

## Mango (*Mangifera indica* L.) kernel flour as a potential ingredient in the development of composite flour bread

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Fruit residues and seed flours have been used to supplement food and feed because of their nutrient dense composition. The present study was undertaken to identify the feasibility of utilizing cereal-legume-seed kernel composite flour in preparation of bread. A composite flour was prepared using refined wheat flour (WF), soy flour (SF), sprouted mung bean flour (MF) and mango kernel flour (MKF). Three variations of composite flour were used for preparation of experimental breads, 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). Refined wheat flour bread served as control for the study. Pertinent physico-chemical, functional and organoleptic attributes were studied in composite flour variations and their bread preparations. Baking losses were estimated in experimental breads. Physical characteristics of the bread variations revealed a percentage decrease in loaf height (14%), weight (1.25%) and volume (25%) with a subsequent increase in mango kernel flour incorporation. Experimental variations maintained an average score of  $7.23 \pm 0.86$  in comparison with the control ( $7.5 \pm 0.5$ ) on a 9 point hedonic rating scale. V-I scored 5% higher than the control. The present study highlighted the significant utilization of mango seed kernel ('Alphonso' variety) in formulation and nutrient enrichment of bread.

**Keywords:** Composite flour, Legume, Mango kernel, Baking loss, Bread.

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### Introduction

Large quantities of wastes are produced by the agro-fruit processing industries which utilize only 2.2 % of the total fruit production<sup>1</sup>. It has been reported that 45 % of wastes are from mangoes, 50 % from citrus fruits and 10 % from apples<sup>2</sup>. The nature of these wastes is generally as peels, stones and seeds. Substantial emphasis has been laid on the need to recover, recycle and upgrade agro- fruit wastes<sup>3</sup>. Fruits residues form a large component of solid waste residue from agro-fruit processing industries. Botanically fruit peels and seeds are the most enriched part of fruits as they act as storage sites for nutrients required by the young plant. They have also been suggested to have antioxidant properties. Fibre-rich by-products may be incorporated into food products as inexpensive, non-caloric bulking agents for partial replacement of flour, fat or sugar, as enhancers of water and oil retention and to improve emulsion or oxidative stabilities<sup>4</sup>.

Mango kernel is a fruit seed kernel that has been pre-established as a non-conventional oilseed owing to its superior fatty acid composition comparable with cocoa butter. The concepts of utilising mango kernel flour in binary and tertiary preparations have been identified but research is still in the nascent stage<sup>5</sup>. This non-conventional source of food has drawn attention due to its suitability to combat nutritional needs of human beings at a lower cost particularly in developing countries<sup>6,7</sup>.

One widely used method of incorporation has been its use in composite flour preparations. 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<sup>8</sup>. 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 to play a considerable role in contributing

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towards the nutritional or functional attribute of the product developed.

In the present study, composite flour bread was prepared using refined wheat flour, sprouted mung bean flour, soya flour and mango kernel flour with an aim to formulate unique protein enriched flour which can also act as a partial fat replacer. Sprouted mung and soya flour have been used as they are well documented sources of protein and lysine, thus aiming to increase the protein content and essential amino acid balance of the resultant bread in an economical way. An attempt has also been made to observe the physical baking losses observed while baking conventional wheat flour and composite flour breads.

## Materials and Methods

### Materials

Refined wheat (*Triticum aestivum* L.) flour, soya (*Glycine max* Merrill) flour and fresh mung bean [*Vigna radiata* (L.) Wilczek] were sourced from a local market. Mango (*Mangifera indica* L.) seeds of *Alphonso* variety were obtained from a mango juice processing industry located in Chennai.

### Preparation of sprouted mung flour

A standard method was followed for preparation of sprouted mung bean flour<sup>10</sup>. 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 were pulverized and passed through 30 mesh standard sieve. Flour was stored in air-tight plastic bags until further use.

### Preparation of mango kernel flour

The mango seeds were collected and rinsed immediately. The kernels were manually removed from seeds and washed to 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 flour and passed through 30 mesh standard sieve<sup>11</sup>. The flour was stored in airtight containers until further use.

