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Full Length Research Paper

QUALITY ASSESSMENTS OF YOGHURTS AND YOGHURT- LIKE PRODUCT FROM LOCAL PLANT MATERIALS (*Cajanus cajan, Vignia ungiculata and Vignia subterranean)*

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Abstract

In recent years, research has been focused on creating foods with higher protein quality through the use of mixtures of cereals and legumes that are thought to be nutritionally balanced due to challenges with food security in underdeveloped nations.In this way, underutilized regional foods including *Cajanus cajan* (Fiofio), *Vignia ungiculata* (Akidi oji), and *Vignia subterranea* (Okpa) were blended with local plant raw materials to create yoghurts. Also, commercial Cowbell milk was used as a control in the yoghurt preparation. As a potential replacement for commercial starter cultures that contain lactic acid-producing bacteria, the investigation also evaluated the impact of utilizing sorghum and millet steep waters as starter cultures (*Lactobacillus bulgaricus* and *Streptococcus thermophilus).* Twenty-twoyoghurt samples were prepared (A1234, B1234, C1234 D, E123, F1234 and G123. They were subjected to proximate, phytochemicals, minerals, vitamins, chemicals, microbial analysis as well as sensory evaluation with a view of understanding the consumer acceptability of the products. Commercially acceptable yoghurt brand-Hollandia yoghurt was also analyzed and used as overall control (sample D). The data generated were analysed using one-way ANOVA followed by Tukey's post hoc test and significant difference set at ($p<0.05$). The result indicated the presence of alkaloids (0.3 - 1.2mg), flavonoids (0.7 - 2.6mg), saponin (0.1 - 0.8mg), tanins (0.2 - 1.2mg) and oxalate (0.1 - 0.5mg). Vitamins, calcium (6.0 - 19.33mg), potassium (1.2 – 24.59mg), magnesium (0.70 - 6.65mg), sulphur (0.0 – 0.1mg) and phosphorus (78 – 166) were at acceptable levels. These and other parameters studied varied significantly ($p<0.05$) for samples fermented with commercial starter culture, sorghum and millet steep water. The microbial result revealed that total viable count (TVC) ranged from 1.0×10^5 minimum to 7.2×10^5 maximum, pathogenic *bacteria* was not seen (nil). Both total viable count (TVC) and pathogenic *bacteria* were in a tolerable level for the three cultures. The result showed significant differences ($p<0.05$) in aroma, appearance, taste, texture and overall acceptance among the different yoghurt samples and fermented cultures. Consequently, yoghurt was successfully produced from local plant raw materials and there is possibility of using sorghum and millet steep water as a substitute for commercial starter culture.

Key words: Yoghurt, quality assessment, sorghum, millet steep and commercial starter culture.

INTRODUCTION

A fermented dairy product called yogurt is made by fermenting milk with *lactic acid* (Ihemeje et al, 2015). Yogurt is defined as foods produced by a distinctive bacterial culture that contains *Lactobacillus bulgaricus and Streptococcus thermophilus* on some ingredients, namely cream, milk, partially skimmed milk, and skim milk, either alone or in combination, according to the Code of Federal Regulations of the United States Food and Drug Administration (FDA, 2013). One of the most popular and healthy foods consumed worldwide is yogurt (Adriana et al, 2018; Shi et al., 2017; Zhi et al., 2018). Yogurt is "a fermented product formed by anaerobic fermentation of lactose in milk with pertinent bacteria (*Lactobacillus bulgaricus and Streptococcus thermophilus)* that are classed as 'probiotic' (friendly, or harmless) microorganisms" (Sanful, 2009). According to market studies, the yoghurt market is anticipated to reach $107,209 million by 2023, representing a 4.5% growth during that period (Prasannan, 2017). One of the most well-liked and widely consumed fermented dairy products is yogurt. Yogurt's history is unknown, however it is thought to have started around 6000 BC, when Neolithic people in Central Asia changed from being food gatherers to being food producers when they started to milk their animals (National Yoghurt Association, 2013). It is often believed that yoghurt and other fermented milk products were unintentionally found when people used to preserve milk in sheepskin bags since unused milk would spoil. Therefore, over the course of centuries, the fermentation of milk gave rise to the production of commercial yoghurt, which opened the door to a variety of commercially available variations with a variety of flavors, shapes, and textures (National Yoghurt Association, 2013). Before adding bulky flavoring additives, yoghurt must meet the composition requirements for milk fat and milk solids non-fat set forth by the United States Department of Agriculture (USDA, 2016). Yogurt is regarded as a nutritious food because of its high nutrient availability, making it a good choice for consumers with gastrointestinal diseases like celiac disease and lactose intolerance. Yogurt also helps with weight management and immunological health. Yogurt consumption is on the rise due to the numerous health advantages it offers, making it the fastest-growing dairy beverage (National Yogurt Association, 2013). In Nigeria and other African nations, legumes are among the underutilized plant sources used in this study. As with maize, rice, wheat, and cassava, none of them have attained the status of a staple food. Therefore, employing these underutilized legumes to make yogurt is a step in the right direction.

Materials and methods

Collection of Materials

The Cowbell milk powder was bought from Cenapo Supermarkct in Okigwe, Imo State. The cereals: sorghum and millet as well as the legumes *Cajanus cajan, Vignia ungiculata*and *Vignia subterranea*werebought from Akwata market, in Enugu State Nigeria and were identified properly by plant specialist in the Department of Plant Science and Biotechnology, Abia State University, Uturu. The commercial starter culture Pascaul Greek (Estilo Griego) was sourced from Shoprite outlet, Abia Mall, Umahia Abia State Nigeria.

Sample Preparation:

The plant materials for yoghurt production were sorted to eliminate spoilt ones. The sorted seeds wereweighed out, and de-hulled and foreign materials removed especially, unhealthy nuts and seeds which could affect the taste and quality of the yoghurt. A 300g of each of the legumes seeds was washed and rinsed with potable water, wet milled separately into slurry with 1.5 liters of potable water using cleaned silver crest blender model: SC 1589(5000W),and the milk extracted subsequently from the resulting slurry of each plant by pressured squeeze using muslin cloth. The extracted milk of the individual grain was pasteurized separately to 82°C for 10 minutes and cooled to a temperature of 42°C. A 200ml of each was transferred to different labeled containers and starter culture introduced.

Production Using the Commercial Cowbell Milk powder

A 400g of commercial cowbell milk powder was fused in 2liters of warm water and stirred thoroughly to give a homogenous mixture. The mixture was heated to 82°C for 10 minutes for pasteurization, and was made to cool to a temperature of 42°C. 200ml each was transferred to labeled sample containers, followed by the introduction of starter culture which promoted the fermentation process.

Formulation of yoghurt Production from 3 legumes crop and conventional milk such as:

Cowbell milk……. A1
Okpa extract……...A2
Akidi oji extract……. A3
Fiofio extract……. A4
Hollandia Yoghurt……. D

SampleA

100%A1 (control)
100%A2
100%A3
100%A4
Fermented with commercial starter culture

Sample B
100%B1 (control)
100%B2
100%B3
100%B4
Fermented with sorghum culture

Sample C
100%C1 (control)
100%C2
100%C3
100%C4
Fermented with millet culture

Sample D (for comparison)

Sample E (variation)
E1 = 50%A2 and50%A3
E2 = 50%A2 and50%A4
E3 = 50%A3 and50%A4
Fermented with commercial starter culture
SampleF (variation)
F1 = 50%A2 and50%A3
F2 = 50%A2 and50%A4
F3 = 50%A3 and50%A4
Fermented with sorghum starter culture

Sample G (variation)
G1 = 50%A2 and50%A3
G2 = 50%A2and50%A4
G3 = 50%A3 and50%A4
Fermented with millet starter culture

Total of twenty-twosamples of yoghurts were produced and assessed.

Proximate analysis:
The analysis of nitrogen/crude protein in the samples was done using the micro-Kjedahl technique as reported in Pearson (1976).

Assuming that all of the protein in the sample is present as nitrogen, it involved estimating the total nitrogen in the sample and converting the nitrogen to protein.

The actual percentage of protein in the samples was estimated using a conversion factor of 6.25 as follows: % crude protein % Nitrogen x 6.25.

