Evaluation of Functional, Proximate, Microbial and Sensory Properties of Pearl Millet-Bambara Ground Nut Yarsala (A Traditional Deep-fried Fermented Puff)

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ABSTRACT – Pearl millet flour were partially substituted with bambara nut(30-50%) to form blends which were used to prepare yarsala; the functional and the microbial status of the blends as well as the proximate and sensory properties of the yarsala were analysed. Supplementation increased the water absorption capacities(1.61-1.69ml/g) and decreased swelling capacities(28.21%-37.68%), the oil absorption capacities(0.91-0.99ml/g) and the wettabilities(10.40-11.57secs) which decreased progressively with increased bambara nut flour addition; the emulsion capacities(37.33-44.22%) and stabilities(29.68-52.33%), foam capacities(30.00-38.74%) and stabilities(5.35-8.61%) were also highest in 30% supplementation thereafter dropped progressively. The moisture, ash, fat, protein, fibre and carbohydrate contents of yarsala were 7.50-8.59%, 1.40-1.62%, 18.05-20.36%, 8.82-15.46%, 1.50-2.20% and 55.41-59.33% respectively; the food energy(444.81-455.84 kcal) were highest in the control. Bacterial, mould-yeast, S.aureus, E. coli, and Coliform counts were 1.07x10^4 - 1.45x10^4, 1.96x10^4 - 2.33x10^4,1.03x10^4 - 2.70x10^4, 1.02x10^4-2.30x10^4 and1.64x10^4-4.25x10^4, Salmonella spp were not detected. There were no significance difference in the appearance and aroma of yarsala however the control had better taste, texture and greater acceptability. Functional properties of the blends as well as the nutrient density of yarsala were enhanced with bambara nut addition; the blends could be utilized for other millet-based food products as well.

Keywords – Millet, Bambara groundnut, Yarsala, Fermentation, Frying

1. INTRODUCTION

Yarsala is a deep-fried puff obtained from yeast fermented batter consisting of cooked grits and uncooked flour. Millets in general are a group of highly variable small seeded grasses widely grown around the world for fodder and human food especially in the semi-arid tropics of Asia (eg India) and Africa (eg Mali, Nigeria and Niger), about 97% of millet production take place in developing countries[3]. In India is a leading producer of millets, and Nigeria a distant second[2]. Pearl millet (Pennisetum glaucum) is thought to be domesticated in Sahel region of West Africa in distant past; where currently it accounts 35%-65% of total cereal consumption per capital[6].According to USDA[3], raw millet contains:11% protein,4.2% fat,72.2% carbohydrate, substantial amounts of dietary fibre, vitamin and minerals especially calcium and iron. Sawaya et al[4] reported the following values for pearl millet flour on dry weight basis:17.4% protein,6.3% fat, 2.8% fibre,2.2% ash; a chemical score of 53, protein invivro-protein digestibility of75.6% and calculated protein efficiency ratio of 1.38, lysine is the most limiting amino acid. Yarsala production and consumption is restricted to northern Nigeria where local women process and distribute the products in makeshift roadside eatries especially during morning hours suggesting that yarsala is a breakfast food. There are dearth of literature on origin of yarsala, its production process and nutritional composition. Although, street foods provide employment along its value chain yet being an unregulated subsector, it is subject to unwholesome practices. Therefore, it could be speculated that increasing eat-always coupled with dependence on a single grain-based traditional diets for calorie and nitrogen may be responsible for endemic malnutrition, especially in a region with low purchasing power [9] and majority cannot afford high quality food. IFC[10] stated that sub-Saharan Africa is home to half of all people in extreme poverty, still exacerbated by continuous cycle of conflict. Muller and Krawinkel[7] reported 35.8% of preschool children in developing countries are underweight, 42% stunted and 9.2% wasted. Grain legumes such as bambara groundnut (Vigna subterranea (L. Verdc.) are natural complement to cereal protein providing an overall essential amino acid balance for lysine deficient cereal-based foods, in addition to much needed macro- and micronutrients[8][9][10]. Bambara nut is a major source of...
cheap dietary phyto protein for both humans and livestock in Sudano-Sahelian parts of tropical Africa and Asia where animal protein is expensive[11] or where religion places restriction on its consumption. Bambara nut is widely grown in Nigeria particularly in the Southern Guinea savanna belt as an intercrop with other crops in marginal soil conditions[12]. Nigeria is the leading producer of this legume in the world[13]. This nut is the third most important grain legume in Nigeria after cowpea and groundnut[14], and is regarded as a complete food. Olaleyel et al.[15] reported that bambara nut contained 2.46-4.36% ash, 2.47-6.99% crude fat, 15.2-22.2% protein, 1.03-2.9% crude fibre, and 51.6-61.9% carbohydrate. Mbiata et al.[16] increased the nutrient density of fermented maize dough by addition of boiled bambara nut; Ijarotimi[17] improved the nutritional composition of cooking banana with fermented bambara nut. Therefore the aim of this study was to evaluate the functional, proximate and sensory properties of yarsala produced from millet-bambara nut blends.