### Preparation of composite flour and bread variations

The experimental variations of composite flour were formulated using refined wheat flour (WF), sprouted mung flour (MF), soya flour (SF) and mango kernel flour (MKF) for preparation of bread. The proportions of composite flour in the three experimental variations were: 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). The variations were selected based on a pilot sensory study conducted to identify three most acceptable breads. Bread prepared from refined wheat flour served as a control for the study. The composition of the experimental and control breads has been mentioned in Table 1. The control and experimental breads were prepared by the straight dough method as given by Akubundu<sup>12</sup>.

### Preparation of sample extract for Total Phenolic Content

The extracts of mango kernel flour (MKF) and composite flour samples were obtained as described in Bloor<sup>13</sup>. Pre-weighted quantity (0.5g) of MKF and V-I, V-II and V-III composite flour 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.

### Functional properties of composite flour blends

All composite flour blends and refined wheat flour were tested for functional properties such as bulk density, water holding capacity, water absorption capacity, oil absorption capacity, bulk density and swelling index, foam capacity and foam stability.

#### Bulk density

Bulk density of samples was determined by a method of Okaka and Potter<sup>14</sup>. 10 g of flour was put into a 100 mL measuring cylinder and tapped to a constant volume. The bulk density ( $\text{gcm}^{-3}$ ) calculated using the formula: Bulk density = weight of flour (g) / flour volume ( $\text{cm}^3$ ).

#### Water holding capacity

Water holding capacity was determined by a modified method of Gould *et al*<sup>15</sup>. One gram of the flour sample (pre-dried) was weighed into a centrifuge tube, 10 mL distilled water was added and vortexed for 30 sec. The sample was allowed to hydrate for 1h at room temperature. The samples were then centrifuged for 30 min at 300 rpm using a bench top centrifuge. The supernatant was discarded and the hydrated sample was weighed.

Table 1 – Ingredient composition of control 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		12.5	25	35
Mango kernel powder		12.5	25	32.5
Soya flour		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

**Water absorption capacity**

The water absorbing capacity of flours was evaluated by a method of Khetarpaul, Grewal and Sood<sup>16</sup>. A pre-weighed quantity of flour was placed in a china dish. Distilled water was gradually added to the sample from a burette. The flour and water were mixed with a glass rod till soft dough was obtained. The kneaded dough was neither stiff nor sticky. The volume of water used was measured. The water absorption power was calculated by: volume of water (mL)/ weight of flour sample (g) X 100.

**Oil absorption capacity**

Sample (1 g) was mixed with 10 mL of vegetable oil in pre-weighed centrifuge tubes. The tubes were stirred for 1 min for complete dispersion of sample in the oil. After 30 min of holding time at room temperature, the sample was centrifuged at 3000 rpm for 25 min. The separated oil was then removed using a pipette and tubes were inverted on oil absorbent paper for 25 min to drain the oil prior to reweighing. The oil absorption capacity was expressed as grams of oil absorbed per gram of the sample<sup>17</sup>.

**Swelling index**

The swelling index of the samples was determined using a modified method of Lin *et al.*<sup>18</sup>. One gram of the flour sample was dispersed in 10 mL of cold distilled water in a graduated centrifuge tube. After a holding time of 5 min at room temperature, the mixture was centrifuged at 2000 rpm for 30 min and volume of sediment recorded as initial volume.

In a pre-weighed centrifuge tube, 1 g of the flour samples was dispersed in 10 mL of distilled water and the suspension was heated in a boiling water bath for 30 min. The suspension was cooled to room temperature under running tap water and then stirred at 2000 rpm for 30 min using a magnetic stirrer. The volume of the heated sediment was recorded as final

volume. Thus the swelling index was calculated as the ratio of final volume to initial volume.

**Foam capacity and stability**

Foaming capacity was determined as described by Narayana and Narasinga Rao<sup>19</sup> with slight modifications. Sample (1 g) was added to 50 mL distilled water at 30±2°C 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.

For foam stability, the flour sample (0.5 g) was blended for 30 min in distilled water (40 mL) at top speed in a blender. The whipped mixture was transferred into 100 mL graduated cylinder. The blender was rinsed with 10 mL distilled water and then gently added to the graduated cylinder. Foam volume in the cylinder was recorded per sample after 30 min standing which was noted as foam stability.

**Proximate compositional analysis of composite flour blends**

The crude protein, fat, crude fibre and total ash content were determined by AOAC (2000)<sup>20</sup>.

