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Research Article

Influence of *Afzelia africana* ('Akparata') and *Mucuna flagellipes* ('Ukpo') on the Quality of Set Yoghurt

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Abstract

Background and Objective: A non-fat yoghurt must contain not more than 0.5% fat and not less than 8.25% milk solids non-fat. The presence of other bacteria and other micro-organisms could lead to undesirable product with undesirable sensory attributes, low shelf life, syneresis or spontaneous whey separation on the surface of low-fat and no-fat set yoghurt. The study was carried out to evaluate the properties of yoghurt made with local stabilizers-'akparata' (*Afzelia africana*) and 'ukpo' (*Mucuna flagellipes*) flours. The samples were subjected to physicochemical, microbial and sensory analyses were determined. **Methodology:** The seeds of *Afzelia africana* were cleaned, roasted for 20 min, de-hulled, winnowed and milled into flour. The seeds of *Mucuna flagellipes* were cleaned, de-hulled, soaked in water for 24 h, boiled for 60 min, oven dried at 70°C and milled into flour. Plain set yoghurt samples were produced with 'akparata' flour and 'ukpo' flour at increasing concentrations 0.1-0.4%. The yoghurt sample without the stabilizers served as then control. Physicochemical, microbial and sensory analyses were carried out using standard methods. Statistical analyses were done using SPSS. **Results:** The formulated yoghurt stabilized using ukpo and akparata at all concentrations improved the protein and fat when compared to the control. The calcium, phosphorus, vitamin A and C contents increased in the yoghurt and the control. The total titratable acid increased with decrease in pH of samples while viscosity increased with increase in concentrations of the stabilizers. The total viable, mould and lactic acid counts of the samples were within acceptable limits. The yoghurt exhibited appreciable sensory properties. **Conclusion:** Akparata" and "ukpo" improved the fat, protein, carbohydrate content and viscosity of plain set yoghurt.

Key words: *Afzelia africana*, formulated yoghurt, local stabilizers, *Mucuna flagellipes*, plain set yoghurt

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Yoghurt is the coagulated milk product obtained by lactic acid fermentation through the action of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*[1]. Yoghurt as a fermented product, can be affected during its production by two major factors namely: the presence of other bacteria and whey separation. The presence of other bacteria and micro-organisms could lead to undesirable product with undesirable sensory attributes and low shelf life. Kappa-casein and pathogenic microorganism are also destabilized on heating. Proper pasteurization of homogenized milk prior to inoculation with starter culture helps to reduce the microbial load of the milk. The texture of yoghurt is supported by the production of exopolysaccharides (EPS) as viscosifying agent, produced by Lactic Acid Bacteria (LAB). It is also suggested that texture is controlled by coagulation as a result of neutralization of the negative charges on the milk proteins as another effect of acid produced by LAB. The EPS is produced by some LAB, depending on the strain[2]. Exopolysaccharide (EPS) produced by LAB, which are generally recognized as safe are widely used to improve the body and texture of yoghurt[3]. Yoghurt made with EPS producing starter cultures has better water binding capacity, which decreases the products susceptibility to syneresis[4]. However, no simple correlation has been established between viscosity and quantity of EPS[5]. Apart from the EPS produced by LAB, stabilizers are usually added before homogenization of milk to prevent syneresis from occurring during the fermentation process of milk. Syneresis or spontaneous whey separation on the surface of set yoghurt is regarded as a defect[6]. Conditions under which considerable whey separation could occur include high incubation temperature (above 45°C), excessive pre-heat treatment (above 80°C for 30 min) and disturbances while the gel is still weak, low acid production (pH 4.9 instead of 4.6) and low total solids[7]. This problem could be reduced or eliminated by increasing the level of milk solids to approximately[8] 15%. Other alternatives include the use of stabilizers (that is, starch, gelatine and vegetable gum) or exopolysaccharide (EPS) producing starter culture[6]. Polysaccharide derived from *Streptococcus thermophillus* and *Lactobacillus bulgaricus* show large variation in composition, charge, spatial arrangement, rigidity and ability to interact with proteins, no defining correlation between EPS concentration and viscosity has been established in real studies[9]. Presently, most of the stabilizers used in yoghurt manufacture are exotic, carboxy methyl cellulose (CMC) being an example. However, these exotic stabilizers are very costly.