2. MATERIALS AND METHODS

2.1 Raw materials collection

Pearl millet and Bambara groundnut, potash(kanwa), yeast, vegetable oil were purchased at the Maiduguri Monday market and conveyed to the Food Lab, FST University of Maiduguri, Borno State, Nigeria for raw material preparation.

2.2 Raw Material Preparation

Pearl millet seeds were sorted, winnowed, then sprinkled with water to condition the seeds, then taken to the mills for dehulling. The dehulled seeds were washed, sun-dried, then milled in a laboratory hammer mill and sieved (425µm) to obtain the millet meal, it was bagged in high density polyethylene bag and left at room temperature until needed. Bambara nut seeds were sorted, washed, air-dried, roasted, cooled, milled and sieved (250µm). The millet meal would be further fractionated before yarsala preparation with 250µm sieve to obtain fine flour and the remaining would be regarded as grits.

2.3 Formulation of the Blends

The following blends were formulated with millet(M) and Bambara nut(B)(30-50) meals on a replacement basis in the following ratios: MB 70:30, MB 60:40, and MB 50:50, while M100:0 and B100:00 served as the control. Each formulation was mixed thoroughly in Kenwood mixer (OWBL335012) at speed 6 for 5 min and individually package until needed. During the preparation, the meal would be sieved with 250µm mesh to obtain the flour and grits.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>M100:0</th>
<th>MB70:30</th>
<th>MB60:40</th>
<th>MB50:50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet flour (g)</td>
<td>68</td>
<td>48</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>Millet grits (g)</td>
<td>32</td>
<td>22</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Bambara nut flour (g)</td>
<td>-</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Common salt (g)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Dried yeast (g)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Kanwa (potash) (g)</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Water (ml)</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

2.4 Yar’tsala Preparation

The millet grits were cooked to doneness with half the quantity of water needed, cooled and mixed with the millet flour in addition to yeast and other ingredients, including the remaining quantity of water. The batter was allowed to ferment 10-12hrs, after which local potash was added to reduce the sourness and mixed. Portions were scooped onto hot oil to fry until golden brown indicating doneness and were removed onto netted container for adhering oil to drain and the yar’tsala cooled. The whole process is presented in the flow chart (Figure1.)
Bambara nut seeds
Sorting
Washing
Drying
Roasting
Grinding
Sieving
Bambara nut flour

Millet Seeds
Sorting
Winnowing
Conditioning
Dehulling
Washing
Drying
Grinding
Sieving
Flour (2 parts)
Grits (one part)
Mixing
Cooking

Yeast
Fermentation

Potash
Mixing

Salt
Deep frying

Millet-Bambara nut yarasala

Fig.1: Flow chart for the production of yar’sala made from millet – Bambara groundnut flour blend.

3. ANALYSIS

3.1 Functional Properties

Oil / Water Absorption Capacity

The centrifugal method as described by Beuchat 18 was used to determine the oil and water absorption capacities (WAC)/(OAC) of the control and the blends. One gram (1g) of sample was mixed with 10ml of distilled water / oil(soybean oil) and mixed for 30 sec, the mixture was allowed to stand for 30 minutes before it was centrifuged at 5000rpm for 30 minutes and the volume of the supernatant was read in a graduated cylinder and result expressed in ml/g

Wettability was determined according to the procedure described by Onwuka 19 using one gram (1g) of sample and 500ml of distilled water in 600ml beaker and the result expressed in seconds.

