

## INDIGENOUS ADDITIVES: EFFECTS ON THE PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF FERMENTED YAM FLOUR AND ITS PRODUCT- *AMALA*

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## ABSTRACT

The inclusion of indigenous additives during the processing of *elubo* (fermented yam flour) has been alleged to result in high quality *amala* (reconstituted fermented yam flour) by improving its colour characteristics, which is a major quality index of *amala*, and other sensory attributes. Therefore, this study was conducted to determine the effect of indigenous food additives on the colour and chemical properties of *elubo* and the sensory properties of *amala*. Five (5) batches of *Elubo* were processed from *Dioscorea rotundata* var. *atoja* with indigenous additives (*ewe okan*, *popooro oka*, *omikan* and *ewe abafe*) and a control sample with no additive. *Amala* samples were prepared from the *elubo* samples using standard method. The chemical properties (proximate composition, pH, starch and sugar content) of the *elubo*; colour parameters: L\* (lightness), a\* (red-green axis) and b\* (yellow-blue axis) of *elubo* and *amala*; and sensory evaluation properties of *amala* were determined using standard procedures. The study showed that indigenous additives had significant ( $p < 0.05$ ) effect on the pH, ash content, crude fat and starch content. The results of the colour parameters showed that L\* and b\* values of the *elubo* samples without additives were the highest (92.22) and lowest (11.92) respectively, as the samples with additives had reduced L\* values ranging between 87.71 to 75.37 and increased b\* values of 12.46 to 13.68 respectively. The additives had significant effect on the L\* (46.78 to 52.90), a\* (3.49 – 6.08) and b\* (9.04 – 13.12) values of the *amala* samples. There were also significant ( $P < 0.05$ ) effects of the additives on the sensory properties of *amala*. Hence, the selected additives used in processing of fermented yam flour (*elubo*) had significant impact on the sensory attributes and colour parameters of the fermented yam flour and its resulting product (*amala*), but no significant effect on most of the chemical properties.

**Key words:** Fermented yam flour, *Popooro oka*, *ewe okan*, *omikan*, quality attributes



## INTRODUCTION

Yam (*Dioscorea spp*) is the second most important tropical root crop after cassava [1]. It is an important staple food crop in Nigeria, produced both for household consumption and as a cash crop [2]. Yam is referred to as an elite crop, because it is a choice crop over other roots and tubers during ceremonies and festivals. It is majorly eaten as boiled, roasted, fried, porridge and pounded yam or blanched, fermented, dried and milled into flour to obtain *elubo* (fermented yam flour).

*Amala* is prepared by reconstituting *elubo* in boiling water to form a thick paste of desired consistency; which could be eaten with different types of soup or vegetables [3]. *Amala* is a delicacy for people of western Nigeria, as the Yorubas see it as an important meal that must be served during important occasions. It is also consumed in some other parts of Africa, including Ghana, Benin Republic; it is referred to as *kokonte* among the Ashante people of Ghana [4].

*Elubo* is traditionally processed by blanching yam tuber slices till the temperature reaches about 70 °C, and removing the heat source, steeping (regarded as fermentation) for about 13 - 24 hours, drying and milling into flour. However, deterioration of colour- a major quality index, occurs rapidly during the processing of *Elubo*. The discoloration in yam tubers, from white/cream to dark brown, is mainly associated with enzymatic browning caused by the presence of polyphenol oxidase in fresh yam tubers [5]. It is believed that the process of blanching and steeping (regarded as fermentation) activates the enzymes, as the heating temperature is not efficient to inactivate the enzymes, thereby promoting the change in colour from cream/white to a slightly darker colour range- desired for *amala* by consumers. It has been established that enzymatic browning can be prevented or limited by the use of reaction inhibitors, by-product extracts, modified atmosphere and physical treatments [6, 7, 8].