Furthermore, stabilizers are also reported to exhibit many secondary functional properties[10]. The use of stabilizers might help in providing a more uniform consistency and lessen batch to batch variation. Also, there could be textural defects related to use of stabilizers, including over-stabilization and under-stabilization. Over-stabilization results in a 'jello-like' springy body of yoghurt while a weak 'runny' body or whey separation can be produced due to under-stabilization[11]. It is more challenging to control the texture of low-fat and no-fat yoghurts because, the presence of homogenized fat which contributes to the structure of yoghurt is either absent or in very low concentrations in these products[12]. The increased acidity then slows the growth of *Streptococus thermophilus* and promotes *Lactobacillus bulgaricus*, stimulated by formate produced in the initial stage. The *L. bulgaricus* produces most the lactic acid and acetaldehyde which together with diacetyl gives characteristic flavor and aroma in yoghurt[13]. The acidification phenomenon is a biochemical process characterized by its complexity and includes several reactions where the starter culture produces lactic acid and aromatic and volatile compounds which bring the particular yoghurt identity. The acidity and low pH resultant from the lactic acid fermentation also induces significant structural changes that are responsible for the yoghurt texture and its rheological characteristics[14]. To stabilize the texture of the yoghurt, stabilizers are usually added prior to homogenization of ingredients for yoghurt manufacture in order to avoid whey separation and to improve mouthfeel and other organoleptic properties of yoghurt. Presently, commercially available yoghurts are mainly stabilized by exotic stabilizers such as carboxyl methyl cellulose, guar gum, carrageenan gum, gelatin, pectin among others. Addition of local stabilizers at certain concentrations to low and no-fat yoghurt could improve the quality attributes of low-fat and no-fat yoghurt. However, problems such as over-stabilization or under-stabilization could be encountered in the formulated yoghurt if proper concentrations of these local stabilizers to be used are unknown.

However, several local stabilizers which are underutilized could be used in place of exotic ones. The flour from *Afzelia africana* ("akparata") and *Mucuna flagellipes* ("ukpo") are examples of such local stabilizers for yoghurt production. *Afzelia africana* (also known as *Afzelia*). *Afzelia africana* plant called "akparata" in Igbo speaking south-eastern part of Nigeria is an economically valuable and drought resistant leguminous tree crop mostly grown in the tropical rainforest zones of west Africa, Senegal in west Africa to the Sudan, Uganda and Tanzania in the east and south Asia (in India). It is occasionally grown in other tropical countries as an ornamental. The leaves of "akparata" are sometimes eaten cooked as a vegetable, young leaves are mixed with ground cereals before cooking. The flowers are used as condiment in sauces. The flour from seeds is used as a substitute for wheat flour in biscuits and doughnuts and also as soup thickners[15]. *Afzelia africana* seed has been reported to contain 24% protein, 4.29% crude fibre, 3.43% ash and 21% lipid[16] and used in providing seed flour and oil[17]. The plant is used in local medicine for general pain relief, digestive problems, such as constipation and vomiting and for internal bleedings (hemorrhagic). The seeds of *Afzelia africana* exhibit "orthodox" storage behavior. At moisture content (MC) of about 8%, the seeds can be stored at ambient conditions for at least 33 months, without significant decrease in viability. For short term storage, the seeds can be stored with moist vermiculite or sawdust at about 25°C, ventilating frequently to ensure aerobic conditions[17].

Mucuna is a genus of around 100 accepted species of climbing vines and shrubs of the family fabaceae, found worldwide in woodlands of tropical areas. *Mucuna flagellipes* Hook. F. is a tree of Papilionaceae (Leguminosae-Papilionoideae, fabaceae) family. *Mucuna flagellipes* occurs from Sierra Leone East to Central African Republic, DR Congo and South to Angola. Its reported occurrence in Uganda is doubtful[18]. It is popularly known as "ukpo" by the Igbo speaking people of south-eastern Nigeria and used as a soup thickener in traditional soups preparation due to its high content of water dispersible polysaccharide (gum) making flour of the seed to be highly pseudoplastic. It comprises pods covered with brownish dense whisker-like hairs called trichomes that are irritating when they come in contact with the skin or eyes. Each pod may contain 1-3 seeds with a hard coating which is white when immature and turns black when mature and dry[19]. The seeds are cracked, boiled, dehulled, ground to powder and added to soup. But as a choice dish, the seeds are cracked, boiled overnight and dehulled. The cotyledons are spiced to taste and served as a delicacy[20]. *Mucuna* species generally have high protein content (2.4-14.4%), lipid (2.8-9.8%), crude fibre (5.3-11.5%), ash (2.9-5.5%) and carbohydrate (59.20-64.88%)[21]. The anti-nutritional factors are dopa, phenolics, tannin, hemagglutinins, trypsin and chymotrypsin inhibitors, phytic acid, saponins and cyanogenic compounds[21] but detoxified to low levels by cooking for 90 min or toasting for 60 min[22]. The seed gum is an emulsifying and suspending agent used for suspensions of sulphadimidine and zinc oxide or to improve moisture retention to reduce crumb firmness breads baking[18]. Though the seeds are preserved dry[23], electrical treatment has become acceptable in processing the seeds as biomaterials[24]. This bothers on the need to keep the product fresh and retain its original food value[25].