Determination of Moisture, Ash, Content, and Crude fibre were determined according to A.O A C Method (1990).

Fat was determined according to Pearson (1976) method.

Carbohydrate content was determined according to the method described by A 0 A C (2015)

Flavonoids was determined according to the method of Boham and Kocipai (1974).

Alkaloids was done according to Harborne (1973) while other phytochemicals such as tannins and oxalate were by the method of Pearson (1976) and Saponinswas determined according to themethod described by Obadoni and Ochuko (2001)

Mineral analysis:
Phosphorous content was determined by ashing the sample in the presence of zinc oxide followed by colorimetric measurement of phosphorous as molybdenum blueaccording to (ASTM 1992)

Determination of Metals: Calcium, Potassium and Magnesium Content
Samples were digested with 30cm3 of aqua regia (a mixture of HNO_3 and HCI in the ratio of 1:3); de-ionized water, double distilled water, conc. HCI, 3M HNO3. Atomic Adsorption Spectrometer model AA-7000 Shimadzu, Japan ROM version 1.01, S/N A30664700709 was used for the analysis of Calcium, Potassium, and Magnesium content respectively.

Analysis of Titratable Acidity
Total titratable acidity was determined by the method described by AOAC (2010). About 5ml of
the sample solution was taken and titrated with 0.1N NaOH using phenolphthalein as indicator.
Titration continued until there was a change in colour to a pink endpoint.

$$\text{Titratable acid (\%)} = \frac{T \times M \times 0.09 \times 100}{V}$$

Total Soluble Solids (T.S.S)
The percentage of T.S.S wascalculated as shown below:

$$\text{T.S.S. (\%)} = \frac{\text{x 100}}{\text{g}}$$

Weight of dry filtrate x 100/1
Volume of sample

Determination of Milk Solids Non-Fat(M.S.N.F)

This was done by calculation after the determination of the lactometer reading.
%M.S.N. F = 0.25LR + 0.2F + 0.4 % Fat and LR Lactometer reading.

Determination of **pH** was determined using a Jenway pH meter model 3510

Determination of Vitamin A

The procedure of Jakutowicz*et al* was used. One gram of the sample was weighed. Then, the proteins were first precipitated with 3m1 of absolute ethanol before the extraction of vit A with 5m1 of heptane. The test tube containing this was shaken vigorously for 5mm. on standing; 3ml from the heptane layer was taken up in a cuvette and read at 450nm against a blank of heptane. The standard was prepared and read at 450nm wavelength and vitamin A calculated from the standard.

Determination of Thiamin (Vitamin B1)

Thiamin complex was removed using weak HCI, and the resulting solution was then treated with the enzyme phosphatase to release free thiamine. A flask containing 1g of the sample was weighed, then 1g of O.2NHCI was added, and the flask was heated to boiling over a water bath for 30 minutes. 5 ml of phosphatase, cooled enzyme

added and incubated at 37°C, filtered and added 2-3g of anhydrous Na2SO4. 5ml of the solution was measured into 5m1 stopped flask and added 3m1 of 15% NaOH. The absorbance was taken at 435nm wavelength. Thiamin was calculated as follow:

$$\text{Thiamine} = \frac{\text{Abs of sample}}{\text{Abs of STD}} \times \frac{\text{Conc of STD}}{\text{weight used}}$$

Determination of Riboflavin (Vitamin B2)

Riboflavin was extracted using weak acids, and after KMnO4 treatment to remove any impurities, it was measured.

The sample's weight was 5 milligrams.

On a water bath, 50 ml of 0.2 NHCl was added, boiled for 1 hour, cooled, and the pH was raised to 6.0 using NaOH.

To get the pH down to 4.5, 1NHCl was added. After filtering, the volume was adjusted to the required level in a l00ml measuring flask.

A l0ml aliquot from a volume of l00ml was taken, and each tube received 1ml of glacial acetic acid before receiving 0.5ml of a 3% KMnO4 solution and being mixed.

0.5m1 of 3% H2O2 was added after 2 minutes, mixed thoroughly, and then the reading at 470 nm was taken.

Calculate for riboflavin as follows

$$\text{Riboflavin} = \text{Abs} \frac{\text{of sample}}{\text{Abs of STD}} \times \frac{\text{Cone of STD}}{\text{weight used}}$$

Analysis of Ascorbic acid (Vitamin C)

A l00ml volumetric flask containing 5g of the sample was weighed, 2.5ml of 20% meta-phosphoric acid was added as a stabilizing agent, and the mixture was then diluted with distilled water. 2.5ml of acetone was added after 10ml of the solution was pipette-collected into a little flask.

Indophenol solution was titrated until a faint pink color remained for 15 seconds.Vitamin C concentration was determined to be mg/100 ml in the sample's intensely colored solution.The calculation was performed with a UV spectrophotometer using water at a wavelength of 264 nm.

Analysis of Vitamin E

1g of sample was weighed into l00mI flask fitted with reflux condenser. 10ml absolute alcohol and 20ml M alcoholic sulphuric acid was added. Refluxed for 45mins and cooled. Then, 50 ml of acid and another 50 ml of distilled water were added before being put into a funnel for separation.

Using 30ml of diethyl ether to extract.Under extremely low heat, the extract was evaporated.Ten milliliters of pure ethanol were used to dissolve the residue.

In a 200 ml volumetric flask, aliquots of the solution and standards (containing 0.3–3.0 mg of vitamin E) were transferred.1ml of concentrated nitric acid was added after adding 5ml of pure alcohol.placed for three minutes in a water bath at 90 C.cooled under a running faucet and alcoholic volume adjustment.At 470 nm, the absorbance was measured in comparison to a blank that contained 1ml of nitric acid and 5ml of 100% alcohol

Microbial Analyses:

The microorganisms in samples were cultivated and identified using surface viable count method

(Miles and Misra, 1938) *Total Viable Count* **(**number of Living Micro-Organisms). The suspension obtained from the isolation of bacteria was diluted with sterile distilled water using sterile pipette. The aim was to obtain a dilution that contained approximately 30 cells in 0.015m1 or 0.015 volumes per drop. Agar plates were divided into eight segments with an indelible marker. A drop of the suspension was inoculated on each segment. These plates were then incubated for 24 hours at 37°C. Developed colonies were counted from the equation below

$$\text{Mean count} — \frac{\text{number of colonies in each segment}}{8}$$

$$\text{Total viable count} - \frac{\text{mean count x dilution factor}}{\text{Vol. per drop}}$$

Dilution factor = 104

Volume per drop 0.01 5m1

Isolation of Bacteria

One grain of the sample was weighed and transferred into sterile test tubes. Sterile saline solution (1 Omi) was transferred to the test tubes containing the samples. The mixture was shaken to obtain uniformity. It was then allowed to set and the supernatant served as the inoculums. Using a sterile loop, a loop full of the supernatant was collected and streaked on the nutrient agar plate. The plates were incubated at 37°C for 48 hours. After the incubation period, the plates were carefully inspected for growth of bacteria.

Identification of Pathogenic Bacteria

With the use of Isolation and Identification of Fungi, some possible colonies of harmful bacteria from the aforementioned isolation were located.

Selective media Mackonkey agar, cetrimide, and desoxcollate citrate agar were used to grow Gram-negative rods.

On mannitol agar, organisms in the shape of cocci were cultivated.The same method used to isolate and identify the bacteria mentioned above was also used to identify the fungi present in the samples.Nevertheless, Saboround dextrose agar (SDA) was employed in place of nutrition agar.

The sterile loop was used to collect 1g of the sample, which was then streaked on SDA plates.

For 48 hours, the plates were incubated at 25 to 28°C.

Microscopy was used to identify the fungi that were present in each sample.

Sensory analysis

Samples were subjected to sensory evaluation using 9-point hedonic method (9 = excellent; 8= like very much; 7=like moderately; 6=like slightly; 5=neither like or dislike; 4= dislike slightly; 3= dislike moderately; 2= dislike very much 1 = extremely poor). Twenty-two formulations sample A to G were examined on the basis of their quality attributes such as Aroma, Appearance, Taste, Texture and Overall acceptability by 36 untrained panelists who were students of JUPEB foundation, ABSU, were recruited and informed about the sensory test. An informed consent was obtained for sensory experimentation with the panelists and research has been carried out in accordance to Sanful method, (2009).

