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

Gervase Ikechukwu Agbara[1,*], Fatima Ajiya Masaya[2], Mamudu Halidu Badau[1], Odera Amin Igwegbe[1], Alkali Mohammed Yakaka[2]

Department of Food Science and Technology,
University of Maiduguri, P.M.B 1069, Maiduguri, Nigeria

Department of Nutrition and Dietetics,
Ramat Polytechnic Maiduguri, P.M.B, 1070, Maiduguri, Nigeria

[*]*Corresponding author's email: iaikhagbara [AT] yahoo.com*

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 - 2.33x10^4,1.03x10^2 - 2.70x10^2, 1.02x10^2-2.30x10^2 and1.64x10^2-4.25x10^2, 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[1]; India is a leading producer of millets, and Nigeria a distant second[2]. Pearl millet (*Pennisetum glacum*) 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 [2].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 invitro-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 [5] and majority cannot afford high quality food. IFC[6] 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 subterranean* (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. Olaleye 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 1: Recipe for millet-bambara nut *yar'tsala* production

Ingredients	M100:00	MB70:30	MB60:40	MB50:50
Millet flour (g)	68	48	40	34
Millet grits (g)	32	22	20	16
Bambara nut flour (g)	-	30	40	50
Common salt (g)	2	2	2	2
Dried yeast (g)	1	1	1	1
Kanwa (potash) (g)	1.5	1.5	1.5	1.5
Water (ml)	75	75	75	75

2.4 *Yar'tsala* Preparation

The millet grits were cooked to doness 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.)

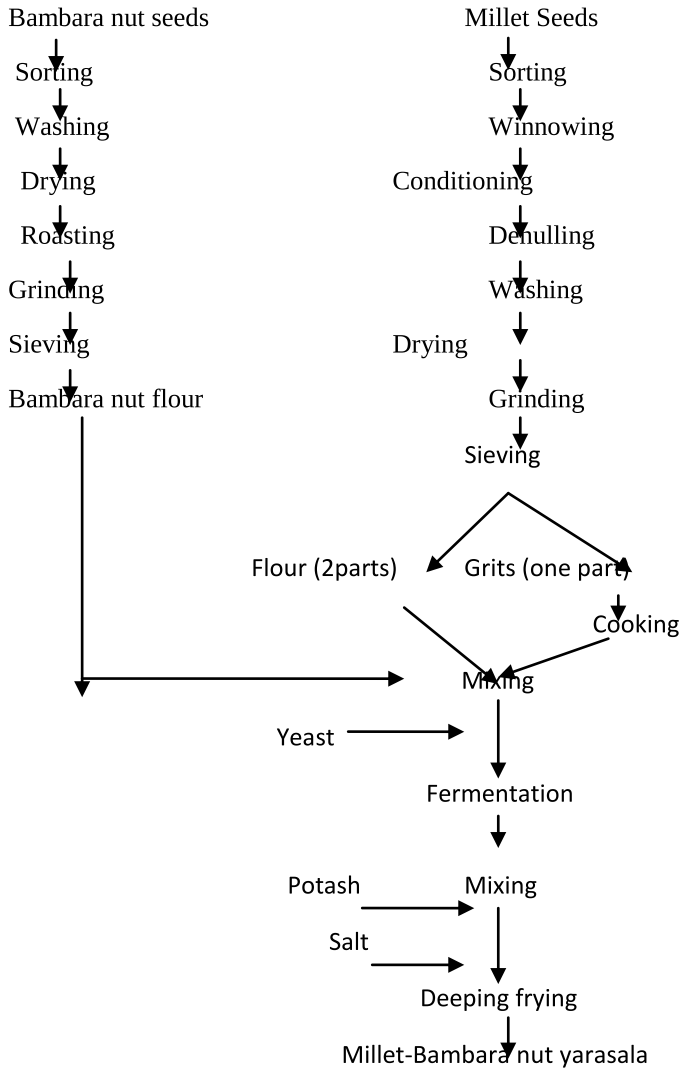

Fig.1: Flow chart for the production of *yar'tsala* made from millet – Bambara groundnut flour blend.