Thus, this additional benefits of using *A. africana* and *M. flagellipes* as stabilizers in yoghurt manufacture has the tendency to increase the general acceptability of the yoghurt stabilized by these local stabilizers in comparison to exotic ones. The main thrust of this study was to produce and determine the influence of these local stabilizers on the proximate and micro-nutrient composition, physicochemical, microbial and sensory properties of plain set yoghurt stabilized using flour from *Afzelia africana* and *Mucuna flagellipes* seeds.

MATERIALS AND METHODS

The study took place at the Department of Food Science and Technology, University of Nigeria, Nsukka between December, 2016 and September, 2017.

Procurement of raw materials: Skimmed milk, yoghurt culture (yoghurment), local stabilizers, ákparata' (*Afzelia africana*) sand 'ukpo' (*Mucuna flagellipes*) were purchased from Ogige market, Nsukka, Nsukka Local Government Area, Enugu state.

Sample preparation

Processing of *Afzelia africana* ('akparata') flour: *Afzelia africana* seeds (Plate 1) were processed into flour as described by Odenigbo and Obizoba[26]. *Afzelia africana* seeds were cleaned and roasted at 150°C for 20-25 min using a roaster. The roasted seeds were cracked and dehulled. The hulls were removed by aspiration of the seed and cleaned. The endosperm were milled into flour, sun-dried for 24 h, sieved and stored in air-tight container as seen in Fig. 1.

Processing of *Mucuna flagellipes* ('ukpo') flour: *Mucuna flagellipes* seeds (Plate 2) were processed into flour as described by Udensi *et al.*[27]. *Mucuna flagellipes* seeds were cleaned and broken to remove the seed coat. The dehulled cotyledons were soaked for 24 h in water at room temperature. The cotyledons were subsequently boiled in water for 30-90 min, dried in a forced draught oven/hot air oven at 70°C and milled into powder using a hammer mill (100 μ mesh size) as shown in Fig. 2.

Plate 1: *Afzelia africana* seed

Plate 2: *Mucuna flagellipes* seeds

Preparation of yoghurt mix: Dried milk sample (250 g) was dissolved in water and made up to 2 L to produce an equivalence of fresh milk. This represented the control containing no stabilizer (sample Y+C). Eight additional yoghurt mixes were produced in the same way as sample Y+C but they contained different types of local stabilizers at different concentrations. The ingredients combinations for the yoghurt mixes were shown in Table 1.

Formulation of plain set yoghurt using *Afzelia africana* flour and *Mucuna flagellipes* flour as stabilizers: The yoghurt was produced in accordance to the procedure of

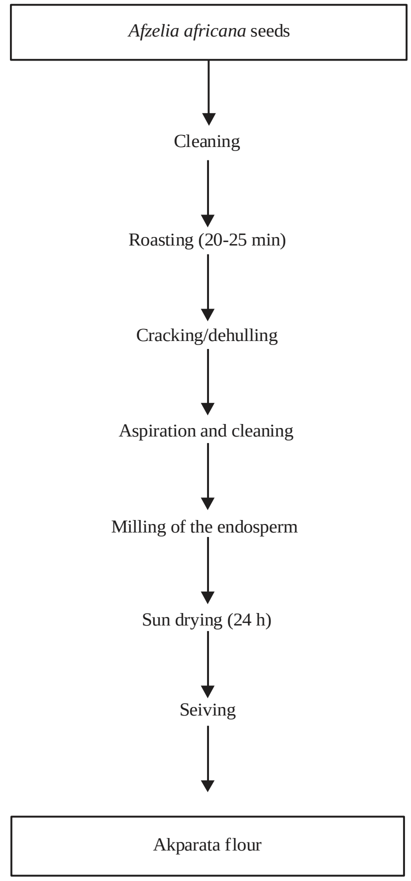

Fig. 1: Modified method of processing "akparata" flour
Source: Odenigbo and Obizoba[26]

Schmidt[28]. Each yoghurt mix with its stabilizer proportion was pasteurized at 85°C for 20-30 min to inactivate the pathogens in a water bath and homogenized at pasteurization temperature. Subsequently, the milk was cooled to inoculation temperature of 43±2°C and then inoculated with 10% yoghurt starter culture (yoghurmet) consisting of *Lactobacillus bulgaricus*, *Streptococcus thermophillus* and *Lactobacillus acidophilus.* The yoghurt mixes were fermented for 12 h at room temperature after which it was cooled and refrigerated, stored and presented for sensory evaluation. Figure 3 showed the flow diagram for the production of yoghurt.