Statistical analysis

Data analysis for quality assessment and chemical measures were performed by analysis of variance and results of the sensory tests were analysed by non-parametric procedures for independent samples at a critical value of $p<0.05$. Results were related by a non-parametric procedure with Spearman's rank correlation coefficient using SPSS statistical software (version 27, SPSS Inc., Chicago, IL, USA). Mean values and standard deviation values were calculated. Sensory data were statistically tested using ANOVA to assess the difference ($p < 0.05$) and post-hoc analysis using Tukey's test was used for mean comparison between samples at a 98% confidence interval. Significance of individual independent variables, 98% confidence intervals and their standard errors of estimates are provided. In addition, sensory evaluation against instrumental analyses are represented in standardized forms of their mean values and standard deviations across all processing types. Also, bias from the commercial sample is shown to elucidate the effect of processing type against the commercial sample calculated amongst the standardized versions

Result and Discussion

Proximate composition

The proximate parameters measured were crude protein, ash content, moisture content, crude fat, crude fiber, and carbohydrate as shown in (Figure 1). Compared to group D (Hollandia yoghurt), the proximate compositions of all the yoghurts ($A_{1, 2, 3, 4}$, $B_{1, 2, 3, 4}$, and $C_{1, 2, 3, 4}$,) i.e. ABC_1: 100% cowbell yoghurt, ABC_2: 100% okpa yoghurt, ABC_3: 100% akidi yoghurt, $ABC_{4:}$ 100% fiofio yoghurt, and combinations of plant sourced yoghurts 50% okpa +50% akidi, 50% okpa +50% fiofio, and 50% akidi +50% fiofio for ($E_{1, 2, 3,}$) 50% okpa +50% akidi, 50% okpa +50% fiofio, and 50% akidi +50% fiofio for ($F_{1, 2, 3,}$) and50% okpa +50% akidi, 50% okpa +50% fiofio, and 50% akidi +50% fiofio for ($G_{1, 2, 3,}$) where EFG_1 fermented with regular starter culture: EFG_2 fermented with sorghum culture, and EFG_3 fermented with millet culture,slightly varied in composition.

The **protein content** was between the ranges of 1.66 % (B_3) to 2.78 % (A_1). In order words, the protein content decreased significantly ($p<0.05$) in yoghurts B_3, G_3, C_3, F_3, G_2 C_4, G_1, E_2 andB_4 (1.66, 1.74, 1.75, 1.79, 1.83, 1.87, 1.88, 1.91 and 1.97%, respectively) and increased non-significantly ($p>0.05$) in yoghurt 100% A_1 (2.78%) while the rest of the yoghurt samples recorded no significant difference($p<0.05$) compared to the overall control yoghurt D (2.62). The result further revealed that the animal sourced yoghurt recorded the highest crude protein compared to the three plant-based yoghurts 100% (akidi, okpa, fiofio) and their 50% combinations. The values obtained here, correspond with the work of Ihemeje *et al*, (2015), also, similar results in low content of protein were reported by (Roy *eta al*, 2015; Mbaeyi *et al*,2017*);* Desouky *et a al.*,2018*)* that protein content decreased in the fruit flavoured treatment with the accumulation of fruit juices because fruit juices are full of lower protein than milk. The declining concentration in protein content could be attributed to proteolytic activity of micro-organism which degrades the protein content due to high amount of acid content of fruit yoghurt The mean proportional level of protein present in all the yoghurt samples are nutritionally significant in terms of the potentials of these yoghurts to contribute to the increased protein intake by the consumers.

The Crude protein has been reported to have some functional attributes such as water absorption, viscosity elasticity, foam stability and fibre formation (Sanful, 2010). The result revealed that the **ash content** of yoghurt fermented with commercial starter, sorghum and millet steep water were statistically significant ($p>0.05$) (Sample A, B, C and E) when compared with the control (sample D) while more significantly differences were seen in varied samples (F and G). The highest value of ash content was recorded in sample 100% animal sourced yoghurts B_1 (0.71%), followed by Sample A_1 and C_1 which recorded (0.58% each) while the lowest ash content was seen in 100% C_3(0.09) B_3(0.10), 50% F_3, $G_{2\&3}$. (0.10 each). Although the ash content values obtained in this study were lower than the value obtained from the control yoghurt D (0.78), but it corresponds with the ash content values gotten by other researchers such as (Ihemeje *et al*, 2015 and Joel *et al*, 2014).A similar performance was reported by Nath *et al* (2020) who showed lower ash content in Almond and dark chocolate containing yogurt than the control yogurt. The content of ash in the samples is the indication of the mineral content which promote bone formation and mineralization (FOX, 1998).

The percentage **crude fat** significantly increased ($p<0.05$) in the 100% animal yoghurt A_1 (1.90%) compared to the control yoghurt D (1.62), and significantly lowered ($p>0.05$) in the rest of the yoghurts{A_{234} to G_{123} i.e. 100% plant -based yoghurts and all the 50%combinations of plant-based yoghurts both treated with all the cultures: E (50% okpa + 50% akidi), F (50% okpa+ 50% fiofio), G (50% akidi + 50% fiofio)} except in some of the individual plant-based yoghurts B_3 and C_3 (akidi and okpa) treated with sorghum and millet culture, the decrease in crude fat (%) was very significant ($p<0.05$). The crudefatcontent of the yoghurts varies with the type of milk and nature of culture used. Yoghurts rich in oil content have been observed to contain "abundant fat and this could be due to the presence of poly-unsaturated fatty acids, which are considered healthy for human body (Ogundele *et al*, 2015). In this investigation, all the yoghurts recorded appreciable values although little below minimal of NIS337:2004 range of 3.0. The decrease in fat content recorded in the samples

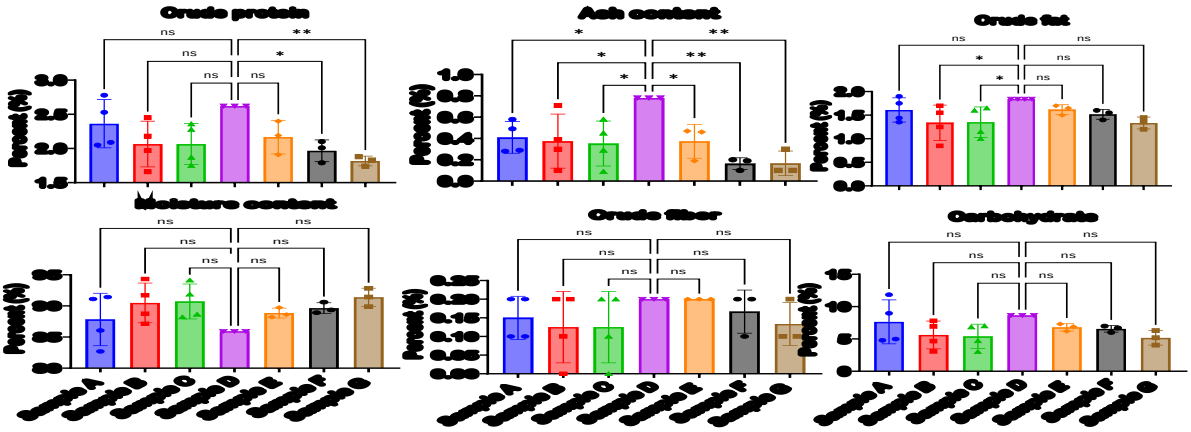
may contribute to increased shelf life by decreasing the chances of rancidity, as higher fat content may easily contribute to the production of off flavour during storage (Olakunle, 2012). The Dietary Guidelines recommends that adult women get 1.5–2% tablespoons and adult men get 2–2.5% tablespoons of oils each day (ODPHP, 2016).