Traditionally, additives such as *ewe abafe* (camel's foot leaf), *popooro oka* (guinea corn stem), *ewe okan* (greenheart leaf) and *omikan* (fermented maize water) are used in the processing of *elubo* to enhance the colour quality. *Ewe okan*, *ewe abafe*, *popooka* and *omi-kan* were stated as the main additives usually used in *elubo* processing (based on interviews with local processors in Iwo local government; Igbeti and Igboho area (Oyo-North)). These leaves and stem are known to be of varying importance, ranging from medicinal, nutritional to functional. They contain active ingredients that are nutritious and therapeutics, containing phytochemicals: used to treat different kinds of diseases, such as antidiabetic, antimicrobial and antioxidant [9, 10, 11, 12]. These phytochemicals have also been reported to be useful for impacting colour effects in processed herbs, drinks or foods [13, 14]. Excellent phytochemical attributes of *ewe abafe* has been reported, ranging from anticancer, antimicrobial, antioxidant, through to its other pharmacological effect [13]. Salau [14] found that sorghum stalk contains significant alkaloid, tannins, cardiac glycoside and saponins, impacting medicinal potentials on this plant part. *Cyliocodiscus gabunensis* plant (greenheart) was reported by Ayuk [12] to exhibit excellent antimicrobial properties.

These indigenous additives are alleged by some traditional processors to result in high quality product of *amala*; some processors believe that the additives impact desired colour and enhance the sensory attributes of *amala*. Additives are usually added to the steeping water prior to blanching, and are left to steep in the water till the end of the 24hr, believed to be the fermentation period. Since the acceptance and quality of *elubo* and *amala* is firstly dependent on the colour, and the use of indigenous additives have not been documented, there is therefore a need to ascertain the claims by evaluating the effects of some of these additives on the colour parameters and chemical properties of *elubo*, as well as the sensory and colour parameters of the resulting *amala*.

## MATERIALS AND METHODS

### Source of Materials

*Dioscorea rotundata* var. *Atoja* was selected for the study, as it is one of the main variety of *D. rotundata* species used for fermented yam flour processing. Ten tubers of yam (about 15 kg) were obtained from a local farm in Iwo Local Government area of Osun State (Latitude 7.6292° N, Longitude 4.1872° E). The tubers were purchased and transported in sacs to the laboratory where the work was carried out. Matured and fresh *ewe okan*, *ewe abafe*; and *popooka* were obtained from a local market in Iwo Local government area of Osun State, while *omikan*, was collected after 48 hours fermentation period of ogi (Table 1).

### Methods

#### *Preparation of elubo (fermented flour)*

Five batches of *elubo* were processed from the yam tubers by modifying the method of Abiodun and Akinoso [15] with that described by local processors interviewed in Oyo north region. Yam tubers were washed under running water to remove adhering soil, peeled and the size reduced to a thickness of about 70 mm by 30 mm, and then randomly divided into five parts. Each part was transferred into different heating medium and then covered with water, after which each of the additives were added to four portions (Sample A- *Ewe okan*; Sample B- *popooka*; Sample C- *omikan*; Sample D- *ewe abafe*), and the last portion served as the control (Sample E- without any additive). A ratio of 1:1 (w/v) (in gram/litres) of water to leaf additives was used, while 1:10 (v/v of *omikan*/water) was used for the water additive (*omikan*). Each portion was blanched, by allowing the temperature to reach 70±2 °C, which took about 15 – 20 minutes, after which it was removed from the heat source. The blanched yams were left to steep in the blanching water for 24 hours to attain a flabby nature, after which it was drained and sun-dried till constant weight. The dried yams were milled to fine flour (*elubo*) using a locally fabricated disc attrition mill and packaged in an air-tight low-density polyethylene bag.

#### *Preparation of amala*

*Elubo* was reconstituted into *amala* by simulating the traditional method in the laboratory. *Elubo* (200 g) was added into 500 ml of boiling water, followed by continuous stirring until a smooth mixture resulted. Followed by the addition of 40 ml of water, covered and slowly cooked for 5 minutes, after which the source of heat was removed and final stirring was done to have a smooth paste, *amala*. The *amala* was



wrapped in aluminium foil in sizes that could be presented to sensory panellists and then stored in Styrofoam box prior to sensory evaluation.