Analysis of *Afzelia africana* and *Mucuna flagellipes* stabilized plain set yoghurt: Apparent viscosity was determined by using Ostwald viscometer and total titratable acidity according to AOAC[29]. A standard pH meter (model 20 pH conductivity meter, Denver Instrument, United Nations Inventory Database) and pH of the yoghurt sample was taken[29]. The proximate analysis of the formulated yoghurt

Table 1: Ingredient mixes for the production of yoghurt samples

Sample code	Stabilizer	Stabilizer conc. in g (%)	Liquid milk (mL)	Starter culture (yoghurmet)
Y+C	None (control)	0.0 (0.0)	2000	10 g
Y+A	Akparata	2 g (0.1)	2000	10 g
Y+A		4 g (0.2)	2000	10 g
Y+A		6 g (0.3)	2000	10 g
Y+A		8 g (0.4)	2000	10 g
Y+U	Ukpo	2 g (0.1)	2000	10 g
Y+U		4 g (0.2)	2000	10 g
Y+U		6 g (0.3)	2000	10 g
Y+U		8 g (0.4)	2000	10 g

Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

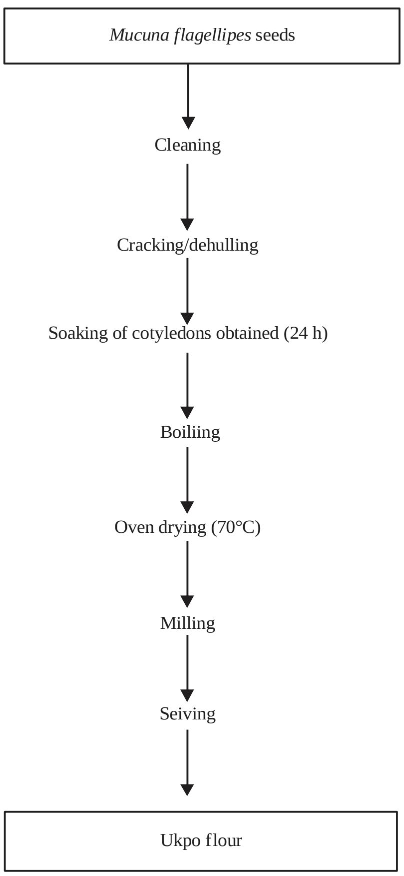

Fig. 2: Processing of *Mucuna flagellipes* ('ukpo') flour
Source: Udensi *et al.*[27]

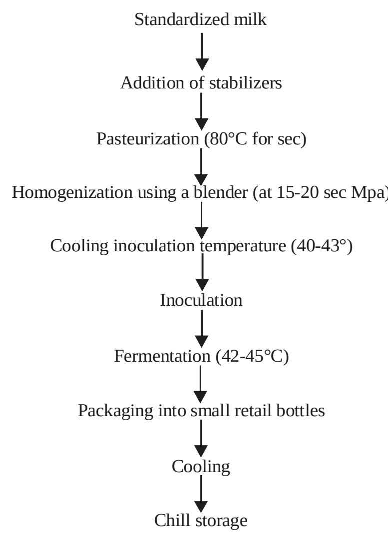

Fig. 3: Processing of yoghurt using "akparata" and "ukpo"
Source: Schmidt[28]

stabilized with *Afzelia africana* and *Mucuna flagellipes* were investigated in the Food Science and Technology Laboratory. Moisture content was determined by air oven method but the protein was measured by determining the total nitrogen in the sample. Ash content was carried out by the incinerating the sample in a furnace according to the procedure of AOAC[29]. The total carbohydrate content (%) in the sample was calculated by difference method. The calcium and phosphorus content was determined using the Atomic Absorption Spectrophotometer method as described by Pearson[30]. The vitamin A and C contents was determined according to the method of AOAC[31]. The total viable and mould counts were carried out using the method described by Prescott *et al.*[32] while the lactic acid bacteria (LAB) was determined as described by Oxoid manual[33].

Sensory evaluation of the formulated yoghurts using *Afzelia africana* and *Mucuna flagellipes*: The sensory evaluation were carried out according to Ihekoronye and Ngoddy[34] using a 20 man semi-trained panelist. The panelists were instructed to indicate their preference of the samples. A nine-point Hedonic scale (where 9 was the highest score and 1 the lowest score) for each characteristic such as colour, flavour, mouth feel and overall acceptability was determined.

Data analysis and experimental design: Data obtained were subjected to one-way analysis of variance (ANOVA) in completely randomized design according to the method of Gomez and Gomez[35]. Significant means were separated by Duncan's new multiple range test using SPSS computer software version 20.