Moisture content expresses the water activity of substances such as food, and other perishable materials. From the figure 1, the results showed that the moisture content for all the treatment groups increased non-significantly ($p>0.05$) for all the experimental groups (A, B, C, E, F and G) compared to the control D (85.92%). Intriguingly, yoghurts made from akidi and okpa treated with sorghum and millet culture, B_3 and C_3 (94.32% and 94.13%), as well as their combinations G_2 and G_3 (91.43% and 92.82%), recorded the highest moisture content than the animal sourced yoghurt (82.69 least and 88.21 highest). The moisture content of this study slightly increased in yoghurts fermented with both regular, sorghum and millet steep water; with mostly those of the plant extraction, recorded higher number per cent (%); sample $B_{3\&4}$, $C_{3\&4}$, $G_{3\&2}$, $A_{3\&4,}$ $F_{3\&1}$ and E (94.32% &91.71%, 94.13% &91.87%, 92.82% &91.43%, 91.42% & 91.11%, 90.61% & 89.36%, and 89.73% respectively). Also, the slightly increments of moisture content observed in yoghurts of the animal source (sample $A_{1,}$ B_1 &C_1) could be as a result of reconstitution of the milk prior to fermentation (Ihemeje *et al*, 2015). The highest moisture content as recorded in akidi oji and fiofio i.e. plant base yoghurt $B_{3\&4}$ (94.32% and 91,71%) and $C_{3\&4}$, (94.13%) is in line with the work of Udeozor (2012) who demonstrated the proximate composition and sensory qualities of tiger nut-soy milk drink, while the moisture contents of some the yoghurts disagree with the range of most commercial yoghurts (80-86 %) as reported by Joel *et al*, (2014). However, moisture can be controlled by the addition of powdered milk or evaporation during pasteurization of milk for desired yoghourt (Stringer, 2000).

The percentage composition of **crude fibre** figure 1, showsnon-significantly difference ($p>0.05$) in all the yoghurts haven recorded an average of 1.0 to 2.0% apiece, in agreement with the control yoghurt D (2.0%) except in yoghurts of B_3 and C_3 (100% akidi and 100% okpa) treated with sorghum and millet cultures, that recorded 0% crude fibre each. A decrease of this value of crude fibre compared to control samples was also reported by Adriana *et al*, (2018); Raju and Pal (2014). The indigestible components of plant material which include cellulose, hemicellulose, pectin, lignin and other plant material are collectively referred to as crude fibre or dietary fibre. It provides roughages, which contributes to a healthy condition of the intestine (Odom *et al*, 2013). Dietary fibres reduce the risk of cardiovascular diseases caused high blood cholesterol level by decreasing cholesterol level in the body (Anderson *et al*, 2009).

The percentage composition of **carbohydrate** was non-significantly ($p<0.05$) higher in A_1 and A_2 (100% cowbell and 100% okpa yoghurts both fermented with regular starter culture) haven scored 11.85% and 8.97% respectively compared to the control yoghurt D (8.64%). Other yoghurts were non-significantly ($p>0.05$) lower than the control, with yoghurt of B_3 and C_3 (100% akidi and 100% okpa) and G_3 (50%akidi + 50%fiofio)treated with sorghum and millet cultures recorded lowest score of 3.07%, 3.03% and 4.04% respectively. The proximate composition of this study is similar to those reported by other researchers (Udeozor; 2012) (Iman, Ogundele, Alhasan and Akoma *et als;* 2013, 2015, 2015 and 2013) respectively. Proximate composition is very useful for compilers of food composition tables and databases that could be used by economist, food service managers, agricultural planers, nutritionist, dieticians, food and agricultural scientist, food technologist, public health scientist etc. (Greenfield and Southgate, 2003).

Figure 1. Proximate composition of Yoghurts fermented with commercial starter, sorghum and millet steep water.



SampleA*: yoghurt fermented with regular culture,* ***Sample B:*** *yoghurt fermented with sorghum culture,* ***Sample C****: yoghurt fermented with millet culture,* ***Sample D****: commercial hollandia yoghurt as control,* ***Sample E****: varied yoghurt fermented with regular culture,* ***Sample F****: varied yoghurt fermented with sorghum culture and* ***Sample G****: varied yoghurt fermented with millet culture*

Phytochemical composition

The phytochemical parameters measured were alkaloids, flavonoids, saponins, tannins, oxalates (Figure 2). The result revealed the quantity of alkaloids, flavonoids saponin, tanins and oxalate presenct in the various yoghurts produced. The quantity of **alkaloid** was not-significantly ($p>0.05$) lowered in animal-sourced yoghurt and all the plant-based yoghurts, except in group B_3, C_3 and G_3, (akidi, akidi, and akidi + fiofio fermented with both sorghum and millet respectively) scored 0.4mg, 0.4mg and 0.3mg each. Remarkably, yoghurts of plants combination (E_3, E_1, F_2 and A_1 of animal source) recorded non-significant ($p>0.05$) increase (1.3, 1.4, 1.2 and 1.2 mg respectively) except least score 0.3mg of G_3 (50% akidi + 50% fiofio) compare to the control D (1.0 mg).

Flavonoid significantly decreased ($p>0.05$) in groups B_3, C_3, and G_3 (0.9, 0.9 and 0.7 mg) compared to the control D (2.2 mg). However, the animal sourced and plants yoghurts treated with all the cultures varied non-significantly ($p> 0.05$) as A_1 (2.6 mg) and E_1 (2.5 mg) recorded the highest percentage flavonoid.

Saponin

There were non-significant differences between the saponin contents of yoghurt samples with the least value (0.2 mg)

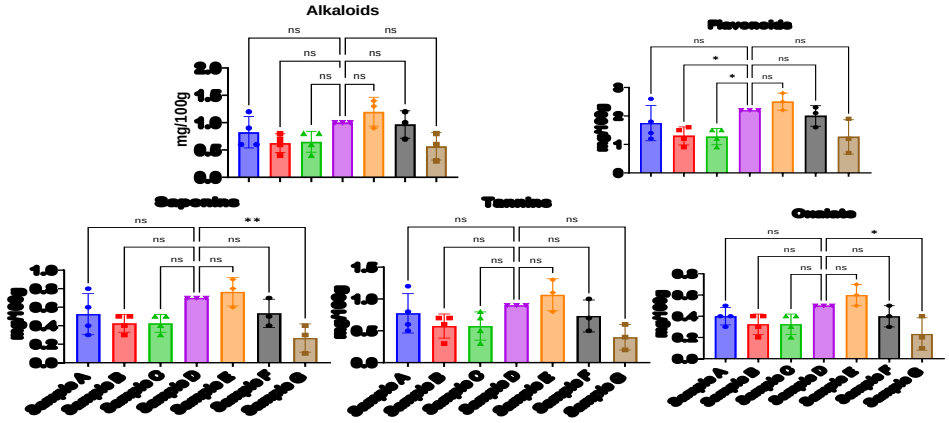
from G and E had the highest value (0.8 mg). The presence of saponin in moderate concentration is consistent with the report in the literature (Obidoa *eta al*,2010). Saponin have been shown to reduce blood glucose and insulin responses to starchy foods and or the plasma cholesterol and triglycerides. Furthermore, saponin have been reported to reduce cancer risk (Thompson,1993). The presence of saponin in the samples could imply that consumption of these yoghurt samples has the potential to lower cholesterol levels in humans due to the hypocholesterolaemia effect of saponin (Osagie, 1998).

Tannin

The tannin content of the samples is shown in **Figure 2** where tannin content of control and other yoghurt samples were almost the same value(1.1mg). It was suggested that the consumption of tannin-containing beverages can cure or prevent a variety of illnesses (Serafini *eta al*, 1994). Also, many human physiological activities, such as stimulation of phagocytic cells, host-mediated tumor activity, and a wide range of anti-infective actions, have been attributed to tannins (Ifesan *eta al*, 2014).

There were non-significant ($p>0.05$) difference in the concentration of **oxalate** among the three cultures except for G_2 and G_3 which differ significantly ($p>0.05$) in oxalate 0.2mg compare to control D (0.5mg). Phytochemicals are important biochemical drivers. Over the years, its wide acceptance has been attributed to the following criteria: bio accumulation, bio availability, higher safety margin and ability to target biochemical pathways (Okereke *et al*, 2017).

Figure 2. Phytochemical composition of Yoghurts fermented with commercial starter, sorghum and millet steep water.



