Development, Physical and Sensory Evaluation of Chapathi (Indian Flatbread) Produced by Utilizing Legumes, Nutri-Cereals and Wheat Flour

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Authors’ contributions

This work was carried out in collaboration with all authors. Author MM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KA and MS managed the analyses of the study. All authors read and approved the final manuscript.

ABSTRACT

In this study, the development and physicochemical of MMFM (minor millet flour mix) and sensory qualities of MMFM chapathis (unleavened Indian flatbread) were evaluated at different proportions. Flour mixes were developed blending of minor millet flour and Nutri-cereals flours with wheat flour in different rations V1(75:25:0) (Millets: Other grains: Wheat flour), V2(60:25:15), V3(50:25:25), V4(45:25:30), V5(30:25:45), V6(0: 75: 25), V7(100), and V8 (100 without gums) respectively and 100% wheat flour used as control. The functional properties of flours mixes were tested and results revealed that swelling capacity, water absorption capacity, oil absorption capacity, gelatinization...
temperature, water retention capacity and bulk density were increased with an increase in the incorporation of other flours with wheat flour. Further, the color values of millet-based chapathis showed significant changes when the level of millet flour substitution was increased. The L* and b* values decreased while a* value increased. Regarding sensory properties, control wheat chapathis had better acceptability than the composite chapathis. Sensory evaluation revealed that overall acceptability for millet and nutricereals flour-based chapathis was awarded the highest score for V6 followed by V5, V4, and V3 as compared to control Chapathi. All chapathis were coinciding the range of ‘like moderately’ to ‘like very much’ for control chapathis while ‘like slightly’ to like moderately’ for experimental chapathis. Based on the generated results, novel chapathis could be formulated by substituting wheat with more than 50% flour.

**Keywords:** Minor millets; composite flour; bulk density; oil absorption; gelatinization temperature chapathi and sensorial attributes.

1. INTRODUCTION

Dietary patterns of people significantly shift from coarse grains to refined foods like refined wheat flour (maida), while rice consumption due to lifestyle changes, urbanization, and occupation patterns. These changes could result in a significant decrease in the overall fiber content of the diet, and associated with rising affluence induced by developmental transition contributed to an increasing prevalence of overweight/obesity [1]. One viable strategy for improving public health is an appropriate modification of the food supply to give products that deliver substantiated health benefits while retaining consumer appeal. Cereals are prime targets in this regard. As dietary staples, relatively small improvements in grain composition (especially in starch and fiber) have the potential to translate into significant health gains at the population level when they are incorporated into food [2]. Although minor millets are nutritionally superior to cereals, yet their utilization in the country is not widespread. They are mostly used in the preparation of traditional dishes. One possible way of extending their utilization could be by blending them with wheat flour after suitable processing. Due to the addition of millet flour to wheat flour or other flours, there would be changes in physicochemical, nutritional and functional characteristics of the millet. Unleavened flat breads-(Indian flatbread) chapathi consume as a staple diet in India, Pakistan, and parts of the Middle East [3]. Chapathis are consumed fresh in households where it may represent 90% of the dietary energy intake [4]. Almost 90% of the wheat produced in India is consumed in the form of chapatti. Only 10% of the wheat produced in India is consumed in making bread/biscuits/cake and such other products. Wheat is a good source of calorie, minerals, vitamins, and phytochemicals like phenols, fair source of protein, amino acids, and dietary fiber [5]. However it is a high Glycaemic index compared to millets, and millets have a low glycemic index, due to this millet called diabetes-friendly grains and could for this reason millet and pulses combination is the could be the best choice for diabetics.

Recent studies indicated that minor millets such as foxtail, little and barnyard are nutritionally superior to conventional food grains and exhibit hypoglycemic effect due to the presence of a higher proportion of complex carbohydrate, resistant starch, and slow rising sugars [6]. Besides, millets contain water-soluble gum β-glucans which improve glucose metabolism. Therefore, the millets are suitable in a diabetic diet to improve metabolic control of glucose. Hence the present study was conducted to develop minor millet-based flour mixes and developed the chapathis using flour mixes, and test the sensorial quality of chapathis.