## Methods of Analysis

### Colour parameters

Hunter Lab colorimeter meter (Colour Tec PCMTM Colour Tec Associates, Konica Minolta sensing, Inc. Japan) was used to determine the colour parameters ( $L^*$ ,  $a^*$  and  $b^*$ ) of the *elubo* and *amala* samples [16]. Brown index (BI) was calculated (Equation i), Metric hue angle, delta Chroma ( $\Delta C$ ) and total colour difference ( $\Delta E$ ) were as calculated using Equations. ii, iii and iv, respectively [17, 18].

$$\text{Brown Index (BI)} = 100 - L^* \quad (\text{i})$$

$$\text{Metric Hue angle} = \text{Tan}^{-1} \frac{b^*}{a^*} \quad (\text{ii})$$

$$\Delta C = \sqrt{[(\Delta a^*)^2 + (\Delta b^*)^2]} \quad (\text{iii})$$

$$\Delta E = \sqrt{[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]} \quad (\text{iv})$$

### Physico-chemical properties

Proximate composition of the samples were determined by AOAC [19], using kjedahl method for crude protein (Method No. 978.04), soxhlet extraction for crude fat (Method No. 930.09), acid and alkaline digestion for crude fibre, muffle furnace for ash content (Method No. 930.05) and oven drying for moisture content. pH was determined by AOAC [19]. Dubois *et al.* [20] method was used to determine starch and sugar spectrophotometrically, as described by Otegbayo [21].

### Sensory evaluation

Thirty semi-trained panellists, comprising of both males and females, varying age range, familiar with the consumption of *amala* were employed for the consumer-oriented sensory evaluation. The samples were evaluated using a 9-point hedonic scale form for scoring the attributes of appearance, taste, aroma, mouldability, smoothness and overall acceptability, where 9 was like extremely, 8 was like very much, 7 was like moderately, 6 was like slightly, 5 was neither like or dislike, 4 was dislike slightly, 3 was dislike moderately, 2 was dislike very much and 1 was dislike extremely. The samples were presented to them on coded plates, under bright lighting with no interference for bias responses.

### Statistical Analysis

Data were analyzed for Analysis of Variance (ANOVA) and means separation of replicate results using Duncan's multiple range test (SPSS package V20). Data were given as means  $\pm$  standard deviation and others are presented in figures.

## RESULTS AND DISCUSSION

### Colour parameters of *elubo* and *amala*

The effect of indigenous additives on the colour attributes of *elubo* (fermented yam flour) and *amala*, as determined by the  $L^*$ ,  $a^*$  and  $b^*$  coordinates of the CIE scale are shown in Figure 1 and 2 respectively. The lightness or luminance component of the fermented yam flour samples were significantly ( $p < 0.005$ ) different from each other,



ranging from 75.37 to 92.22 and 7.78 to 24.63 respectively, with sample B (with *popooka*) having the least lightness and highest brown index, that is the darkest and sample E (without additive) having the highest lightness and least brown index. This implied that *Popooka* had the highest effect on the colour attributes of yam flour, followed by *ewe abafe*, *ewe okan* and then *omikan*. Research has shown that *popooka* (guinea corn stem) is an important local food colorant, containing significant amount of phenolic compounds [9, 22]; Ayuk *et al.* [12] also reported on the phytochemicals present in *Cyclicodiscus gabunensis* (*ewe okan*). Camel's foot leaf or monkey bread leaf (*ewe abafe*) also contains significant amount of phytochemicals which are medicinal, and also contributory to colour changes as qualitatively and quantitatively reported to contain colour active ingredients [23, 24]. These implied that the additives, especially *popooka*, *ewe abafe* and *ewe okan* has important colour constituents present in them that was infused into the yam slices in the course of blanching, steeping and fermentation.