Table 2: Effect of two local stabilizers on the proximate composition of the formulated plain set yoghurt

Stabilizers	Sample (%)	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Control	Y+C (0.0)	90.68±0.01[a]	0.57±0.01[g]	1.01±0.01[i]	2.79±0.01[i]	4.98±0.01[e]
Akparata	Y+A (0.1)	84.01±0.14[d]	0.81±0.01[d]	1.62±0.14[f]	3.74±0.01[d]	9.86±0.01[d]
	Y+A (0.2)	83.26±0.01[f]	0.91±0.14[c]	1.72±0.14[d]	3.78±0.01[c]	10.34±0.01[c]
	Y+A (0.3)	82.72±0.14[g]	1.35±0.01[b]	1.81±0.01[c]	3.81±0.01[b]	10.36±0.01[c]
	Y+A (0.4)	81.19±0.01[h]	1.42±0.21[a]	2.14±0.01[a]	3.83±0.14[a]	11.46±0.14[a]
Ukpo	Y+U (0.1)	86.02±0.21[b]	0.57±0.14[g]	1.21±0.01[h]	2.87±0.01[h]	9.37±0.14[e]
	Y+U (0.2)	84.64±0.01[c]	0.67±0.01[f]	1.42±0.01[g]	2.92±0.01[g]	10.20±0.28[c]
	Y+U (0.3)	83.62±0.01[e]	0.69±0.14[e]	1.66±0.01[e]	3.13±0.01[f]	10.91±0.14[b]
	Y+U (0.4)	83.26±0.14[f]	0.81±0.14[d]	1.89±0.01[b]	3.18±0.01[e]	10.88±0.01[b]

Values are Means±standard deviation of duplicate readings. Means on the same column with different superscripts are significantly ($p<0.05$) different, Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

RESULTS AND DISCUSSION

Effect of two local stabilizers ('akparata' and 'ukpo') on the proximate composition (%) of plain set yoghurt: The Table 2 showed the proximate composition of the formulated plain set yoghurt. It showed that the moisture content of yoghurt decreased with increase in concentration of the stabilizers. This could be explained by the ability of stabilizers to increase the viscosity of yoghurt by increasing the total solids content and reducing the moisture content of yoghurt[36]. The lower moisture content of yoghurt samples with 'akparata' at all concentrations compared to sample 'ukpo' at same concentrations was partly due to nature of their biological make up which reduces the moisture content of 'akparata'[21]. It was observed that 'ukpo' stabilized yoghurt at these concentrations ad higher viscous effect than ukpo which had higher moisture content at all concentrations, respectively. There was no significant ($p>0.05$) difference between in all which corroborates the fact that 'akparata' has greater viscous effect than sample 'ukpo' at different concentrations. The ash content was in agreement with Alakali *et al.*[37], where the ash content of yoghurt increased with increase in concentration of stabilizers which was presumably due to the higher calcium and phosphorus content in *Afzelia africana* seeds compared to that in *Mucuna flagellipes*[26]. It was observed that there was no significant ($p>0.05$) difference between sample with 'akparata' at concentration 0.1% and 'ukpo' at concentration 0.4%. However, there was significant ($p<0.05$) difference between sample at all concentrations of 'akparata' and those at same concentrations of 'ukpo', respectively. Sample with 'akparata' had higher ash content due to the higher calcium and phosphorus content in 'akparata' compared to 'ukpo'[27]. According to Okaka and Okaka[38] normal extracellular calcium concentration is necessary for blood coagulation and integrity of intercellular cement substances. The control had the least fat content (1.01%) due to the skim milk that was used and the standard composition of low fat yoghurt[39] is 0.8%. Moreso, the fat content of samples with 'ukpo' increased. Similar increases in concentration of local stabilizers in yoghurt increased the fat content of the yoghurt was observed by Mbaeyi-Nwaoha *et al.*[40]. Also, the protein content of sample with 'ukpo' increased which was attributed to the high protein content of 'akparata'[22] and 'ukpo'[21]. It was observed that sample 'akparata' had higher protein content at all concentrations due to higher protein content in 'akparata'[16] and partly due to roasting which increased the protein content of 'akparata[21]. The control had the least carbohydrate content and was significantly ($p<0.05$) different from all the stabilized yoghurt which could be deduced that the carbohydrate content of 'apkarata' and 'ukpo' increased. According to Ihekoronye and Ngoddy[34], the very high carbohydrate content of these seeds as well as their ability to form viscous gums at low concentrations (0.1-1%) shows that they belong to the class of food ingredients known as hydrocolloids.