2. MATERIALS AND METHODS

2.1 Raw Materials

The experiments were conducted in the Food Lab and Food Analysis Laboratory in the Department of Foods and Nutrition, Post Graduate Research Centre, Professor Jayashankar Telangana State Agricultural University, Hyderabad. Raw materials viz., millets, wheat flour, green gram, barley, soya flour and fenugreek, and guar gum were procured from the local market, all the chemicals used in this study are of the analytical grade for the present study. The initial moisture content of flours and chapatis were determined by hot air
oven drying method as recommended by AOAC [7].

2.2 Preparation of Minor Millet Flour Mix

Initially, selected millets, green gram, oats, fenugreek seeds, wheat flour, and defatted soya flour was purchased and removed foreign materials manually. All selected ingredients dried 3-4 hour in try drier at low temperature (45°C). Followed by this, the dried grains were ground into flour by a commercial kitchen blender (MX-898M, Panasonic, Malaysia). Finally, ground flours were screened through a mesh sieve of 40 µm (Retsch Test Sieve, Germany) and the flour obtained was kept in polyethylene bag sealed and stored at 30°C until further analysis.

2.2.1 Preparation of chapathis

Chapathis were prepared by following the method as reported by previous researchers [8,9] with slight modifications. The chapathi dough was prepared by mixing composite flour with the pre-determined optimum amount of water and salt (1.5%). The dough was covered with a wet cloth and was set aside to rest for 30 minutes at room temperature (25± 1°C). The dough was divided into equal portions and rolled into a round sheet (18 cm in diameter and about 2 mm in thickness). The chapathis were baked on a pan on each side. After baking, chapathis were cooled at room temperature before packing in sealed pouches.

2.2.2 Sensory evaluation

The sensory assessments were conducted in a purpose-built, six-booth sensory evaluation laboratory. A panel of 20 members consisted of staff and post-graduate students of the Department of Foods and Nutrition, Post Graduate and Research Centre, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad. The panelists did not know the project objectives. Chapathi samples were coded using random three-digit numbers and served with the order of presentation counter-balanced. The panelists were provided with a glass of water and instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for acceptability based on its colour, texture, taste, flavour and overall acceptability using nine-point hedonic scale (0 = Dislike extremely to 9 = Like extremely).

2.3 Evaluation of Functional Properties of Flours

The functional properties of flours were analyzed i.e. water absorption capacity (WAC, %), oil absorption capacity (OAC, %), Foaming capacity (FC, %), Swelling capacity (%), Water retention capacity (g/g), Tap density, Gelatinization temperature (GT, °C), and Bulk density (g/cc).

2.3.1 Swelling capacity

Swelling capacity was determined by the method described by [10]. The 100 mL graduated cylinder was filled with the sample to 10 mL mark. The distilled water was added to give a total volume of 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 left to stand for a further 8 min. The volume occupied by the sample was taken after the 8th min.

2.3.2 Water absorption capacity and oil absorption capacity

One gram of sample mixed with 10 mL distilled water and allow to stand at ambient temperature (30±2°C) for 30 min, then centrifuged for 30 min at 3,000 rpm or 2000 x g. Water absorption was examined as percent water-bound per gram flour. The oil absorption capacity was also determined by the method of [11] One gram of sample mixed with 10 mL soybean oil (Sp. Gravity: 0.9092) and allow to stand at ambient temperature (30±2°C) for 30 min, then centrifuged for 30 min at 300 rpm or 2000 x g. Water absorption was examined as percent water-bound per gram flour. 9908178376.

2.3.3 Gelatinization temperature

Gelatinization temperature was determined using standard procedure [12]. One gram flour sample was weighed accurately in triplicate and transferred to 20 mL screw-capped tubes. Ten mL of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. At complete gel formation, the respective temperature was measured and taken as gelatinization temperature.