Sample A*: yoghurt fermented with regular culture,* ***Sample B:*** *yoghurt fermented with sorghum culture,* ***Sample C****: yoghurt fermented with millet culture,* ***Sample D****: commercial hollandia yoghurt as control,* ***Sample E****: varied yoghurt fermented with regular culture,* ***Sample F****: varied yoghurt fermented with sorghum culture and* ***Sample G****: varied yoghurt fermented with millet culture*

Mineral composition

The mineral parameters evaluated were calcium, phosphorus, potassium, magnesium and sulphur contents (Figure 3). The results showed that the **calcium** content for all the treatment groups decreased non-significantly ($p<0.05$) for all the experimental groups except for 100% cowbell fermented with regular, sorghum and millet culture A_1 (19.33nm), B_1(14. 66nm) and C_1(14.66nm) recorded highest score compared to the control D (14 nm), while all the plants yoghurt both the mixed in all the culture treatments recorded lower calcium concentration (5.33 nm) on average.

The result of **potassium** shows non-significantly ($p<0.05$) difference among the yoghurts of both plants and animal sources ($A_{1,2,3,4}$, $B_{1,2,3,4}$ and $C_{1,2,3,4}$) ranges from 1.23nm minimum to 6.03 nm maximum, treated with commercial culture, sorghum and millet compare with the control D

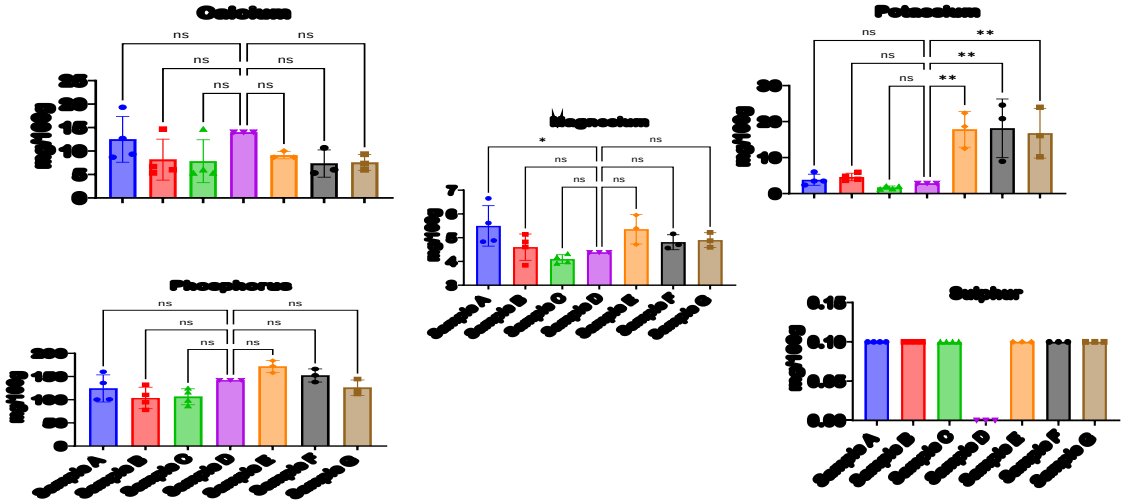
(2.86nm), whereas yoghurts of plant combinations ($E_{1,2,3,}$ $F_{1,2,3,}$ and $G_{1,2,3,}$) (ranges from 8.97nm minimum to 23.97nm maximum) recorded more significantly ($p>0.05$) increase compare to the individual yoghurts and the control D (2.8 nm).

Magnesium content for all the treatment groups increased non-significantly ($p>0.05$) above the yoghurt control D (4.38 nm) in all the experimental groups with the exception of B_4 (3.84 nm), C_1(3.92 nm) C_3(3.98 nm), and F_1 (0.70 nm) that were decreased non-significantly ($p<0.05$). Intriguingly, yoghurt made from 100% okpa (A_2,) treated with commercial culture recorded the highest magnesium content (6.66 nm) followed by 50% okpa + 50% akidi E_1 (5.952 nm).

There are non-significantly difference ($p>0.05$) in the **phosphorus** content for all the treatment groups in all the experimental groups (A, B, C, E, F and G) compared to the control (142.0 mg). However, some of the plant combinations E_1(172.6 mg), E_3 (184.0 mg) and F_2 (166.2 mg) recorded the highest phosphorus concentration while 100% akidi and 100% okpa) treated with sorghum and millet cultures B_3 (78.0 mg) and C_3 (86.2 mg) were the least in concentration of phosphorus.

Sulphur content of all the treatment groups increased non-significantly ($p>0.05$) for all the experimental groups (A, B, C, E, F and G) compared to the control (0.0%). Remarkably, yoghurts made from plants and animal, as well as their combinations, recorded between 0.0 to 0.1 % of Sulphur concentration in relation with the control D (0.0%) value. This result of mineral concentration justifies the assertion of Gray (2007) that yoghurt is a very good source of essential minerals needed for human metabolism or functionality of cells (Ihemeje *et al*, 2015). The results also, are in conformity to the work of Mbaeyi *et al.*, (2009) who demonstrated the effect of fermentation on the mineral composition of Ogi (fermented maize) blended with bambara groundnut. However, the results are not in agreement with FDA, (2009) range of (Ca: 132ppm, P: 38.5ppm and Mg: 46.1ppm).

Figure 3. Mineral composition of Yoghurts fermented with commercial starter, sorghum and millet steep water.



Sample A*: yoghurt fermented with regular culture,* ***Sample B:*** *yoghurt fermented with sorghum culture,* ***Sample C****: yoghurt fermented with millet culture,* ***Sample D****: commercial hollandia yoghurt as control,* ***Sample E****: varied yoghurt fermented with regular culture,* ***Sample F****: varied yoghurt fermented with sorghum culture and* ***Sample G****: varied yoghurt fermented with millet culture*

Vitamin content

The Vitamin content assessed include ascorbic acid, fat soluble vitamins (B complex) and water soluble vitamins (A.D.E.K) as enclosed in Figure 4.The result shows that the percentage (%) of **Vitamin B1,** were not-significantly lowered irrespective of fermented culture($p>0.05$) in all of the 100% yoghurts with concentration range of B_3C_3 (0.01% each), $A_3A_4B_2B_4C_1C_2C_4$(0.02mg each) and A_2B_1(0.03 mg each) excluding non-significantly increased cowbell A_1 (0.05 mg) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p<0.05$) and recorded concentration range of $E_2F_1G_1$ (0.05 mg each), F_2(0.06 mg), E_1(0.07 mg) and E_3(0.08 mg) with exception of F_3G_2 (0.03 mg each) and G_3 (0.01 mg) in comparison with the control yoghurt D (0.04 mg).

In a similar way, **Vitamin B2** was non-significantly lowered irrespective of fermented culture($p>0.05$) in all of the 100% yoghurts with concentration range of B_3C_3(0.05% each) B_4C_4(0.06 mg each), A_3(0.07 mg), A_4(0.08 mg), and $A_2B_1\mathbf{B}_2C_1C_2$ (0.10 mg each) excluding non-significantly increased cowbell A_1 (0.16 mg) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p<0.05$) and recorded concentration range of E_3(0.20 mg), E_1(0.18 mg), F_2(0.16 mg), E_2(0.14 mg)with exception of F_1(0.12 mg), G_1(0.10 mg), F_3(0.09 mg)G_2(0.07 mg) and G_3(0.02 mg) in comparison with the control yoghurt D (0.14 mg).

Also, **Vitamin B3** was non-significantly lowered in any case of fermented culture($p>0.05$) in all of the 100% yoghurts with concentration range of B_3C_3 (0.02 mg each), $A_3A_4B_4C_4$(0.04 mg each), $B_2C_1C_2$(0.05 mg each) and A_2B_1(0.06 mg each) excluding the non-significantly increased cowbell A_1 (0.10 mg) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p<0.05$) and recorded concentration range of E_3(0.14%), E_1(0.12%), F_2(0.11%), E_2(0.10mg)F_1G_1(0.09 mg each), with exception of F_3(0.07mg)G_2(0.05mg) and G_3(0.02mg) in comparison with the control yoghurt D (0.08mg).