Effect of two local stabilizers ('akparata' and 'ukpo') on the micronutrient composition of plain set yoghurt: Data in Table 3 showed the micronutrient composition of the formulated plain set yoghurt where the control had the lowest phosphorus content while sample with 0.4% 'ukpo' had the highest phosphorus content. The phosphorus content at all concentrations increased with increase in both concentrations of 'akparata' and 'ukpo', respectively. The similar trend was probably due to the roasting method used for the preparation of 'akparata' flour. Roasting drastically reduces the moisture and mineral content of food materials[25]. Sample Y+C had the highest calcium compared to sample containing all concentrations of 'akparata') and 'ukpo'. The calcium content of 'akparata and 'ukpo' yoghurt samples increased with increase in concentration of each stabilizers. However, the calcium content of sample containing all levels of 'akparata' was lower than those of containing 'ukpo') probably due to roasting of 'akparata'. Roasting drastically reduced the moisture and mineral content of food materials[41]. Vitamins A

Table 3: Effect of two local stabilizers (akparata and ukpo) on the micronutrient composition of plain set yoghurt

Stabilizers	Sample (%)	Phosphorus (mg/100 g)	Calcium (mg/100 g)	Vitamin A (mg/100 g)	Vitamin C (mg/100 g)
Control	Y+C (0.0)	129.19±0.05[e]	32.46±0.02[a]	35.92±0.05[a]	38.93±0.05[a]
Akparata	Y+A (0.1)	130.31±0.34[d]	16.55±0.07[g]	32.67±0.04[b]	36.76±0.21[b]
	Y+A (0.2)	132.64±0.03[bc]	17.27±0.23[f]	30.56±0.04[c]	33.28±0.08[e]
	Y+A (0.3)	133.58±0.03[ab]	18.26±0.50[e]	27.31±0.08[e]	33.05±0.04[f]
	Y+A (0.4)	133.74±0.08[ab]	19.19±0.01[d]	26.65±0.07[f]	34.23±0.21[c]
Ukpo	Y+U (0.1)	130.43±0.03[d]	18.11±0.04[e]	30.17±0.23[d]	33.69±0.06[d]
	Y+U (0.2)	131.84±0.06[c]	19.64±0.28[c]	26.49±0.07[f]	32.19±0.11[g]
	Y+U (0.3)	133.98±0.02[a]	19.79±0.01[c]	25.94±0.21[g]	31.23±0.05[h]
	Y+U (0.4)	134.53±1.39[a]	20.44±0.16[b]	25.13±0.05[h]	20.43±0.07[i]

Values are Means±standard deviation of duplicate readings. Means on the same column with different superscripts are significantly ($p<0.05$) different, Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

Table 4: Effect of two local stabilizers ('akparata' and 'ukpo') on the physicochemical properties of plain set yoghurt

Stabilizers	Sample (%)	Viscosity (Cp)	pH	Total titratable acid
Control	Y+C (0.0)	3.31±0.06[c]	4.02±0.13[d]	0.33±0.02[e]
Akparata	Y+A (0.1)	2.13±0.08[f]	6.06±0.08[a]	0.35±0.03[e]
	Y+A (0.2)	3.29±0.08[c]	6.07±0.03[a]	0.40±0.01[bcd]
	Y+A (0.3)	3.49±0.08[b]	5.15±0.57[c]	0.48±0.21[a]
	Y+A (0.4)	3.90±0.01[a]	5.26±0.35[b]	0.48±0.04[a]
Ukpo	Y+U (0.1)	1.91±0.04[g]	5.07±0.01[c]	0.36±0.03[cde]
	Y+U (0.2)	2.30±0.11[e]	5.27±0.04[b]	0.42±0.01[abc]
	Y+U (0.3)	2.98±0.01[d]	5.28±0.01[b]	0.42±0.03[abc]
	Y+U (0.4)	3.37±0.11[c]	6.20±0.06[a]	0.45±0.01[ab]

Values are Means±standard deviation of duplicate readings. Means on the same column with different superscripts are significantly ($p<0.05$) different, Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

and C contents of the sample without any stabilizer differed ($p<0.05$) significantly from other concentrations. The control had the highest vitamin A and C contents. The vitamin A and vitamin C of sample Y+A (containing 0.1, 0.2 and 0.3% A) and sample Y+U (containing 0.1, 0.2, 0.3 and 0.4% U) decreased significantly with increase in concentration of 'akparata' and 'ukpo' respectively.

Effect of two local stabilizers ('akparata' and 'ukpo') on the physicochemical properties of plain set yoghurt: Table 4 displayed the physicochemical properties of the formulated plain set yoghurt. The viscosity of samples containing all levels of 'akparata' increased with increase in concentration of 'akparata' and 'ukpo', respectively. The increase in viscosity could probably be from the interaction between the protein which is positively charged and polysaccharide which is negatively charged[42]. Sample containing 0.1% 'ukpo' had the lowest viscosity compared to sample Y+A because pH was closer to the isoelectric point (pI) of protein. The isoelectric point of milk proteins (mainly caseins) was 4.6. Chances of weaker protein-polysaccharide complex formation is more when solution pH is almost equal to protein pI, because at that pH range, surface charge of protein becomes nearly zero[43].