2.3.4 Water retention capacity

The water retention capacity was determined as the standard procedure [13]. The 1.0 gram of the
sample (P0) was suspended in 10 ml of distilled water with constant stirring for 30 minutes and centrifuged at 3000 rpm for 20 minutes, the supernatant was removed, the wet residue was recorded and weighed (P2). The sample was dried at 105°C to constant weight (P1). The WRC was calculated as the ratio of the water retained to the initial dry weight of the sample as given below:

\[ \text{WRC (g water/g dry sample)} = \frac{P2 - P1}{P0} \]

Where,

P2 - the weight of the wet sample
P1 - the weight of dried sample
P0 - weight of the initial weight (dry) sample

### 2.3.5 Colour

The color of the samples measured using a Hunter Lab Colorimeter (Colour Quest XE Hunter lab, USA) was employed to measure the color of the flour samples. A white and black standard tile was used for calibration. The color values were expressed as L* (whiteness/darkness), a* (redness/greenness), and b* (yellowness/blueness).

### 2.4 Statistical Analysis

The data obtained from the various experiments were recorded during the study and were subjected to statistical analysis as per the method of “Analysis of Variance” by Factorial Randomized Block Design (factorial R.B.D.). The significant difference between the means was tested against the critical difference at 5% level of significance [14], using WINDO STAT software.

### 3. RESULTS AND DISCUSSION

#### 3.1 Physical Characteristics of Chapathis

The physical characteristics of minor millet-based chapathis were presented in Table 1. Based on the results, it was noticed that the water absorption of millet-based composite flours had increased significantly (P<0.05) level. The moisture content of millet based flour mixes ranged between 8.06 to 11.48 g, and the control had 8.6 g it was higher than V1, V3, V and V8 and V2 and V7 have high moisture content. The moisture content of composite flours decreased with an increase in proportions of millet flours. These results are agreement with [15], the highest moisture content was observed for the blends of taro, rice and pigeon pea flour which resulted in a reduction of moisture content of composite flours decreased with the decrease in proportions of wheat flour from 100% to 30%.

Functional properties are the intrinsic physicochemical properties that reflect the complex interaction between the composition, structure, confirmation and physicochemical properties of protein and other food components and the nature of the environment in which these are associated and measured [16].

#### 3.2 Water Absorption Capacity (WAC)

Water absorption capacity (WAC) of flour has an important role in the food product preparation process, as it influences other functional and sensory properties. The water absorption capacity of flour mixes ranges from 208 to 137.7 g/100 g and control had the lowest water absorption capacity (135.8) compared to millet flour mixes. An increase in the WAC of millet flour mixes could be attributed to comparatively higher complex carbohydrate content in millet and other used flours than the wheat flour. The result suggests that the addition of millets, green gram, and barley flour to wheat flour affected the amount of water absorption. This could be due to the molecular structure of the millets, green gram, and barley starch which inhibited water absorption, as could be seen from the lower values of WAC, with an increase in proportions of other flours to wheat flours. A similar observation was reported by [15].

#### 3.3 Oil Absorption Capacity

Oil absorption capacity was high in control (100% wheat flour) with 207 g/100 g and increasing order observed with the increase of wheat flour ration incorporation. The V7 and V8 flour mixes showed higher oil absorption capacity but lower than control and not significant from control. Results revealed that the combination of pulse, coarse cereals and oats decreased the oil absorption capacity compared to the wheat flour.

#### 3.4 Bulk Density

Bulk density of millet flour mixes ranged between 0.272 to 0.280 g/cm³ whereas in the case of wheat flour 0.2736 g/cm³. The higher bulk density of millet flour mixes may be due to the presence of more crude fiber in composite flour is similar to the observation made by Singh et al.
higher water absorption of WP composite flours it was not applicable to combined flours. The trend was in with incorporation of millet flour but 85 for millet based chapathis making of control wheat flour 68.0 presented in Table 1. Water absorption for dough control wheat flour and millet flour mix is Water uptake capacity for dough making of other variations of flour mixes. V5 of flour mixes had lower WA compared to variations (p<0.05) at 5% level. The control and V4 and V6 were significantly different from other variation of flour mixes and control, V1, V2, other variation of flour mixes and control, V1, V2, V7, and V7 are significantly different from other variation of flour mixes and control, V1, V2, V4 and V6 were significantly different from other variations (p<0.05) at 5% level. The control and V5 of flour mixes had lower WA compared to other variations of flour mixes.