**Determination of total phenolic content**

Total phenolic content of the extracts was determined colorimetrically, using Folin-Ciocalteu method, as described by Singleton *et al.*<sup>21</sup>. Aliquots of 0.5 mL of the extract were added to 0.5 mL of Folin-Ciocalteu reagent, followed by addition of 0.5 mL of an aqueous 7.5% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a model UV/VIS spectrophotometer. A blank sample consisting of water and reagents was used as a reference.

The results were expressed as milligrams of gallic acid equivalents per gram powder (mg GAE/g

powder) by reference to the gallic acid calibration curve using the following equation:

$$Y = 0.0158 + 0.0917 X \quad r^2 = 0.99$$

#### Physical analysis of control and experimental breads

Loaf height (in cm) & loaf weight (in g) were evaluated by a method of See *et al*<sup>22</sup>. A graduated scale and a calibrated weighing scale were used to determine loaf height and weight, respectively. Loaf volume of the formulated breads was determined by seed displacement method<sup>20</sup>. The specific volume of bread was calculated by dividing volume of loaf (cc) by weight of loaf (g) as stated in the standard AACC method<sup>23</sup>.

#### Physical baking losses

Physical baking losses were analyzed in terms of moisture loss<sup>24</sup>. Loss was also calculated by the baking yield. This was determined by comparing dough weight before placing in the oven with the final bread weight. Bread yield losses reported in this study include the entire baking process from the weight of the dough at mixing to final bread weight. The loaves were weighed after 1 h of completion of the baking process. This baking loss was a measure of loss of moisture of the bread during baking and expressed in terms of percentage (%).

#### Organoleptic evaluation

The sensorial acceptance of the breads and their specific organoleptic properties were estimated by a semi trained sensory panel. The panellists were chosen from members of post graduate food technology course at M.O.P Vaishnav College for Women, Chennai. A 9- point hedonic scale was used to mark the sensory scores for the products<sup>22</sup>.

#### Statistical analysis

Triplicate determinations were made for each of the product attributes. Data obtained was analysed for

statistical significance using the Student's t test. Statistical analysis was performed using MINITAB® Release 14.12.0.

## Results and Discussion

#### Functional properties of composite flour blends

Functional properties are the intrinsic physicochemical characteristics which may affect the behavior of food systems during processing and storage. Adequate knowledge of these properties indicates the usefulness and acceptability of a product. Functional properties of composite flour blends used to prepare the bread were analyzed to understand their role in developed product.

Bulk density was least in case of standard flour variant and increased gradually in composite flour variants (V-I, V-II and V-III), respectively (Table 2). 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*<sup>25</sup>. Bulk density generally varies with respect to variation in particle size. The individual flour components used in composite flour blends have a higher bulk density than refined wheat flour, thus causing slight increase in overall bulk density. According to Chowdhury *et al*<sup>26</sup>, bulk density of flour blends increases with increase in blend percentage as compared to control.

The water holding capacity was comparatively higher in composite flour blends (1.2 – 1.4 g/g) when compared to control (Table 2). Research has revealed that higher starch and fibre content of the composite flours blends can cause a subsequent increase in water holding capacity and moisture retention. The ability of flour to bind and hold more water was reported to have a significant correlation with its starch content<sup>27</sup>. A similar trend was observed in water absorption capacity of experimental flour blends (Table 2). V- III

Table 2 – Estimation of functional and proximate properties of standard and composite flour variants

Parameters	Standard flour	V-I*comp flour	V-II*comp flour	V-III* comp flour
Bulk Density (g/mL)	0.9259±0.0004	0.9361±0.0006	0.9468±0.0003	0.9558±0.0005
Water Holding Capacity (g H <sub>2</sub> O/g)	1.02±0.0200	1.2±0.0251	1.3±0.0251	1.42±0.0200
Water Absorption Capacity (%)	62.71±0.03	63.84±0.05	66.91±0.03	70.48±0.04
Oil Holding Capacity (g oil/g)	2.5±0.036	1.6±0.0152	1.5±0.0321	1.3±0.0264
Swelling Index	4±0.05	3.86±0.05	3.75±0.05	3.64±0.05
Protein %	11.23±0.1	13.95±0.05	16.67±0.06	18.54±0.04
Fat %	1.84±0.04	3.37±0.05	4.75±0.05	5.64±0.04
Crude fibre %	2.4±0.04	2.3±0.08	2.1±0.09	1.9±0.05

\*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)

showed the highest water absorption capacity around 12.4 % higher than that of refined wheat flour. The absorption of more water during mixing is a typical characteristic of composite flour starches<sup>28</sup>. It has been reported that the dough made from composite flour absorbed more water than dough made from wheat flour<sup>29, 30</sup>.