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 80ºC 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 Narasinga[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 0C 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 (H_2SO_4)(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×(Protein)+4×(CHO) + 9×(Fat)]

3.3microbial 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[28]. 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(MB50:00) 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.[29] observed a contrary trend for multi grain blend (wheat, rice, green gram and sweet potatoes), the observations of[25];[26] 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 [30].

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%,70:30MB – 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 [31]. Particle size and processing method among others influence swelling capacity [29]. 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*[31] and LeGuerrere *et al*[32] 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 [21]. Bambara nut flour had the highest EA and ES (48.99% and 39.68%), the highest FC 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 and FS followed the same trend. Vijayalkumari and Mohankumari [25]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 corneous endosperm. Hydration properties in general are influenced by protein quality, its molecular size and configuration, net value of the polar and non polar amino acids [33]; [34], therefore EA and FC might be a good index of protein quality and quantity. Yarsala, a deep fried puff requires higher EA for reduced oiliness, higher FC for sponginess and reduced oil retention.

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

Parameter	M100:00	B100:00	MB70:30	MB60:40	MB50:50
BD(g/cc)	0.580±0.01[a]	0.53±0.01[a]	0.522±0.01[a]	0.503±0.01[a]	0.500±0.43[a]
WAC(ml/g)	1.28±0.04[e]	1.77±0.01[a]	1.69±0.01[b]	1.66±0.02[c]	1.61±0.81[d]
OAC(ml/g)	2.30±0.01[a]	0.99±0.12[b]	0.97±0.21[b]	0.93±0.04[c]	0.91±0.03[c]
SC(%)	70.33±4.51[a]	25.08.±4.00[c]	37.68±02.52[b]	32.19±1.67[b]	28.21±4.05[c]
Weta(sec)	8.61±0.35[e]	15.46±0.56[a]	11.57±0.40[d]	10.82±0.20[c]	10.40±0.67[b]
FC(%)	5.35±0.61[c]	45.87±1.03[a]	38.74±0.35[a]	32.73±0.86[b]	30.00±1.81[b]
FS(%)	2.38±0.17[c]	11.83±0.95[a]	8.63±0.32[a]	5.78±0.13[b]	5.35±0.05[b]
EC(%)	31.67±2.80[c]	48.99±0.91[a]	44.22±0.70[a]	39.67±1.53[a]	37.33±1.53[b]
ES(%)	22.00±1.52[a]	39.68±1.52[a]	33.33±1.53[a]	30.10±1.00[b]	29.68±1.00[b]

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 yar'tsala 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*[4]. Olaoye et al[15] 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[35] noted that processing of cereals and legumes increased nutrient availability or digestibility but leads to a reduction in nutrient quality and quantity.

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

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

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 Table1. 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 455.85kcal/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 4: Proximate Composition of Millet-Bambara nut Yar'tsala and Control

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

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 (1.07×10^4 – 1.45×10^4cfu/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 1.96×10^4 to 2.33×10^4cfu/g higher in the blends, most molds can survive at water activity of 0.85 or less, the presences of toxigenic species and elaboration of mycotoxins is a source of concern since some of these toxins are heat stable. Pinho and Furlong[38] set maximum limit for mold/yeast count for baked goods at 10^3cfu/g, total viable and mold/yeast counts were regarded as satisfactory whenever less than 10^4cfu/g and 10^6cfu/g respectively[39]. Presence of coliforms (1.64×10^2 to 4.25×10^2cfu/g), gram negative non-sporulating bacteriaceae indicates contamination from impure water sources, food contact surfaces or carry over from raw materials. Presence of *E.coli*(1.02×10^2 – 2.30×10^2cfu/g) an enteric pathogen indicates fecal contamination directly or indirectly. Presences of *E.coli* or maximum coliform counts of 100cfu/g is enough for a recall of RTE foods from shelves because bacteriaceae are useful indicators of hygiene, process failure or inadequate heat treatment [39]. No visible growth was recorded for *Salmonella spp* in the flour/blends. Pathogens associated with foodborne disease outbreaks involving flour are *salmonella spp* and *E.coli* (STEC 0121 and 0157H7) [40]. *Staphylococcus aureus* is a normal flora of humans, its presence (1.03×10^3 – 2.70×10^3cfu/g) indicates contamination from handlers. There is a risk of enterotoxin intoxication when *S.aureus* counts is in excess of 10^5cfu/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,1.08×10^5 – 1.99×10^5, Coliform counts, 4.0×10^4 – 6.1×10^4, *E.coli* counts 1.5×10^4 – 2.3×10^4, fungal counts, 1.5×10^4 – 9.8×10^4. Oluwana *et al*[42] reported a total plate and fungal counts of 1.0×10^3cfu/g and 1.0×10^4cfu/g respectively for wheat-potato composite flour. *Yar'tsala* is deep – fried, a step in its preparation which is able to inactivate bacterial vegetative cells and spores.