Swelling capacity was determined by the method described by Okaka and Potter 20 using 100ml measuring cylinder filled with sample to 10ml mark and distilled water was added to total volume of 50ml. Then mixed vigorously and the suspension left to stand and the volume occupied by the sample was recorded after 30mins and the results expressed in ml/g.

Emulsion activity was determined by the method of Yatsumatsu et al. 21 using 10ml distilled water and 10ml olive oil in a graduated centrifuge tube, then centrifuged at 2000 x g for 5 min. Emulsion activity was calculated as the ratio of the height of emulsion layer to the total height of the mixture expressed in percentage.
Emulsion stability (ES) was obtained by heating the emulsion at 80°C for 30mins, then cooled and centrifuged at 2000 x g for 15mins. ES was regarded as the ratio of the height of emulsified layer to the total height of the mixture expressed in percentage.

Foam capacity and Foam stability were determined by the method of Nayarana and Narasingga[22]. One gram (1g) of flour or blend was placed in 100ml measuring cylinder, the mixture was continuously shaken for 5mins, the foam capacity expressed in percentage was taken as the difference in volume after and before whipping, foam stability was recorded one hour after shaking as percentage of initial foam volume.

Bulk density was determined using the procedure described by Narayana and Narasinga [22] and the results were expressed in g/cc.

3.2 Proximate Composition

The proximate composition of the yar’tsala, raw material (millet and bambara nut flours) were determined using the procedures of AACC[23]. Moisture content was determined by drying the sample at 105 OC for 1.5 hours. Protein contents (% N x 6.25) was determined by the Kjedahl method. Crude fat was determined using Soxhlet extraction with petroleum ether. The ash content was determined by dry ashing in a muffle furnace at 550c for 5h. Dietary fiber was determined using alternate digestion of 1g sample with dilute sulphuric acid (H2SO4)(1.25%) and dilute sodium hydroxide (1.25%)-solutions, washing, drying and finally ashing in muffle furnace at 550c for 3 hours. Carbohydrate content was calculated by ‘difference’. Energy(E) values (Kcal) were obtained by multiplying the values of carbohydrate, protein and fat with Atwater conversion factors, then summing up: E= [4\times(Protein)+4\times(CHO)+ 9\times(Fat)]]

3.3 microbial Analysis

Microbial enumeration was carried out according to the method outlined by Harigan and McCane[24]. Samples(1g each) were aseptically obtained and homogenized with 0.1% peptone water, serial dilutions were obtained, 0.1ml of 10⁻² and 10⁻³ dilutions were pour plated in triplicate petri dishes on Plate count agar for bacterial count, Sabouroud Dextrose agar(SDA) for mould-yeast count. Selective media were used to isolate some bacteria: Eosin Methylene Blue agar for E.coli, Manitol Salt agar for S. aureus, MacConkey for Coliform, Brilliant Green Bile broth for Salmonella spp. Duplicates plates were incubated for 48h, 37C, except plates for mould-yeast count which were incubated for 3-5 days at room temperature(28±2C). Colonies were enumerated using digital colony counter (Gallen Kamp, UK). Results were expressed in colony forming unit per gram (cfu/g).

3.4 Sensory Evaluation

The sensory evaluation of the yarsala samples were carried out using 10 semi-trained judges comprising randomly selected students and staff of the Department of Food Science and Technology, University of Maiduguri, and the attributes assessed were appearance, taste, fermented aroma, texture, oiliness and overall acceptability, using a nine-point Hedonic scale. (where one and nine represent “extremely dislike” and “extremely like”, respectively. Coded samples were randomly presented to the panelists and water was provided for rinsing month in between tasting.

3.5 Statistical Analysis

Determinations were done in triplicates unless otherwise stated and data obtained were subjected to one-way analysis of variance (ANOVA). Means were separated using Least Significance Difference(LSD), alpha was set at 5% (p< 0.05).The statistical analysis was carried out using SSPS version16.