Oil absorption capacity was higher for standard refined wheat flour which decreased gradually from composite flour V-I to composite flour V-III (Table 2). The lower oil absorption of composite flour variants might be due to the presence of high protein constituents such as legume flours. A large proportion of hydrophilic groups and polar amino acids on the surface of the protein molecules have been observed to cause an increase in oil absorption capacities of flours<sup>31</sup>. Variation in water and oil absorption capacity of composite flours may be due to difference in concentration of protein, their degree of interaction with water and oil and possibly their conformational characteristics.

Swelling index (Table 2) was highest for refined wheat flour ( $4 \pm 0.05$ ). Swelling index of composite flour blends showed 3.6-9.9 % reduction with V I at 3.86, V II – at 3.75 and V III at 3.64. 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<sup>32</sup>.

Foam capacity was highest for refined wheat flour (8 %) and almost negligible foam capacity observed for sprouted mung flour and mango kernel flour. Foam stability was estimated and found to be absent in the flour blends.

#### **Proximate compositional analysis of composite flour blends**

Proximate composition is important in determining quality of raw material. It is often used as a basis for establishing the nutritional value and overall acceptance of developed food products.

The crude protein content of composite flour blends (13.95-18.58 g %) was significantly higher than refined wheat flour (Table 2). This could be attributed to significantly higher protein content of individual flour components namely soya<sup>33</sup> and sprouted mung<sup>34</sup> that were incorporated in composite flour formulation. This increase in protein content of the composite flour breads was in accordance with

Olaoye *et al.*<sup>35</sup>. Difference in the functional properties of flour blends when compared with refined wheat flour could also be associated with higher protein content of composite flour blends.

The crude fat content of refined wheat flour was 1.85 % and that of experimental composite flour blends: V-I, V-II & V-III were 3.31 %, 4.77 % and 5.64 %, respectively. The crude fibre content decreased by 4.1 % in V-I, 12.5 % in V-II and 20.83 % in V-III as compared to the standard refined wheat flour. The crude fat % was significantly higher in composite flour primarily because of higher fat content of mango kernel flour. Mango kernel flour has been identified as a high fat source with crude fat content ranging from 8-16 % (Ref. 36). The high fat nature of the composite flour formulations would explain the ability to prepare bread from V-III without the addition of any shortening. This feature also highlights the possibility of using high fat seed flours like mango kernels as sources of natural fat replacers.

The total phenolic content increased gradually from V-I to V-III composite flour. The total phenolic content of V-I, V-II and V-III were 3.83, 6.9 and 10.21 mg GAE/g of samples. The total phenolic content was significantly higher in composite flours due to the presence of mango kernel flour. Similar research findings have been reported by Ashoush and Gadallah<sup>11</sup>. It has also been reported that sprouted mung can cause an increase in the total phenolic content as described by McCue & Shetty<sup>37</sup>.

#### **Physical analysis of experimental and control breads**

The loaf weight, loaf height, loaf volume and specific volume decreased gradually with increased proportion of composite flours (Table 3). 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 reduction in loaf weight. This finding is in agreement with that reported by Aluko and Olugbemis<sup>38</sup>, who found lower volumes associated with composite flour in baked products as opposed to pure wheat flour products. The finding can also be attributed to lower levels of gluten network in the composite flour dough and consequently decreased ability for the dough to rise.

The moisture content of control bread was minimum (29.2 %) and increased gradually in V-I, II, & III of composite flour breads (Table 3). The loss of moisture content on baking decreased with increased proportion

of composite flour, thus baking loss (Table 3) also decreased in composite flour breads. This could be due to the compactness of crumb of the composite flour breads which led to greater water holding capacity. It was also observed in the study that the composite flour variations showed an improved potential of water holding capacity, owing to a difference in the level of water holding capacity of starches present in them. Berton *et al*<sup>39</sup> reported that flour hydration depended on starch damage during milling. The increased amount of damaged starch could have resulted in a higher water holding capacity of composite flour samples compared to that of the control<sup>40</sup>.