The trend was extended to **Vitamin A,** thatwas non-significantly lowered regardless of fermented culture($p>0.05$) in all of the 100% yoghurts with concentration range of B_3C_3 (2.0 and 2.2ug), B_4C_4(3.8 and 3.7 ug), A_3A_4(4.1 and 4.3ug), B_2C_2(5.8ug each),C_1(6.3mg) and A_2B_1(7.0ug each) excluding non-significantly increased cowbell A_1 (10.2ug) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p<0.05$) and recorded concentration range of E_3(11.4ug), E_1F_2(10.8 and 10.4ug), E_2(9.6ug) F_1(8.0ug) F_2(0.06ug), and with exception of G_1(7.6ug), F_3(6.2ug), G_2 (5.0ug) and G_3 (3.8ug) in comparison with the control yoghurt D (7.9ug).

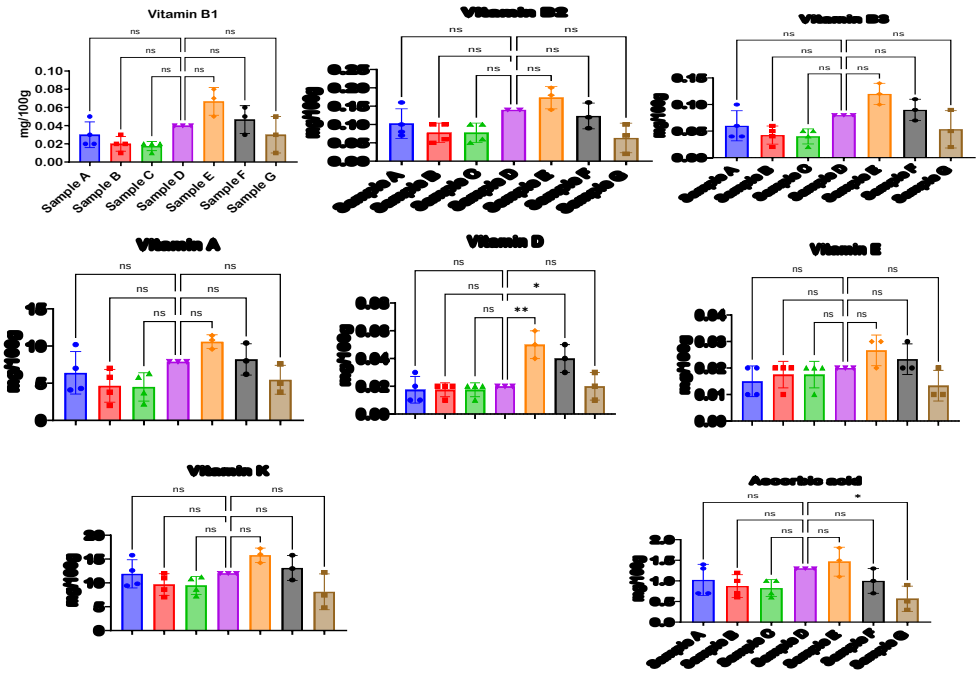
Vitamin D showed non-significant difference ($p\leq 0.05$) regardless of fermented culture in groups ($A_{1,\,2,\,3,\,4}$, $B_{1,\,2,\,3,\,4}$, $C_{1,\,2,\,3,\,4}$,) i.e. in all of the 100% yoghurts with concentration range of $A_3A_4B_3C_3$ (0.01mg each), A_2B_1 B_2 B_4 $C_1C_2C_4$ (0.02mg each) except for A_1(0.03mg) while 50% varied yoghurts irrespective of fermented culture were very significantly increased ($p<0.05$) and recorded concentration range of E_3(0.06mg), E_1F_2(0.05mg each), E_2F_1(0.04mg each), F_3G_1(0.03mg each) and G_2(0.02mg) together with G_3 (0.01mg) recorded non significantly difference all in comparison with the control yoghurt D (0.02 mg).

Vitamin E also share non-significant difference ($p\leq 0.05$) irrespective of fermented culture($p>0.05$) with almost all of the 100% yoghurts with concentration range of $A_3A_4B_3C_3$ (0.01mg each), $A_1A_2B_1B_2B_4C_1C_2C_4$(0.02mg each) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p>0.05$) and recorded concentration range of $E_1E_3F_2$(0.03mg each), $E_2F_1F_3G_1$(0.02mg each) and G_2G_3(0.01mg each) recorded non significantly lower in comparison with the control yoghurt D (0.02mg).

Vitamin K was also similar to the preceded vitamins as it were non-significantly ($p \leq 0.05$) lower in all the fermented cultures ($p>0.05$) with almost all of the 100% yoghurts with concentration range of B_3C_3(7.0 and 7.2mg), B_4C_4(8.6mg each), A_3A_4(9.4 and 9.8mg), C_2(10.8mg), B_2C_1(11.0 and 11.2mg)andB_1(12.0mg)exceptA_1 A_2 (15.8 and 12.6mg) while 50% varied yoghurts fermented in all the cultures were non-significantly increased ($p>0.05$) and recorded concentration range of E_3 (17.2mg), E_1(16.0mg), F_2(15.8mg), E_2 (14.2mg), F_1(13.0mg), F_3 G_1(12.2mg) and G_2(7.4mg) and G_3(4.8mg) recorded more significantly lower in comparison with the control yoghurt D (12.0mg).

Vitamin C, was non-significantly lowered irrespective of fermented culture($p>0.05$) in all of the 100% yoghurts with concentration ranged of B_3C_3 (0.06mg each), $A_3A_4B_4C_4$ (0.7mg each), $B_2C_1C_2$(1.0mg each), and B_1(1.2mg) excluding non-significantly increased cowbell A_1 (1.4mg) and A_2(1.3mg) while 50% varied yoghurts irrespective of fermented culture were non-significantly increased ($p<0.05$) and recorded concentration range of E_3(1.8mg), E_1(1.5mg)and F_2(1.3mg), G_1 (0.05mg each), and with exception of E_2(1.1mg), F_1(1.0mg), F_3G_2 (0.03mg each) and G_3 (0.01mg) in comparison with the control yoghurt D (1.3mg). Vitamins are important nutritional components required for the normal functioning of the human body (USDA, 2014).

Figure 4. Vitamin composition of Yoghurts fermented with commercial starter, sorghum and millet steep water.



Sample A*: yoghurt fermented with regular culture,* ***Sample B:*** *yoghurt fermented with sorghum culture,* ***Sample C****: yoghurt fermented with millet culture,* ***Sample D****: commercial hollandia yoghurt as control,* ***Sample E****: varied yoghurt fermented with regular culture,* ***Sample F****: varied yoghurt fermented with sorghum culture and* ***Sample G****: varied yoghurt fermented with millet culture*

Chemical analysis

Chemical properties analyzed include: pH, titratable acidity (T. A), total soluble solids (T.S. S), viscosity (cP) and milk solid non-fat (M.N.S. F) Figure 5. The result revealed that **milk solid non-fat (MNSF)** composition was non-significantly ($p>0.05$) lowered in all of the yoghurts regardless of fermented culture, except in group A_1, (15.41%) also A_2 (12.19) 100% cowbell and 100% okpa respectively both fermented with commercial culture, compared to the control yoghurt D (12.24%).