3.5 Gelatinization Temperature (GT, °C)

The temperature at which gelatinization of starch takes place is known as the gelatinization temperature [19]. GT of flours ranged from 62°C to 68°C. The highest GT was found for V7 (100% millet) flours (68.0°C) and lowest for V1 (without wheat flour millets and other grains) (62.2°C). GT was increased with an increase in the incorporation of millets, green gram dhal, soya and barley flour with wheat flour. The study revealed that the flour which was higher in starch content took the lowest temperature for gelatinization.

3.6 Water Retention Capacity

The highest WRC ranged between 1.0 g to 2.17 g and control low (1.3 g/g) capacity compared to developed flour mix except V7 variation with (1.0 g). This is could be the addition of the gum. The increasing trend showed in the millet-based flour mix.

3.7 Water Activity

The water activity of chapathis ranged between 0.328 to 0.381 and the lowest as shown in the V5 and the highest was found in the V8. The WA of V3, V7, and V7 are significantly different from other variation of flour mixes and control, V1, V2, V4 and V6 were significantly different from other variations (p<0.05) at 5% level. The control and V5 of flour mixes had lower WA compared to other variations of flour mixes.

3.8 Physical Parameters of Developed Millet-based Chapathis

Water uptake capacity for dough making of control wheat flour and millet flour mix is presented in Table 1. Water absorption for dough making of control wheat flour 68.0 ml and 65 to 85 for millet based chapathis the increasing trend was in with incorporation of millet flour but it was not applicable to combined flours. The higher water absorption of WP composite flours might be due to more water absorption of pulses due to its higher protein content. Present results are in agreement with the previously reported values [20]. The baking time of chapathis was ranged between 2.02 to 3.2 minutes and control had 2.38 minutes. The baking time of chapathis was significantly increased with millet flour incorporation at (p<0.05) level as presented in Table 2. This may be attributed to increased levels of polysaccharide in the composite flour due to the incorporation of millet and other nutrient grains. It has been postulated that these polysaccharides resemble pectic substance and result in increased water absorption capacity and viscosity [21], consequently showing an increase in baking time.

The colour measurements of the composite chapatis substituted with different levels of millet flour are depicted in Table 4. From the results, it was noticed that the lightness (L*) of the composite chapathis displayed a decreasing trend along with decreasing the millet flour but it did not apply to the V3 of chapathi. The reducing values of L* indicates that the composite chapathis are darker in colour at higher levels of substitution of millet flour. Similar results was observed by [22]. The composite chapathis substituted with different levels of jering seed flour is showed that the lightness (L*) of the composite chapathis displayed a decreasing trend along with the increasing substitution level of jering flour. It decreased from 74.07 (control) to 41.29 (100% substitution level).

3.9 Sensory Evaluation

From the results, it was found that all the sensory parameters of chapathis of millet-based variations (except for the appearance, colour and flavour), were significantly affected as compared to the control wheat chapattis. The sensory scores of all the parameters decreased correspondingly to the millet flour substitution levels. However, the scores about the colour decreased from 7.9 (wheat chapatis) to 7.8 (chapathis substituted with 30% millet flour). Millet flour-based chapathis were not significant from control in the colour. Generally the panelists prefer chapathis with a slightly darker colour than the control wheat chapathis. This result is comparable to the results reported by another study [23] wherein the incorporation of more than 10% of cowpea flour and 25% of potato flour in the composite chapathis resulted in a decrease of sensory scores for colour. In terms of flavor, a significant decrease in mean scores was noted.
Table 1: Mean scores of physical parameters of minor flour min

