05 <sup>c</sup>	2.3±0.08 <sup>a</sup>	6.9±0.094 <sup>c</sup>
V-III	18.54±0.04 <sup>d</sup>	5.64±0.04 <sup>d</sup>	2.4±0.04 <sup>a</sup>	10.20±0.085 <sup>d</sup>

V-I (WF: SF: MF: MKF=85:5:5:5), V-II (WF: SF: MF: MKF=70:10:10:10), V-III (WF: SF: MF: MKF=60:14:13:13, where, WF = (Refined) Wheat Flour, SF = Soy Flour, MF = Mung Flour (Sprouted), MKF = Mango Kernel Flour

\*Mean values bearing the same superscript do not differ significantly ( $p < 0.01$ )

of using high fat seed flours like mango kernels as sources of natural fat replacers.

**Crude fibre content**

The crude fibre content of the standard bread was 1.9 % and the same for the three experimental bread variations (V-I, V-II and V-III) was reported to be 2.1, 2.3 and 2.4 % respectively (Table 5). Though the increase in crude fibre content was not statistically significant ( $p < 0.01$ ), it might have caused due to the incorporation of high fibre mango kernel flour. The Pearson’s correlation analysis showed a negative correlation of fibre content with loaf volume, loaf height and specific volume. Thus, it can probably be stated that this increase in fibre content also caused the decrease in loaf volume, specific volume and loaf height.

**Total phenolic content**

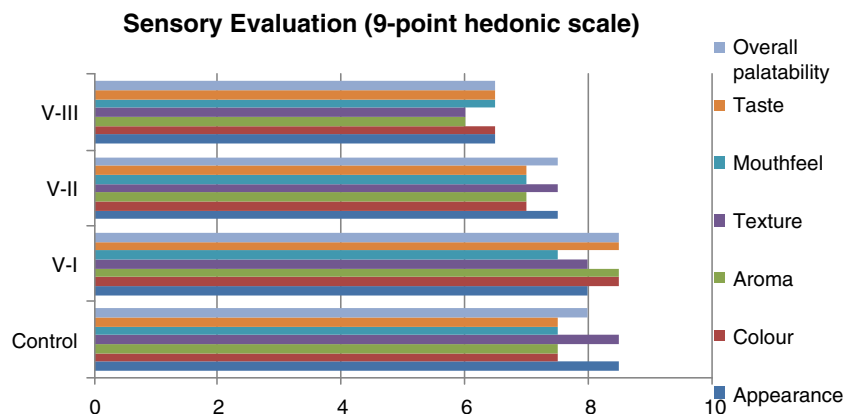
The total phenolic content was found to increase significantly ( $p < 0.01$ ) in composite flour bread variations. The total phenolic content of the standard bread was nil and that of the experimental breads V-I, V-II and V-III with 15, 30 and 40 % composite blend respectively were found

to be 3.83, 6.9 and 10.21 mg GAE/g respectively. Thus it can probably be stated that the total phenolic content was significantly higher ( $p < 0.01$ ) in composite flours due to the presence of mango kernel flour, since mango kernel had proved to be a good source of phenolics (Ashoush and Gadallah 2011). It was also been reported that sprouted mung can cause an increase in the total phenolic content as described by McCue and Shetty (2002). This increase in phenolic compounds could be associated with the flavor changes in composite bread variations as observed from organoleptic evaluation of this study.

**Organoleptic properties of standard and experimental breads**

The organoleptic properties as well as the sensory evaluation scores of the standard and experimental breads are presented in Fig. 2. The Sensory evaluation of the standard and experimental breads was conducted by a panel comprising ten semi-trained members. The evaluation was done on a nine-point hedonic scale. Sensory evaluation scores revealed that the composite flour breads obtained lower scores compared to the standard bread in terms of appearance, texture and mouth-feel. There were significant difference ( $p < 0.01$ ) in the values of standard and the three composite flour bread variants in terms of appearance, colour, aroma, texture, taste and overall

**Fig. 2** Sensory scores for standard and composite flour breads





acceptability. But there were no significant difference ( $p < 0.01$ ) observed in the values of mouth-feel amongst all the bread variations.

## Conclusion

The study made an attempt to identify bread formulations using cereal-pulse-fruit seed composite flours. Physical analysis of breads from composite flour variations prepared using *Totapuri* mango seed kernel flour and protein rich sources such as soya and sprouted mung bean have been found to be comparable with the standard. Functional properties of composite flour bread identified through the study clearly reveal the feasibility of using cereal-pulse-fruit seed composite flours in bread formulations. Organoleptic evaluation of the experimental and control formulations clearly show that the experimental variations with higher fruit seed flour had lower descriptive colour and taste scores. However the experimental bread formulations reveal higher protein content and also highlight the possibility of using high fat seed flours like mango kernel as sources of natural fat replacers.

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