Table 5: Microbial quality of flour/blends under 21-day room temperature storage

Blend/flour	TVC ($\times10^4$)	M/YC($\times10^4$)	S.aures($\times10^2$)	E.coli($\times10^2$)	Sal	Coli($\times10^2$)
M100:00	1.07 ± 0.05^e	1.96 ± 0.15^b	2.7 ± 0.07^a	1.03 ± 0.07^b	ND	2.01 ± 0.10^b
B100:00	1.16 ± 0.07^d	2.04 ± 0.05^b	1.14 ± 0.08^a	1.08 ± 0.03^b	ND	1.64 ± 0.24^c
MB70:30	1.31 ± 0.10^b	2.15 ± 0.08^b	1.14 ± 0.03^a	1.21 ± 0.06^a	ND	2.01 ± 0.14^b
MB60:40	1.23 ± 0.06^c	2.33 ± 0.07^a	1.03 ± 0.10^b	2.30 ± 0.07^a	ND	2.07 ± 0.01^b
MB50:50	1.45 ± 0.08^a	2.28 ± 0.08^a	1.06 ± 0.11^b	1.02 ± 0.09^b	ND	4.25 ± 0.15^a

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, the score decreased with progressive addition of bambara nut flour. Adapting to 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

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

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 couple of weeks free of microbial contamination and also will find use in the preparation of other traditional millet-based food products apart from yarsala.

6. REFERENCES

1. McDonough, C.M., Rooney, L.W., Serna-Saldivar, S.O.,(2000) The Millets. Food Science and Technology: Handbook of Cereal Science and Technology, CRC Press 2[nd], pp.177-210.
2. FAOstat (2011). "Production,Crops,Millet,2010 Data." Statistic Division, Food and Agriculture Organization of United Nations, Rome, Italy.
3. USDA (2015)."Raw millet per 100 g, full report" National Nutrient Data Base, Release, 28
4. Sawaya, W.N., Khalil, J.K. and W. J. Safi (1984) Nutritional Quality of Pearl Millet and Bread. *Plant Foods Human Nutrition*, 34 (2):117-125.
5. World Bank(2015).Gross National Income Per Capita, Retrieved on 20[th] September,2016 from :http://data.worldbank.org/catalogue-of-data/development indicators.
6. IFC Annual Report (2017).Sub-Saharan Africa: Bringing Progress to Half of the Worlds Poor. Retrieved on Monday 5[th] February, 2018 from:Adwww.ifc.org/annualreport.
7. Muller, O. and Krawinkel, M (2005). Malnutrition and Health in Developing Countries. *CMAJ*, 173:279-286.doi:10.1503/cmaj.0503 42.
8. Tizazu, H and Emire, SA (2010).Chemical Composition, Physicochemical and functional properties of lupin (Lipinusalbis) seeds grown in Ethiopia. *Africa journal of Food Agric*. *Nutrition* and *Development*.10(8):3029-3046p.20-21,National Agricultural Statistics Services, USDA ,Washington DC. http://usda.manlib.conell.edu/usda/current/cropprodsu…
9. Quedrago, M., Quedrago, J.T., Tinere, J.P., Balma, D., Dabire, C.B. and Konate, G.(2008). Characterization and evaluation of accessions of Bambara groundnut(Vigna subterranean L. Verdcourt) from Burkina Faso. *Scientia Naturalis*,5:191-197.
10. Ali, M.A. M; El-Tinay, A.H; Elkhalifa, A.E.O., Mallasy, L.O, Babikeri, E.E(2012). Effect of different supplementation level of soybeans flour on pearl millet functional properties. Food and Nutrition Science 3:1-6
11. Linnemann, A.R. (1974). Thermal Regulation of Phonological Development and Growth of Bambara ground nut. Ph.D Thesis, University of Netherlands.