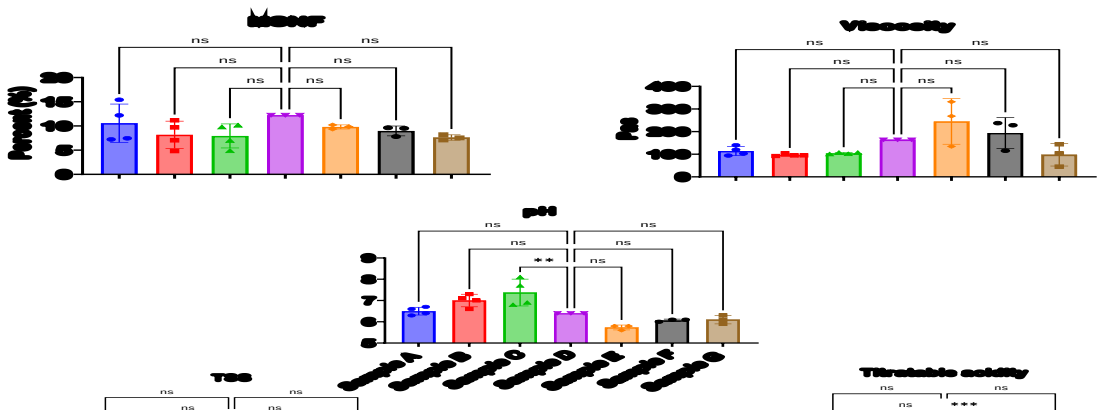
Also, the result of **Viscosity** was alsonon-significantly ($p>0.05$) lowered in all of the 100% yoghurts with concentration ranged between 92.0 to 140mpas while the 50% varied yoghurts also ranged between 45.2mpas to 331.8mpas as compared to the control yoghurt D (164.3mpas). Surprisingly, 50% varied yoghurts such as E_1(268.5mpas), E_3 (331.8mpas), F_1, (228.2mpas)and F_2, (237.2.5 mpas)recorded high concentration of viscosity than the yoghurt control D (164.3 mpas). and those of the 100% yoghurts. 50%akidi + fiofio yoghurt fermented with regular starter culture, highest concentration of viscosity E_3 (331.8mpas), while 50%akidi + fiofio yoghurt fermented with millet steep water scored lowest concentration of viscosity G_3(45.2mpas). Interestingly, viscosity results are in agreement with those obtained by Adriana *et al*, (2018); Crispín-Isidro *et al*. (2015) which reported that gel firmness increases at a level of 2–4mpas inulin addition.

The result revealed varied **pH** levels among the tested samples. The pH of the cowbell yoghurts and the un-combined plants i.e. 100% yoghurts $A_{1, 2, 3, 4}$, $B_{1, 2, 3, 4}$, and $C_{1, 2, 3, 4}$,) fermented with commercial starter, sorghum and millet steep cultures were appreciably higher ranged from 6.3 to 8.1 ($p<0.05$) than those of the combined plant i.e. 50% yoghurts ($E_{1, 2, 3,}$ $F_{1, 2,3}$ and $G_{1, 2, 3}$) that ranged from 5.6% to 6.3. A highly-significant difference ($p<0.05$) was observed in the yoghurt of 100% group $C_{1,}$ C_3 and $B_{1,}$ as they scored very more (8.1 7.7 and 7.3) respectively than the control yoghurt D (6.4). However, the general consensus about the pH value for acceptable and good quality product ranges between 3.5 and 4.6 according to Tugba, 2022; Biberoglu and Ceylan, 2013; Ezeonu, Tatah, Nwokwu, and Jackson, 2016; Tamime and Deeth, 1980; Tomovska, Gjorgievski, and Makarijoski, 2016. Also, 3.38minimun and 4.80maximun for Egyptian Yoghurt Standards (EOSQC), (2005)

The result further showed that there was no statistical difference in the level of **total soluble solid (TSS)** among the yoghurt samples that were fermented with commercial starter culture, sorghum and millet steep culture both the100% and 50% yoghurts except for yoghurts $B_{3,4}$, $C_{3,4}$ and G_3 that recorded (0.00 % each) compared to the control D (0.10 %). The total solids are an indication of the dry matter content of the yoghurt samples (Joel *et al*, 2014; Belewu *et al.*, 2010; Khalifa *et al* 2011).

Titrated acidity (T. A) of the result showed high significantly reduction on group ($C_{1, 2, 3, 4}$,) and non-significantly($p<0.05$) lower among both yoghurts animal and plants source treated in all the cultures. Interestingly, group ($E_{1, 2, 3}$) and G_3 50% combination of plant fermented with the commercial starter culture recorded highly significantly ($p<0.05$) values (0.14, 0.14 and 0.16 % each) and (0.12 %) than the control sample D (0.10 %). Reason for the lower titrated acidity could be due to more availability of lactose to the fermenting microbes (Joel *et al*, 2014). However, these values of titrated acidity recorded are non-significantly($p<0.05$) lower than the average of 0.6% acidity recommended for plain yoghurts (Joel *et al*, 2014; Eke *et al*,2013).

Figure 5. Chemical analysis of Yoghurts fermented with commercial starter, sorghum and millet steep water



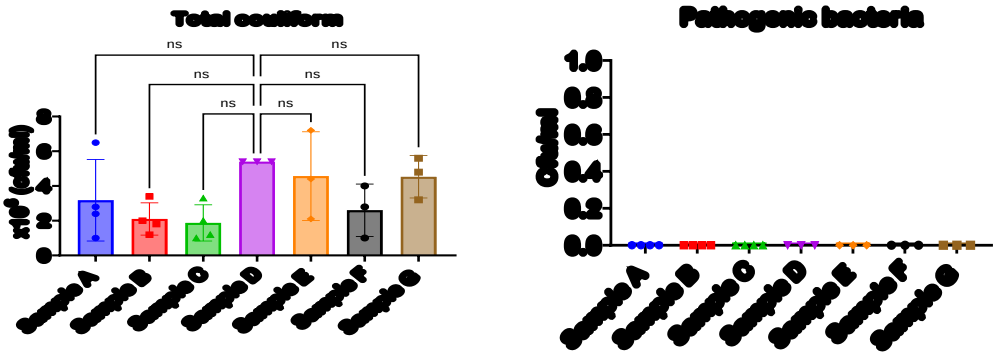
***Sample A**: yoghurt fermented with regular culture, **Sample B:** yoghurt fermented with sorghum culture, **Sample C**: yoghurt fermented with millet culture, **Sample D**: commercial hollandia yoghurt as control, **Sample E**: varied yoghurt fermented with regular culture, **Sample F**: varied yoghurt fermented with sorghum culture and **Sample G**: varied yoghurt fermented with millet culture*

Microbial analysis

The examined microbial include: Total microbial load (viable counts) (TVC) and potential pathogen bacteria, Figure 6. ***Total coliform*** results showed that the content for all the treatment groups decreased non-significantly ($p<0.05$) for all the experimental groups compared to the control D (5.4×10^6) with the exception of 100% okpa yoghurt treated with commercial culture A_2, (6.5×10^5) and 50% akidi + fiofio yoghurt treated with sorghum and millet steep water E_3 ($7.2 \times 10^{5)}$ G_3 (5.6×10^6) that recordednon-significantly ($p<0.05$) higher than the control D (5.4×10^6). The analysis further revealed that the *total viable counts (TVC*) of the microbiological analysis contains 1.0×10^6,6.5×10^5,2.8×10^6,2.4×10^6,1.2×10^6, 2.0×10^6,1.8×10^6, 3.4×10^6, 1.0×10^6, 1.2×10^6,2.0×10^6, 3.3×10^5, 5.4×10^6, 4.4×10^5,2.1×10^6,7.2×10^5,2.8×10^6,1.0×10^5, 4.0×10^6, 3.2×10^6,4.8×10^6 and 5.6×10^6 for all the groups (($A_{1, 2, 3, 4}$, to $G_{1, 2, 3,}$) respectively in colony forming unit (cfu/ml) which is in agreement with Nigeria National Industrial Standard for yoghurt (NIS337:2004). Also, the study of Farinde *et al*., in 2009 reported that the standard yoghurt bacterial load range should be < ($1x10^6$cfu/g).

Total coliform and ***Escherichia coli,* (Pathogenic bacteria)***were* absent in all the yoghurt samples, suggesting that the yoghurts were safe and suitable for consumption (NIS337:2004). However, there were an unsteady rise of yeast/mould observed from yoghurts of okpa yoghurt treated with commercial culture (A_2) and mixture of akidi + fiofio yoghurt treated with sorghum (E_3) that recordednon-significantly ($p<0.05$) higher than the control (D).(6.5×10^5cfu/ml and 7.2×10^5cfu/ml respectively) which is in conformity with the report of Abrar, *et al* (2009). Interestingly, all the yoghurts recorded values within the normal range (6.33cfu/ml and 10.33cfu/ml) (NIS337, 2004) of Nigeria Industrial Standard, (2004), Egyptian yoghurt Standards (EOSQC), (2005) Turkish Standard Institute (1989) and National Yoghurt Association, (2006) all stated that a maximum count of 10cfu/ml of coliform group bacterial is acceptable in yoghurt. Hence, in this study, the samples with the values less than or equal to 10cfu/ml are therefore justified suitable and safe for consumption. Absence of *Escherichia coli* and *coliforms* as reported will extend the shelf-life of the products.