Table 4 showed that total titratable acid for sample containing 0.2 and 0.3% 'akparata' increased with decrease in pH probably due to lactic acid produced during fermentation of lactose in milk, while the total titratable acid for sample having 0.1 and 0.4% 'akparata) varied . The variations could be as a result of possible generation of acids or alkali at much lower or higher concentrations of 'akparata' in yoghurt. The total titratable acid of sample containing all levels of 'ukpo' increased with increase in pH and such anomaly could be as a result of production of alkali in sample Y+U, with increase in concentration of 'ukpo'. According to Mbaeyi-Nwaoha *et al*.[40], the decrease in acidity of a sample containing local stabilizer with increase in concentration of the local stabilizer in the sample could be attributed to the inability of ions to travel through the viscous liquid.

Effect of two local stabilizers on the microbial count of plain set yoghurt: Table 5 showed the microbial count (CFU mL^{-1}) of plain set yoghurt produced with local stabilizers ('akparata' and 'ukpo'). The total viable count increased from 2.72×10^5 CFU mL^{-1} to 2.98×10^5 CFU mL^{-1} while the total viable count of the sample Y+A (containing 0.4%) varied. The increase in total viable count for sample Y+A (containing 0.1, 0.2 and 0.3%) with increase in concentration of 'akparata', suggested the possible generation of acids or alkali which favoured microbial growth by 'akparata'. Calcium, phosphorus and potassium contents in 'akparata' could create an alkaline or acidic medium suitable for the growth of micro-organisms. The sample with 0.0% stabilizer had lower total viable count

Table 5: Effect of two local stabilizers on the microbial count of plain set yoghurt

Stabilizer	Sample (%)	Total viable count (CFU mL^{-1})	Lactic acid bacteria (CFU mL^{-1})	Mould count (CFU mL^{-1})
Control	Y+C (0.0)	2.02×10^5	1.3×10^5	4×10^1
Akparata	Y+A (0.1)	2.72×10^5	1.4×10^5	2×10^1
	Y+A (0.2)	2.80×10^5	2.8×10^5	2×10^1
	Y+A (0.3)	2.98×10^5	9.3×10^4	5×10^1
	Y+A (0.4)	2.35×10^5	4.4×10^4	3×10^1
Ukpo	Y+U (0.1)	1.37×10^5	1.7×10^5	1×10^1
	Y+U (0.2)	1.62×10^5	2.1×10^5	2×10^1
	Y+U (0.3)	1.85×10^5	2.9×10^5	3×10^1
	Y+U (0.4)	2.04×10^5	1.2×10^5	3×10^1

Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

Table 6: Effect of 2 local stabilizers (akparata and ukpo) on sensory characteristics of plain set yoghurt

Stabilizers	Sample (%)	Colour	Aroma	Taste	Consistency	Mouth feel	Overall acceptability
Control	Y+C (0.0)	7.95 ± 0.94^a	7.15 ± 1.04^a	7.30 ± 0.98^a	6.65 ± 1.46^a	6.50 ± 1.73^a	7.05 ± 1.50^a
Akparata	Y+A (0.1)	6.50 ± 1.61^b	4.90 ± 1.59^b	4.70 ± 1.84^b	5.30 ± 1.38^b	5.15 ± 1.31^b	5.75 ± 1.45^b
	Y+A (0.2)	6.35 ± 1.14^b	5.75 ± 1.33^b	5.25 ± 1.77^b	5.55 ± 1.28^{ab}	5.30 ± 1.72^b	5.95 ± 1.47^{ab}
	Y+A (0.3)	6.50 ± 1.54^b	5.70 ± 1.56^b	5.40 ± 1.93^b	5.90 ± 1.41^{ab}	5.50 ± 1.64^{ab}	6.10 ± 1.68^{ab}
	Y+A (0.4)	5.90 ± 2.02^b	5.30 ± 2.00^b	5.45 ± 1.88^b	5.35 ± 2.01^b	5.10 ± 1.83^b	6.00 ± 1.56^{ab}
Ukpo	Y+U (0.1)	5.65 ± 1.46^b	5.55 ± 1.79^b	5.90 ± 1.33^b	5.60 ± 1.35^{ab}	5.70 ± 1.56^{ab}	6.05 ± 1.64^{ab}
	Y+U (0.2)	6.20 ± 1.54^b	6.05 ± 1.61^b	5.85 ± 1.63^b	5.95 ± 1.36^{ab}	5.95 ± 1.54^{ab}	6.10 ± 1.62^{ab}
	Y+U (0.3)	5.70 ± 2.11^b	6.00 ± 1.33^b	5.80 ± 1.70^b	5.70 ± 1.59^{ab}	5.85 ± 1.57^{ab}	5.90 ± 1.62^{ab}
	Y+U (0.4)	5.55 ± 2.24^b	6.05 ± 1.96^b	5.50 ± 2.06^b	5.55 ± 2.11^{ab}	5.55 ± 1.90^{ab}	5.70 ± 1.87^b