12. Thotapilla, G and Rossel, H.W. (1997). Identification and Characterization of Various Viruses Infecting Bambara groundnut() in Nigeria. *Int. J. of Pest Management*, 43:177-185
13. FAO (2009). FAOstat. Food and Agriculture of the United Nations, Rome Italy. http://faostat.fao.org/default.aspx.
14. Mkandwire, C.H.(2007).Review of Bambara ground nut Production in Sub-Saharan Africa. *Agricultural Journal*, 2:464-470.
15. Olaleye, A.A., Adeyeye, E.A., Adesina, A.J. (2013). Chemical Composition of Bambara groundnut (Vigna subterranean L. Verdc.). B*angladesh J. Scientific and Industrial Research*, Vol.48, Issue 3.
16. Ijarotimi, O.S.,(2008).Nutritional Composition, Microbial Status, Functional and Sensory Properties of Infant Diets Formulated from Cooking Fruits(Musa spp ABB genome) and Fermented Bambara groundnut(Vigna subterranean. Verdc.) Seeds. *Nutrition and Food Science* 38:325-340.
17. Mbiata, T.I., Ikenebomeh, M.J., and Ezeibo, S. (2009). Evaluation of Content and Functional Properties of Fermented Maize Flour Blended with Bambara Ground nut. *African Journal Food Science*, 3:107-107-112.
18. Beuchat, L.R. (1977).Functional and electrophoretic Characteristics of Succinylated Peanut Flour Protein. *Journal of Agric. Food* Chem25:258-261.
19. Onwuka, G.I. (2005). Food Analysis and Instrumentation, pp.93-140, Naphthali Prints, Lagos Nigeria.
20. Okaka, J.C. and Potter, N. N.(1977). Functional and Storage Properties of Cowpea Powder-Wheat Flour Blends in Bread making, *J. Food Sci*.2 (3):828-833.
21.Yatsumatsu,K.,Sawada,K.,Moritaka,S.,Toda,JandInshii,K (1972) Whipping and emulsifying properties of soybean products.Agric.Biol.Chem.,362:719-727*727.*
22. Narayana, K. and Narasinga, M.S.(1984) Functional Properties of Raw and Heat Processed Winged Bean (Psophocarpus tetranolobus) Flour. J. Food Science,49:944-947.
23. AACC American Association of Cereal Chemist (2000) *"Approved methods of the American Association of Cereal Chemist*" 10th Edition, The Association, ST Paul, Minnesota USA.
24. Harigan, W.E. and McCane, M.C. (1976). Laboratory Methods in Food and Dairy Microbiology, pp 71-78: Academic Press, London
25. Vijayalkumar,P.T. and Mohankumar, J.B. (2009).Formulation and Characterization of Millet Blends Incorporated Composite Flour.*Journal of Agricultural Sciences*, Vol.1, Issue 2.
26. Kaushal, P., Kumari, V., and Sharman, H.K. (2012). Comparative Study of Physicochemical, Functional, Anti-nutritional and Pasting Properties of Taro(Colcasia esclenta) Rice, Pigeon pea Flours and their Blends. *LWT-Food Sci. Technol.*,48:59-68,doi:10.1016/j.int.2012;02.028.
27. Padmashree, .S., Vijayalakshmi, L. and Puttaraj, S.(1987).Effect of Traditional Processing on Functional Properties of Cowpea (Vigna unguiculata) Flour. *J. Food Sci.* and Tech.,24:221-225.
28. Onimawo, J.A., A.H., Momoh, and A., Usman (1998) Proximate Composition and Functional Properties of Bambara ground nut (Voandeiza subterranean).Plant *Foods Human Nutr*.53:155-158.