<table>
<thead>
<tr>
<th>Sample code</th>
<th>WAC (g/100 g)</th>
<th>OA (g/100 g)</th>
<th>BD (g/g)</th>
<th>GT</th>
<th>WRC (g/g)</th>
<th>WA(%)</th>
<th>Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>208.0±3.05(^a)</td>
<td>207±1.8(^a)</td>
<td>0.292±0.011547(^a)</td>
<td>64.0±0.23 (^bcd)</td>
<td>1.33±0.01(^d)</td>
<td>0.354±0.02(^c)</td>
<td>8.6±0.01(^c)</td>
</tr>
<tr>
<td>V1</td>
<td>206.6±3.5(^a)</td>
<td>172.2±1.973153(^c)</td>
<td>0.278±0.006(^b)</td>
<td>62.6±0.288(^d)</td>
<td>1.38±0.01(^d)</td>
<td>0.366±0.02(^b)</td>
<td>8.48±0.02(^d)</td>
</tr>
<tr>
<td>V2</td>
<td>206.0±3.51(^a)</td>
<td>190.2±3.82(^b)</td>
<td>0.280±0.01(^b)</td>
<td>63.0±0.34641(^d)</td>
<td>1.52±0.02(^c)</td>
<td>0.362±0.007(^b)</td>
<td>11.48±0.08(^b)</td>
</tr>
<tr>
<td>V3</td>
<td>180.4±2.645751(^c)</td>
<td>191.1±6.080296(^b)</td>
<td>0.280±0.017321(^b)</td>
<td>64.0±0.57735(^bcd)</td>
<td>1.59±0.01(^b)</td>
<td>0.371±0.002(^a)</td>
<td>8.5±0.02(^d)</td>
</tr>
<tr>
<td>V4</td>
<td>137.7±6.735726(^c)</td>
<td>194.7±3.511885(^b)</td>
<td>0.280±0.011547(^b)</td>
<td>64.1±2.253886(^bc)</td>
<td>1.39±0.02(^c)</td>
<td>0.361±0.01(^b)</td>
<td>8.7±0.01(^c)</td>
</tr>
<tr>
<td>V5</td>
<td>172.3±6.155(^c)</td>
<td>196.2±2.52(^b)</td>
<td>0.281±0.023094(^b)</td>
<td>65.0±0.11547(^b)</td>
<td>1.35±0.03(^c)</td>
<td>0.328±0.01(^c)</td>
<td>14.32±0.01(^a)</td>
</tr>
<tr>
<td>V6</td>
<td>190.6±5.09(^b)</td>
<td>196.7±5.131(^b)</td>
<td>0.283±0.005774(^b)</td>
<td>67.9±0.866025(^a)</td>
<td>2.17±0.30(^a)</td>
<td>0.354±0.01(^b)</td>
<td>8.5±0.07(^c)</td>
</tr>
<tr>
<td>V7</td>
<td>177.8±2.688(^c)</td>
<td>204.6±3.95(^a)</td>
<td>0.293±0.005774(^a)</td>
<td>68.5±1.154(^a)</td>
<td>1.0±0.01(^e)</td>
<td>0.373±0.02(^a)</td>
<td>11.2±0.02(^b)</td>
</tr>
<tr>
<td>V8</td>
<td>205.3±2.968(^a)</td>
<td>206.6±2.749(^a)</td>
<td>0.297±0.002(^a)</td>
<td>68.8±0.288(^a)</td>
<td>1.7±0.2(^b)</td>
<td>0.381±0.02(^a)</td>
<td>8.06±0.01(^d)</td>
</tr>
</tbody>
</table>