4. RESULTS AND DISCUSSION

There were significant variation (p<0.05) in functional properties of the flours and the blends (Table 2). The general observation was the decrease in the value of the parameters tested with increased replacement of millet flour with Bambara nut flour. Bulk densities (g/cc) insignificantly (p>0.05) decreased from 0.580g/c for millet flour to 0.500g/c millet-bambara nut blend(MB 50:50). Vijayalkumari and Mohankumari[25] and Kaushal et al[26] reported a similar trend and comparable observations. Bulk density measures the amount of matter (nutrients) in a unit volume, and is influenced by flour particle size and moisture content. End-use requirement of a blend determines the desirability for low or high bulk density, however food formulation for complementary feeding requires blends of lower bulk density to avoid paste thickening[27], also blends with lower bulk densities would possess higher nutrient density apart from ease of storage and transportation. Bambara nut flour had the highest water absorption capacity (WAC) 1.77g/ml significantly different from others and the least value was observed in millet flour(1.28g/ml).WAC of the blends varied significantly from
1.61g/ml (MB50:50) to 1.69ml/g (MB 70:30), equally millet (M100:00) and Bambara nut (B100:00) flours had highest oil absorption capacities (OAC) respectively 1.23ml/g and 0.99ml/g. Addition of Bambara nut to millet flour led to decreased WAC and OAC. Chandra et al. observed a contrary trend for multi grain blend (wheat, rice, green gram and sweet potatoes), the observations of were in tandem with these findings. WAC and OAC values reflect the net balance of hydrophilic and hydrophobic amino acids, in addition to protein size, molecular configuration and interaction with other food components not necessarily the quantity of protein alone.

Millet flour had the highest swelling capacity (70.33%) and Bambara nut flour the least 25.08%, those of the blends peaked at 30% bambara nut addition, thereafter decreased significantly with increased replacement of millet flour with Bambara nut (37.68%, 70:30 MB – 28.21%, 50:50 MB). Swelling capacity measures the strength of attractive forces within starch granules, their ability to imbibe and swell or an indicator of extent of starch damage. Particle size and processing method among others influence swelling capacity. Higher WAC and SC are needed in some food formulations and preparations such as break making. Higher WAC and lower OAC blends are desirable for yarsala preparation, addition bambara nut increased WAC but decreased the OAC which is desirable and decreased SC of the blends which is not desirable.

Wettability measures the ease of hydration or reconstitution with water. Millet flour had the highest ease of reconstitution (8.6 sec), Bambara nut the least (11.50 sec) and for the blends the ease of hydration varied significantly (p<0.05) from 10.40 sec (MB50:50) – 11.57sec (MB 70:30). Adebowale et al. and LeGuerrere et al. similarly observed the same trend. Bigger particle sizes have the greater ability to overcome the surface tension created by water molecules than fine particles indicating that Bambara nut flour had finer particle size, therefore the ease of reconstitution would decrease with addition of Bambara nut.

Emulsion activity (EA) and Stability (ES), foam capacity (FC) and stability (FS) of the blends increased, highest in MB70:30, thereby decreased with increased addition of Bambara nut flour, a similar trend in all. Amphipathic nature of protein, a surface active agent can form and stabilize emulsions or foam formations. Bambara nut flour had the highest EA and ES (48.99% and 39.68%), the highest PC and FS (45.87% and 11.83%), millet flour the least emulsion or foam activities; 31.67% EA and 5.35% FC respectively; MB50:50 had the least EA and FC respectively 37.33% and 30.00% (EA); the ES followed the same trend. Vijayalkumari and Mohankumari observed a similar trend for multi-grain blends, the same workers blamed decrease in functional properties on the coarseness of millet flour due to its molecular configuration and net value of the polar and non-polar amino acids.

WT = Wettability
BD = bulk density; WAC/OAC = water/oil absorption capacity; FC/FS = foam capacity or stability; EA/ES = emulsion activity or stability, Weta = wettability.