Values are Means±standard deviation of twenty panelists. Means on the same column with different superscripts are significantly ($p<0.05$) different. Y: Yoghurt, A: Akparata, U: Ukpo, C: Control

compared to sample containing all concentrations of 'akparata' presumably due to its lower mineral content which caused less alteration in pH of yoghurt. Samples containing all levels of 'ukpo' had a total viable count which increased from 1.37×10^5-2.04×10^5 CFU mL^{-1} which could be due to the possible generation of acids or alkali medium which favour microbial growth by 'ukpo'. However, the decrease in total viable count for sample containing 0.0% stabilizer from 2.02×10^5-1.85×10^5 CFU mL^{-1} for sample containing 0.3% 'ukpo' suggested that the stabilizer had anti-microbial effect. The lower total viable count of sample at all levels of 'ukpo' compared to sample at all concentrations of "akparata" also suggested that the 'ukpo' has antimicrobial effect which was in agreement with Uchegbu *et al.*[44].

The lactic acid bacteria content (Table 5) of sample containing 0.1, 0.2 and 0.3% 'akparata' increased from 1.4×10^5-9.3×10^4 CFU mL^{-1} while the lactic acid bacteria content of sample containing 0.4% 'akparata' varied. The increase in lactic acid bacteria content for sample Y+A (containing 0.1, 0.2 and 0.3% 'akparata') with increase in 'akparata', suggested possible alteration of yoghurt pH to a favourable one for the growth of lactic acid bacteria. The variation of sample at concentration 0.4% could also be as a result of alkali or acid generation in yoghurt. This was in line with Nwosu[45], who reported the variations in acid content of foods thickened with different concentrations of 'achi', 'ofo' and 'ukpo' during processing. The lactic acid bacteria content of sample Y+U (containing 0.1, 0.2 and 0.3% 'ukpo') also increased or decreased from 1.7×10^5-2.9×10^5 CFU mL^{-1} as a result of increase or decrease in acidity of the medium. Also, the mould count increased for sample containing 0.1, 0.2 and 0.3% 'akparata' with increase in concentration of 'akparata, while the mould count of sample containing 0.4% 'akparata' did not follow the trend. But the mould count increased for sample containing all concentrations of 'ukpo with increase in concentrations of 'ukpo'.

Effect of two local stabilizers ('akparata' and 'ukpo') on the sensory characteristics of plain set yoghurt: Table 6 showed the sensory scores of the formulated plain set yoghurt. The addition of the stabilizers lowered the colour scores within the treatment. The aroma, taste and mouthfeel of the formulated yoghurt sample differed ($p<0.05$) significantly for both 'ukpo' and 'akparta' at all concentrations. The taste of sample containing 0.2% 'ukpo' did not follow the trend. The consistency of sample containing all levels of 'ukpo' were significantly ($p>0.05$) the same and had similar texture. The control had the highest overall acceptability and was significantly ($p<0.05$) different from sample containing 0.1% 'akparata) and 0.4% 'ukpo'. The high sensory scores and overall acceptability of yoghurt stabilized with high compatibility with the fresh milk from which the yogurt was made. This is in agreement with a previous report affirmed that milk powder gave yoghurt a firm body, better consistency and unique flavor[46].

CONCLUSION

From the results of the study, "akparata" and "ukpo" increased the fat, protein, carbohydrate viscosity and improved colour, aroma, taste, texture, mouthfeel and overall acceptability of the plain yoghurt. The formulated yoghurt was microbiologically safe for consumption by the panelists although sample containing 0.4% 'ukpo' was the least preferred.

SIGNIFICANCE STATEMENTS

This study shows that flour from too scanty local seeds could be used as stabilizing agents in soups, yoghurt and other foods. *Mucuna flagellipes* flour, for example, is used as a soup thickener in most rural Igbo speaking communities of southern Nigeria. The seeds of *Afzelia africana* and *Mucuna flagellipes* which are indigenous and locally available could serve as better alternatives to exotic stabilizers, thus, avoiding wastage of our local raw materials and minimize cost for indigenous food processors. Finally, this study would show that the use of *Afzelia africana* and *Mucuna flagellipes* in yoghurt manufacture would add variety to consumer options as well as improve the textural, sensory and health benefits of the stabilized yoghurt.

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