Note: Means ± S.D.
Values with different superscript letters in a column are significantly different at (p<0.05) level. V= Variations, V1(75:25:0) (millet+ nutricereals wheat flour), V2(60:25:15) V3 (50:25:25) V4( 45:25:30), V5(30:25:45) V6(0: 75: 25) V7( 100) and V8(100 without gums). WAC=Water absorption capacity, OAC=Oil absorption capacity, GT=Gelatinization temperature BD=Bulk density, WRC=Water retention capacity, WA=Water activity.
Table 2. Physical parameters mean scores of minor flour mixes

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Water uptake (ml)</th>
<th>Baking time (minutes)</th>
<th>Colour Δ L</th>
<th>A</th>
<th>B</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>68.0±0.88e</td>
<td>2.38±0.031e</td>
<td>36.45±0.12e</td>
<td>6.31±0.49bc</td>
<td>23.12±0.31a</td>
<td>43.78±0.12d</td>
</tr>
<tr>
<td>V1</td>
<td>65±0.17e</td>
<td>3.28±0.031a</td>
<td>49.31±0.08ab</td>
<td>6.83±0.088bc</td>
<td>24.45±0.44a</td>
<td>55.46±0.21a</td>
</tr>
<tr>
<td>V2</td>
<td>72±0.17d</td>
<td>2.95±0.02b</td>
<td>43.62±0.07d</td>
<td>5.29±0.022d</td>
<td>21.15±0.03bc</td>
<td>48.76±0.23c</td>
</tr>
<tr>
<td>V3</td>
<td>75±1.65d</td>
<td>2.81±0.07b</td>
<td>51.4±0.13a</td>
<td>6.53±0.103bc</td>
<td>19.18±0.04bcd</td>
<td>55.25±0.14a</td>
</tr>
<tr>
<td>V4</td>
<td>75±0.32c</td>
<td>2.00±0.015d</td>
<td>44.1±0.15d</td>
<td>9.93±0.506a</td>
<td>22.04±2.60d</td>
<td>47.3±0.69c</td>
</tr>
<tr>
<td>V5</td>
<td>80±0.29b</td>
<td>2.02±0.012de</td>
<td>46.87±0.07bc</td>
<td>7.3±0.119b</td>
<td>23.85±0.18a</td>
<td>53.1±0.12b</td>
</tr>
<tr>
<td>V6</td>
<td>65±0.09d</td>
<td>2.02±0.015de</td>
<td>35.76±0.03e</td>
<td>6.21±0.126c</td>
<td>24.2±0.05a</td>
<td>43.63±0.04d</td>
</tr>
<tr>
<td>V7</td>
<td>85±0.18a</td>
<td>2.9±0.028b</td>
<td>42.83±2.38cd</td>
<td>7.42±0.358b</td>
<td>17.98±2.21b</td>
<td>43.43±0.23d</td>
</tr>
<tr>
<td>V8</td>
<td>85±0.21a</td>
<td>2.37±0.067c</td>
<td>50.95±0.12a</td>
<td>4.74±0.178d</td>
<td>17.34±0.20cd</td>
<td>54.03±0.94b</td>
</tr>
</tbody>
</table>