Table 2: Functional properties of millet-bambara nut (MB) blends for yarsala preparation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M100:00</th>
<th>B100:00</th>
<th>MB70:30</th>
<th>MB60:40</th>
<th>MB50:50</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD (g/cc)</td>
<td>0.58±0.01</td>
<td>0.53±0.1</td>
<td>0.52±0.1</td>
<td>0.50±0.1</td>
<td>0.50±0.1</td>
</tr>
<tr>
<td>WAC (ml/g)</td>
<td>1.28±0.04</td>
<td>1.77±0.11</td>
<td>1.69±0.1</td>
<td>1.66±0.02</td>
<td>1.61±0.81</td>
</tr>
<tr>
<td>OAC (ml/g)</td>
<td>2.30±0.01</td>
<td>0.99±0.12</td>
<td>0.97±0.21</td>
<td>0.93±0.04</td>
<td>0.91±0.03</td>
</tr>
<tr>
<td>SC (%)</td>
<td>70.33±4.5</td>
<td>25.08±4.00</td>
<td>37.68±2.52</td>
<td>32.19±1.67</td>
<td>28.21±4.05</td>
</tr>
<tr>
<td>Weta (sec)</td>
<td>8.61±3.5</td>
<td>15.46±0.56</td>
<td>11.57±0.40</td>
<td>10.82±0.20</td>
<td>10.40±0.67</td>
</tr>
<tr>
<td>FC (%)</td>
<td>5.35±0.61</td>
<td>45.87±1.3</td>
<td>38.74±0.35</td>
<td>32.73±0.86</td>
<td>30.00±1.81</td>
</tr>
<tr>
<td>FS (%)</td>
<td>2.38±0.17</td>
<td>11.83±0.95</td>
<td>8.63±0.32</td>
<td>5.78±0.13</td>
<td>5.35±0.05</td>
</tr>
<tr>
<td>EC (%)</td>
<td>31.67±2.80</td>
<td>48.99±0.91</td>
<td>44.22±0.70</td>
<td>39.67±1.53</td>
<td>37.33±1.53</td>
</tr>
<tr>
<td>ES (%)</td>
<td>22.00±1.52</td>
<td>39.68±1.52</td>
<td>33.33±1.53</td>
<td>30.10±1.00</td>
<td>29.68±1.00</td>
</tr>
</tbody>
</table>

BD = bulk density; WAC/OAC = water/oil absorption capacity; FC/FS = foam capacity or stability; EA/ES = emulsion activity or stability, Weta = wettability.

Table 3 shows the proximate composition of millet and Bambara nut flour used to formulate millet-bambara nut (MB) blends for yarsala production. The protein, fat, ash and fiber contents of Bambara nut flour were higher than that of millet, but millet contains the highest amount of carbohydrate being a cereal grain. These values were lower than the proximate composition of the whole millet reported by USDA(2015) but were comparable to values reported by Sawaya et al. Olaoye et al. reported ash, protein, fat and carbohydrate of Bambara nut as 2.46-4.36%, 15.2-22.2%, 2.47-6.99% and 51.6-61.9% respectively. Oghbaei and Prakash noted that processing of cereals and legumes increased nutrient availability or digestibility but leads to a reduction in nutrient quality and quantity.
The moisture, ash, fat, protein, fibre and carbohydrate contents of different yarsala as shown in Table 4 were: 7.50 – 8.59%, 1.40 – 1.62%, 18.05 – 20.36%, 8.82 – 15.46%, 1.50 - 2.20% and 55.41 – 59.33% respectively. The result indicates a decrease in moisture, fat and carbohydrate content and an increase in protein, ash and crude fiber content with supplementation of millet with bambara nut flour which is expected. Ayo et al.[36] reported a similar trend in beniseed-millet based masa, similar northern Nigeria food product. Bambara nut flour is reported to contain high level of protein, ash and fiber.[37] Deep-frying, a unit operation in yarsala preparation was responsible for high fat content, however the control (M100:00) had the highest fat content, this was due to the fact that millet flour had the highest oil absorption capacity as shown in Table 1. Higher fat content is not desirable because it will lead to development of rancid flavor and odor that is a reduced storage potential. The energy value varied from 444.81 to 455.85 kcal/100g. The control had the highest energy value which decreased minimally with addition of bambara nut. Yar’tsala made from the control (M100:00) had the highest moisture content of 8.59% decreased in yarsala made from the blends.. The low moisture content (8.59 – 7.50) indicates better storage stability. Ayo et al.[36] similarly reported similar decrease in moisture content with addition of pulse flour.