Figure 6. Microbial analysis of Yoghurts fermented with commercial starter, sorghum and millet steep water.



***Sample A**: yoghurt fermented with regular culture, **Sample B:** yoghurt fermented with sorghum culture, **Sample C**: yoghurt fermented with millet culture, **Sample D**: commercial hollandia yoghurt as control, **Sample E**: varied yoghurt fermented with regular culture, **Sample F**: varied yoghurt fermented with sorghum culture and **Sample G**: varied yoghurt fermented with millet culture*

Sensory Scores of Yoghurts

Aroma, appearance, taste, texture, and overall acceptance Figure 7, were the sensory qualities evaluated. The statistical analysis revealed that there were significant differences ($p<0.05$) among the yoghurt samples in the sensory attributes observed. Sample A_1 (100% cowbell yoghurt fermented with regular starter culture) had the highest score (8.3) higher, while sample $F_{1,\ 2,3}$ and $G_{1,\ 2,\ 3}$ (50% okpa + akidi, okpa +fiofio and akidi + fiofio yoghurts treated with sorghum and millet steep water) had the lowest score range (1 to 1.2 %)lower in **Aroma** as compared with control yoghurt D (8.0%).

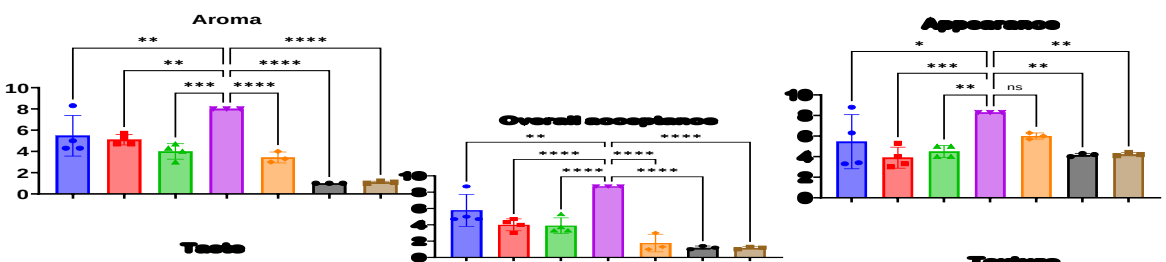
In **Appearance**, sample A_1 (100% cowbell yoghurt fermented with regular starter culture) had the highest score (8.8) higher, while sample $F_{1,\ 2,3}$ and $G_{1,\ 2,\ 3}$ (50% okpa + akidi, okpa +fiofio and akidi + fiofio yoghurts treated with sorghum and millet steep water) had the lowest score range (4.1 to 4.3 %) lower **as** compared with control yoghurt D (8.3%).

The result also revealed that in the yoghurt **taste**, sample A_1 (100% cowbell yoghurt fermented with regular starter culture) had the highest score (8.0) higher, while sample $F_{1,\ 2,3}$ and $G_{1,\ 2,\ 3}$ (50% okpa + akidi, okpa +fiofio and akidi + fiofio yoghurts treated with sorghum and millet steep water) had the lowest score range (1 to 1.1 %)lower as compared with control yoghurt D (7.7%).

However, in **texture**, Sample A_1 (100% cowbell yoghurt fermented with regular starter culture) had the highest score (7.0) but lower, while sample $F_{1,\ 2,3}$ and $G_{1,\ 2,\ 3}$ (50% okpa + akidi, okpa +fiofio and akidi + fiofio yoghurts treated with sorghum and millet steep water) had the lowest score range (1 to 1.1 %) much lower **as** compared with control yoghurt D (8.0%). It is important to say that: the texture of fermented dairy products is highly associated with composition of the milk, heat treatment, starter culture used, and acidification rate as well as storage conditions Tugba, (2022). Therefore, textural necessity can be difficult to achieve, especially in low-fat and fat-free products.

Finally, in **overall acceptance,** also sample A_1 (100% cowbell yoghurt fermented with regular starter culture) had the highest score (8.7) equal to, while sample $E_{1,2}$, $F_{1,\ 2,3}$ and $G_{1,\ 2,\ 3}$ (50% okpa + akidi, okpa +fiofio and akidi + fiofio yoghurts treated with sorghum and millet steep water) had the lowest score range (1.0 to 1.4%) lower **as** compared with control yoghurt D (8.7%). The overall results showed that the sensory evaluation response of participants with regard to all the yoghurts were absolutely in relation to the fortification of animal sourced milk (cowbell) and addition of additives to the control yoghurt D (Hollandia plain yoghurt). The five parameters evaluated were observed to be significantly increased or equal to and to an extent non-significant differ in both the yoghurts fermented with the regular starter culture and sorghum and millet steep water with appreciable values been recorded in 100% yoghurts such as on average of 4.0minimun to 8.0maximun across all the parameters evaluated. Interestingly, a similar analysis has been reported by Nath *et al*, 2020, and also by Ryan *et al*, 2020 where mango enriched yoghurt showed overall improvement in sensory scores.

Figure 7. Sensory Scores of Yoghurts fermented with commercial starter, sorghum and millet steep water.



Sample A**: yoghurt fermented with regular culture, **Sample B:** yoghurt fermented with sorghum culture, **Sample C**: yoghurt fermented with millet culture, **Sample D**: commercial hollandia yoghurt as control, **Sample E**: varied yoghurt fermented with regular culture, **Sample F**: varied yoghurt fermented with sorghum culture and **Sample G**: varied yoghurt fermented with millet culture.

Conclusions

The study has presented 22 yoghurts formulations and blends combining with 2 selected potential cultures: sorghum and millet that possess the *Lactobacillus bugaricus* and *Streptococcus thermophilus*as alternative to commercial starter culture for yoghurt fermentation. The obtained results from all the formulations and control yoghurt, demonstrated that the production of yoghurt from plants raw materials and or integration of plant extracts from Okpa, akidi oji and fiofio is feasible and viable. Also, from the study was seen the feasibility of sorghum and millet steep water having the potential to ferment milk for yoghurt production. However, there is need for further research on eliminating beany flavour and unhealthy aroma associated grains and cereals used in the yoghurt production, as unwholesome aroma could discourage yoghurt producers from using the local culture, for the fear of their product being rejected by the consumers. The mean proportional level of proteins, carbohydrates, phytochemicals, vitamins and minerals present in all the yoghurt samples are nutritionally significant in terms of the potentials of these yoghurts to contribute to the dietary balanced for dairy consumers. The results obtained from mineral and vitamins contents also justifies the assertion that yoghurt is a very good source of essential minerals needed for human metabolism or functionality of cells, and are also important source of vitamins for nutritional components required for the normal functioning of the human body. Furthermore, the absence of *Escherichia coli* and *coliforms* as reported will extend the shelf-life of the products. However, the result further revealed that the animal sourced yoghurt recorded the highest overall preference base on the sensory evaluation scores compared to the three plant-based yoghurts 100% (akidi, okpa, fiofio) and their 50% combinations.With this satisfactory results obtained from yoghurt produced from local plant raw materials, it is therefore, advised that individuals should welcome, use and promote yoghurts, beverages and other foods made from full or blends of *Cajanus cajan (Fiofio), Vignia ungiculata (Akidi oji) and Vignia subterranea **(Okpa)***

Declarations

1. **Ethical Approval and Consent to Participate:** Not Applicable
2. **Consent for publication:** The submission of the manuscript to your journal is by our permission.
3. **Competing interests:**There is no conflict of interest.
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   Prof Eberechkwu Akalihu Udensi– Coordinator and leader of the Research team, manuscriptreviewer, co- supervised the sample preparations.
   Prof Sunday Onyekwere Eze - manuscriptreviewer and supervised the sample preparations.
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   Mr Chioma Ernest Ubiji. – procured raw materials, formulated, prepared and monitored the samples prior to Laboratory analysis.

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