Note: Data presented in Mean ± Std.Error, V= Variation

Table 3. Sensorial quality of minor millet-based chopathis

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Appearance</th>
<th>Colour</th>
<th>Texture</th>
<th>Taste</th>
<th>Flavour</th>
<th>Over all acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>8.100±0.191a</td>
<td>7.900±0.216a</td>
<td>8.250±0.160a</td>
<td>8.100±0.161a</td>
<td>7.950±0.185a</td>
<td>8.100±0.161a</td>
</tr>
<tr>
<td>V1</td>
<td>6.800±0.345c</td>
<td>6.800±0.233b</td>
<td>6.100±0.376c</td>
<td>6.800±0.304b</td>
<td>6.700±0.325a</td>
<td>6.600±0.328b</td>
</tr>
<tr>
<td>V2</td>
<td>6.750±0.307c</td>
<td>6.850±0.284a</td>
<td>6.300±0.333b</td>
<td>6.850±0.254b</td>
<td>6.550±0.303a</td>
<td>6.500±0.286b</td>
</tr>
<tr>
<td>V3</td>
<td>7.700±0.193b</td>
<td>7.650±0.287a</td>
<td>7.000±0.271a</td>
<td>7.150±0.335b</td>
<td>7.400±0.255a</td>
<td>7.400±0.197a</td>
</tr>
<tr>
<td>V4</td>
<td>7.450±0.266b</td>
<td>7.350±0.274a</td>
<td>7.000±0.271a</td>
<td>7.200±0.277b</td>
<td>7.200±0.236a</td>
<td>7.350±0.233a</td>
</tr>
<tr>
<td>V5</td>
<td>8.00±0.166a</td>
<td>7.850±0.244a</td>
<td>8.150±0.185a</td>
<td>8.000±0.162a</td>
<td>7.950±0.170a</td>
<td>7.950±0.170a</td>
</tr>
<tr>
<td>V6</td>
<td>8.100±0.176a</td>
<td>7.950±0.185a</td>
<td>8.000±0.185a</td>
<td>8.000±0.152a</td>
<td>7.9±0.170a</td>
<td>8.00±0.168a</td>
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<tr>
<td>V7</td>
<td>5.500±0.359</td>
<td>5.400±0.400c</td>
<td>5.300±0.448c</td>
<td>5.650±0.418c</td>
<td>5.550±0.462c</td>
<td>5.150±0.449c</td>
</tr>
<tr>
<td>V8</td>
<td>6.100±0.324c</td>
<td>5.950±0.294c</td>
<td>5.600±0.351c</td>
<td>5.500±0.344c</td>
<td>6.100±0.298b</td>
<td>5.550±0.285c</td>
</tr>
</tbody>
</table>

Note: V= Variation, Data presented in Mean ± S.E
when more than 30% of millet flour was incorporated into the composite chapathis. As for the taste, aftertaste (a taste that persists in the mouth after consuming something) and texture, the mean scores were adversely affected by increasing levels of millet flour in the chapattis. The control wheat chapathi (100% wheat flour) were rated the highest with 8.10 and 100% Millet rated lowest with 5.5. The decrease in the mean scores can be attributed to the intense characteristic taste of millet flour. Hence, the taste of millet-based chapathi affected more than 50% millet incorporation due to millets have more antinutritional and antioxidants could be the one reason for taste.

However, the application of household thermal treatments such as steaming on legumes to improve the overall aroma and taste of seed meals [24]. On the other hand, a decrease in mean scores for texture can be attributed to the fact that the composite chapathis become harder when more millet flour is incorporated into the formulations. Overall, control wheat chapathis were more acceptable by the sensory panelists followed by millet-based chapathis with 30, 45, and 50% millet flour. It was noticed that the chapathis prepared from 100% of millet flour were rated the lowest for all sensory attributes evaluated. This could be the fact that the chapathis were darker, harder and exhibiting the characteristic flavour of millet which were found to be unfavorable. These results were in agreement with those reported [25] in which the overall acceptance of wheat-rice bran composite breads decreased as more rice bran was incorporated into the bread. The supplementation of soy flour in wheat flour at the level of 5% to 20% for chapattis preparation revealed that the scores of various sensory attributes ranged between 6.0 to 8.6. The values were highest is T7 and T8 ranged between 8.3 to 8.6 [9].

4. CONCLUSION

In this study, for the first time we attempted to develop novel chapathis by substituting wheat with more fifty percent minor millet flour along with nutricereals incorporation. Although 100% of wheat chapathi was organoleptically more acceptable than the millet-based chapathis, the sensory quality of millet flour-based chapathis was not significantly (P<0.05) formed control chapathi in the aroma and appearance and taste. This indicates that millet flour possesses a higher potential to act as an alternative functional ingredient in wheat products. The reported work is expected to encourage the utilization of composite flour by blending local underutilized millets into wheat products people who suffer from celiac disease cannot consume wheat at all. This will eventually benefit consumers as well as able to extend the commercial opportunity for this product.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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