**Table 3: Proximate composition of main raw materials (millet and Bambara nut flours) for blend formulation**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Millet flour</th>
<th>Bambara nut flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture(%)</td>
<td>10.81±0.01a</td>
<td>11.05±0.06a</td>
</tr>
<tr>
<td>Protein(%)</td>
<td>10.41±0.31b</td>
<td>18.32±0.71a</td>
</tr>
<tr>
<td>Fat(%)</td>
<td>4.06±0.52b</td>
<td>4.43±0.40a</td>
</tr>
<tr>
<td>Ash(%)</td>
<td>2.18±0.02b</td>
<td>3.30±0.01a</td>
</tr>
<tr>
<td>Fiber(%)</td>
<td>2.28±0.62b</td>
<td>2.60±0.61a</td>
</tr>
<tr>
<td>Carbohydrate(%)</td>
<td>70.26±0.50a</td>
<td>60.30±0.51b</td>
</tr>
<tr>
<td>Energy(Kcal/100g)</td>
<td>359.22±1.50a</td>
<td>354.35±2.21b</td>
</tr>
</tbody>
</table>

CHO = carbohydrate, E/kcal = Energy

Microbial profile of the flour/blends (Table 5) used for yar’tsala production indicates significant difference (p<0.05) exists among the mean values recorded. Bacterial contamination (1.07×107 – 1.45×104 cfu/g) were more in the blends than in the millet and Bambara nut flours. Low moisture content or water activity (≥0.87) of the most flours do not support microbial growth therefore not a major safety concern, but microbial spores can remain dormant until appropriate conditions ensure their germination and proliferation. The mold/yeast count (M/YC) varied significantly from 1.96×104 to 2.33×104 cfu/g higher elevated storage temperature from handlers. There is a risk of enterotoxin intoxication when *S.aureus* counts is in excess of 102 cfu/g especially at higher elevated storage temperature.[39] Okoye et al.[41] surveyed microbial quality of cowpea flour sold in markets in Enugu (South East Nigeria) and reported the following values(cfu/g): total viable counts,1.08×103 – 1.99×105, Coliform counts, 4.0×103 – 6.1×104, *E.coli* counts 1.5×104 – 2.3×104, fungal counts, 1.5×104 – 9.8×104. Oluwana et al.[42] reported a total plate and fungal counts of 1.0×105 cfu/g and 1.0×106 cfu/g respectively for wheat-potato composite flour. *Yar’sala* is deep – fried, a step in its preparation which is able to inactivate bacterial vegetative cells and spores.

**Table 4: Proximate Composition of Millet-Bambara nut Yar’tsala and Control**

<table>
<thead>
<tr>
<th>Yarsala</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Protein (%)</th>
<th>Fiber (%)</th>
<th>CHO (%)</th>
<th>E(kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M100:00</td>
<td>8.59a</td>
<td>1.40</td>
<td>20.36a</td>
<td>8.82b</td>
<td>1.50b</td>
<td>59.33a</td>
<td>455.84</td>
</tr>
<tr>
<td>MB70:30</td>
<td>8.30ab</td>
<td>1.50ab</td>
<td>18.81b</td>
<td>13.37c</td>
<td>2.51a</td>
<td>55.51b</td>
<td>444.81</td>
</tr>
<tr>
<td>MB60:40</td>
<td>7.68b</td>
<td>1.54b</td>
<td>18.55ab</td>
<td>14.62b</td>
<td>2.20ab</td>
<td>55.41b</td>
<td>447.07</td>
</tr>
<tr>
<td>MB50:50</td>
<td>7.50b</td>
<td>1.62a</td>
<td>18.05c</td>
<td>15.46</td>
<td>1.74b</td>
<td>55.63b</td>
<td>446.81</td>
</tr>
</tbody>
</table>

CHO = carbohydrate, E/kcal = Energy
Table 5: Microbial quality of flour/blends under 21-day room temperature storage