#### Organoleptic evaluation

The color, aroma, taste and overall palatability of V-I composite flour bread was rated higher than control bread. The taste and flavour of V-I and V-II composite flour bread were improved with incorporation of mango kernel flour (MKF). However, at levels 30 % of MKF, the breads had a slight bitter taste (Fig. 1). It has been reported that mango kernel flour lends a slightly bitter taste due to its high polyphenol and tannin content. Presence of tannin in MKF could also be a reason for enhanced colouration of the final baked product. This feature explains the relatively lower colour score for V-II and V-III composite flour breads with increased

Table 3 – Physical attributes and baking losses of control and experimental breads

Parameters	Standard flour	V-I*	V-II*	V-III*
Loaf Weight (g)	400±5	395±5	392±5	390±5
Loaf Height (cm)	7.16±0.15	6.1±0.1	5.5±0.2	4.5±0.25
Loaf Volume (mL)	1245±2.51	930±3	895±2	780±3
Specific Volume (mL/g)	4.3±0.6	2.4±0.4	2±0.4	1±0.4
Moisture %	29.26±0.3	31.36±0.08	34.92±0.07	39.39±0.36
Baking loss %	31.81±0.1	28.42±0.06	24.32±0.06	20.58±0.1

\*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)

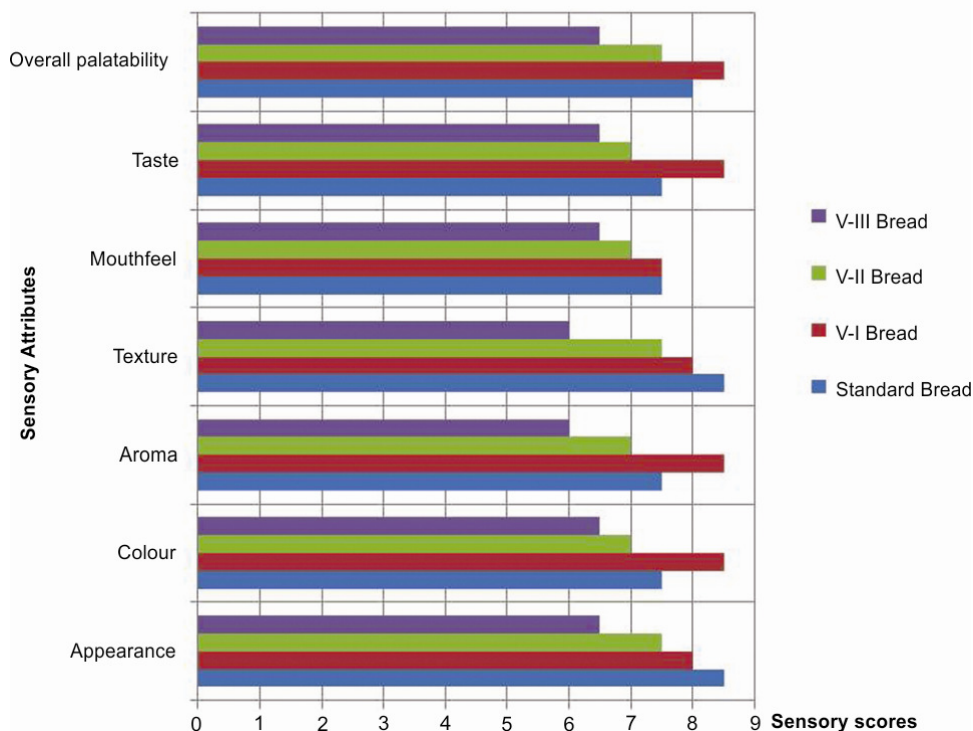


Fig. 1 – Sensory scores for control and experimental breads on a nine point hedonic scale.

proportion of mango kernel flour. These data were in accordance with Arogba<sup>41</sup> and Ajila *et al.*<sup>42</sup>.

## Conclusion

The present study observed the possibility of formulating breads using composite flours. Composite flour variations prepared using mango seed kernel and protein rich sources such as soya and sprouted mung bean have been found to be comparable with wheat flour on several physico-chemical aspects. Bread preparations (V – I) made from the composite flour variations revealed that the presence of kernel powder and legume seed powders in lower proportions yielded breads with similar organoleptic and physical properties as refined wheat flour breads. The study identified the viability of using agricultural by products such as mango seed kernel in the development and enrichment of leavened bread.

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