29. Chandra, S., Singh, S. and Kumari, D (2015).Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuit. *Journal Food Sci., Technology*, 52(6):3681-3688.
30. Sathe, S.K. and Salunkhe, D. K. (1981). Functional properties of the Great Northern Bean (Phaseolus vulgaris. L) Proteins: Emulsion Formation and Gelation Properties. *J. Food Science*, 46:71-81.
31. Adebowale, A.A., M.T., Adegoke, S.A., Sanni, M.O., Adegunwa, and G.O., Fetuga (2012) Functional and Biscuit Making Potential of Sorghum-Wheat Flour Composite (2012) Am. *J Food Technol.7*(6):372-379. Doi:10.3923/ajft.2012.372.379
32. L. Chel-Guerrero, V., Perez-Flores, D., Betancur-Acona and G. Davila-Ortiz (2002). Functional Properties of Flour and Protein Isolates from Phaseolus lunatus and Canavalia ensiformis Seeds. J. Agric.FoodChem.50(3):584-591 Doi:10.1021/jf010778j.
33. McWaters, K.H., and Brantley, B.B., (1982) Characteristics of Akara Prepared from Cowpea Paste and Meal *International Journal of Food Science* 36:66 – 88. .
34. Iwe, M.O., Onyeukwu, U., Agiriga, A.N., (2016). Proximate, Functional and Pasting Properties of FARO 44 ,African Yam Bean and Brown Cowpea. *Cogent Food and Agriculture*,Vol.2, Issue1.
35. Oghbaei, M. and Prakash, J.(2016) Effect of Primary Processing of Cereals and Legumes on its Nutritional Quality: A Comprehensive Review. Cogent Food and Agric.Vo.2, Issue1
36. Ayo, J.A., Ouoha, G., Agu, H., Ayo, V.A., Avu, E.O., Sosanya, M., and Adeosun, F. (2012). Effect of added beniseed paste of millet based masa. *African Journal of Food Science and Technolog*,3(10):236-243.
37. Igbabul, B., Adole, D., Sule, S. (2013). Proximate Composition, Functional and Sensory Properties of Bambara nut (Voandzeia subterranean) Cassava(Manihot esculentus) and Soybean(Glycine max) Flour Blends for Akpeka Production. Curr. Res. Nutr. Food Sci.Vol.1, Issue 2 doi://dx.doi.org/10.12944/CRNFSJ.1.2.06.
38. Pinho, B.H. and Furlong, B.E.(2000).The occurrence of Molds and Yeasts and Mycotoxins in Prcooked Pizza Dough Sold in Southern Rio Grand do Sul. *Braz.J.Microbiol*..31(2): http;//dx.doi.org/10.1590/S1517-8382200000020007
39. EC Regulation (2005). Microbiological criteria for foodstuffs: European Commission Regulation 2073. Retrieved on June 29th, 2017 from, http://www.fsai/upload files/consol-Reg.2073-2005.pdf.

40. Food Source Information (2015) Flour: Colorado Food Safety Center of Excellence. Retrieved on 7th June, 2017 from, http://www.fsi.colostate.edu/flour
41. Okoye, J.J., Ene, G.I., and CC Ojobor (2017) Chemical and microbial of commercial cowpea flours sold in Enugu state, Nigeria, *International Journal of Food Nutrition Science Vol*.6(1) Jan. 2017.
42. Oluwana, I.B., Malomo, S.A., Ogbodogbo, E.O..(2012). Quality Assessment of Flour and Bread from Sweet Potato-Wheat Composite Blends. *Int. Journal of Biol. And Chem. Sciences.*Vol.6, Issue 1.