<table>
<thead>
<tr>
<th>Blend/flour</th>
<th>TVC (×10^5)</th>
<th>M/YC (×10^5)</th>
<th>S. aureus (×10^4)</th>
<th>E. coli (×10^4)</th>
<th>Sal</th>
<th>Coli (×10^5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M100:00</td>
<td>1.07±0.05^a</td>
<td>1.96±0.15^a</td>
<td>2.7±0.07^a</td>
<td>1.03±0.07^a</td>
<td>ND</td>
<td>2.01±0.10^a</td>
</tr>
<tr>
<td>B100:00</td>
<td>1.16±0.07^a</td>
<td>2.04±0.05^b</td>
<td>1.14±0.08^a</td>
<td>1.08±0.03^b</td>
<td>ND</td>
<td>1.64±0.24^c</td>
</tr>
<tr>
<td>MB70:30</td>
<td>1.31±0.10^b</td>
<td>2.15±0.08^b</td>
<td>1.14±0.03^a</td>
<td>1.21±0.06^a</td>
<td>ND</td>
<td>2.01±0.14^b</td>
</tr>
<tr>
<td>MB60:40</td>
<td>1.23±0.06^c</td>
<td>2.33±0.07^a</td>
<td>1.03±0.10^b</td>
<td>2.30±0.07^a</td>
<td>ND</td>
<td>2.07±0.01^b</td>
</tr>
<tr>
<td>MB50:50</td>
<td>1.45±0.08^a</td>
<td>2.28±0.08^a</td>
<td>1.06±0.11^b</td>
<td>1.02±0.09^b</td>
<td>ND</td>
<td>4.25±0.15^a</td>
</tr>
</tbody>
</table>

Total viable count (TVC), Mould Yeast Count (MYC), Salmonella spp (Sal), Coliform (Coli)

There were no significant difference in the appearance and aroma scores of all the various yarsala (Table 6), however yarsala made from millet flour had better taste and texture perhaps due to higher oil content. It received the highest acceptability score, yet yarsala made from the blends were acceptable as a new or modified old product usually meets initial resistance even though it could be a better alternative.

Table 6 Sensory attributes of the control and millet-bambara nut yarsala

<table>
<thead>
<tr>
<th>Samples</th>
<th>Appearance</th>
<th>Aroma</th>
<th>Oiliness</th>
<th>Taste</th>
<th>Texture</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>M100:00</td>
<td>7.50±0.03^a</td>
<td>7.23±0.25^a</td>
<td>8.02±0.05^a</td>
<td>7.71±0.03^a</td>
<td>7.80±0.05^a</td>
<td>8.00±0.13^a</td>
</tr>
<tr>
<td>MB70:30</td>
<td>7.36±0.20^b</td>
<td>7.21±0.21^c</td>
<td>7.46±0.04^a</td>
<td>6.82±0.04^a</td>
<td>7.02±0.03^b</td>
<td>7.25±0.05^b</td>
</tr>
<tr>
<td>MB60:40</td>
<td>7.05±0.21^a</td>
<td>6.90±0.11^b</td>
<td>7.31±0.07^b</td>
<td>6.31±0.04^bc</td>
<td>6.43±0.04^d</td>
<td>6.80±0.08^e</td>
</tr>
<tr>
<td>MB50:50</td>
<td>7.23±0.25^a</td>
<td>6.51±0.10^a</td>
<td>6.02±0.03^a</td>
<td>6.11±0.02^a</td>
<td>6.69±0.04^c</td>
<td>6.40±0.07^b</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Yarsala is one of various millet-based foods of northern Nigeria, although millet is a rich coarse cereal however its consumption as a single cereal will not supply the needed macro- and micronutrients for nutrition and wellness. Addition of bambara ground nut to millet flour not only reduced oil absorption during frying but also enhanced the nutrient density of yarsala. The blends would store well under dry condition at room temperature for a long period due to higher oil content. There were no significant difference in the appearance and aroma scores of all the various yarsala (Table 6), however yarsala made from millet flour had better taste and texture perhaps due to higher oil content. It received the highest acceptability score, yet yarsala made from the blends were acceptable as a new or modified old product usually meets initial resistance even though it could be a better alternative.

6. REFERENCES

3. USDA (2015). "Raw millet per 100 g, full report" National Nutrient Data Base, Release, 28