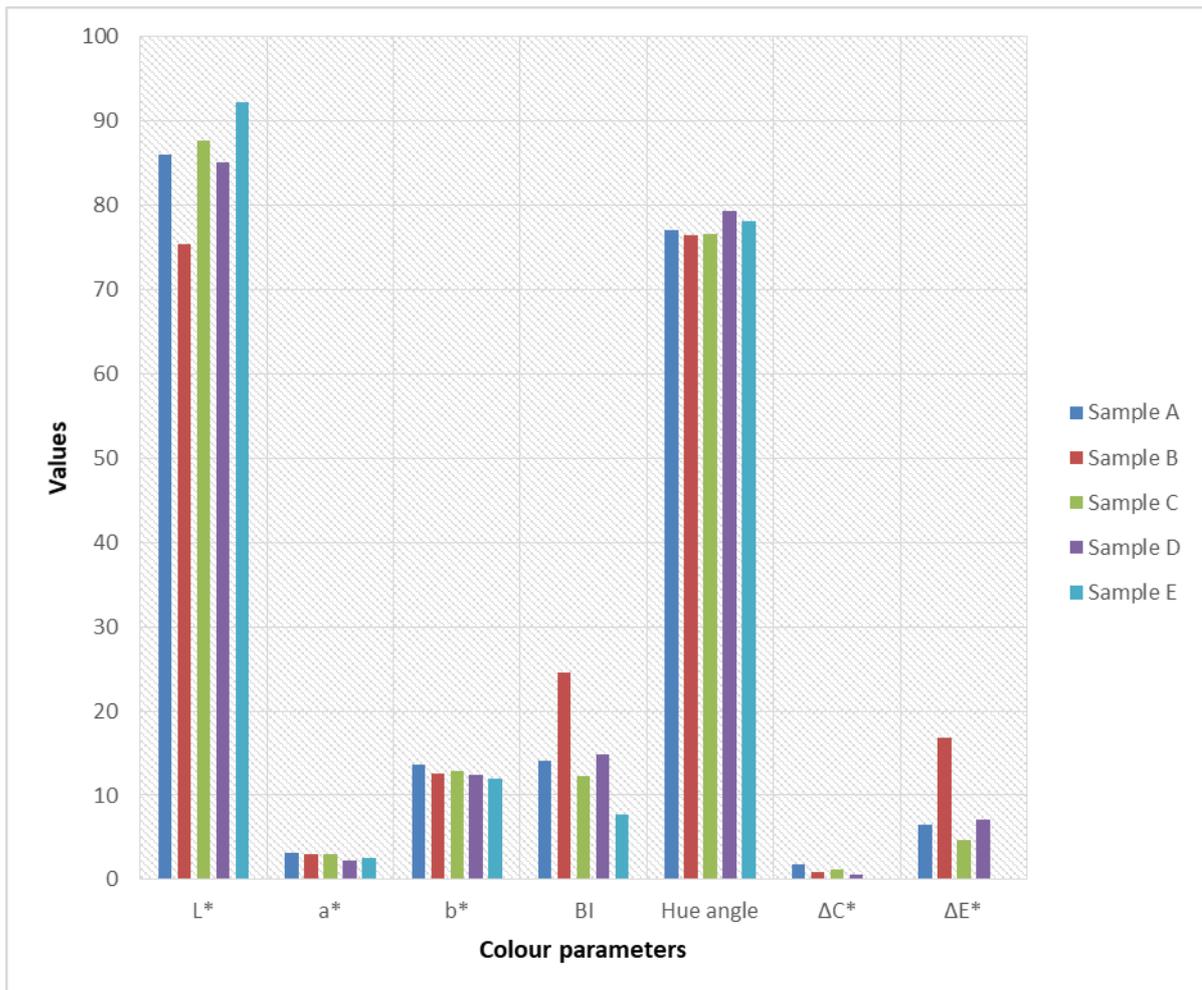
The L\* values and brown index of *amala* ranged from 46.78 to 52.90 and 47.1 to 53.22 respectively, showing significant differences ( $p < 0.05$ ) among the samples, with the sample without additive having the highest lightness and least brown index, and sample fermented with *ewe okan* having the least light colour, or the darkest. The additives had significant levels of effects on the colour of the resulting *amala*; as *ewe okan* had the highest colour impact, reducing the whiteness, followed by *popooka*, then *ewe abafe* and *omikan*. However, the colour change that occurred in *amala* after flour reconstitution was as a result of non-enzymatic browning caused by mailard reaction that occurred during heat treatment between free sugar and amino acid of the flour; as well as thermal degradation of the colourless complex polyphenols to coloured phenols during reconstitution [25, 26]. Traditionally, it is believed that these indigenous additives contribute to the desired browning of *amala*; as different varieties present different colours on blanching. Some varieties have higher browning rate, while others remain as they are without changing colour. Hence, the indigenous additives are believed to control the browning rate of those higher, and impact desired browning in those with very low browning rate during the blanching and steeping period. Corroboratively, the result showed that the additives had significant effect on the colour of *elubo* and *amala*, as it contributed to reducing the lightness or whiteness of the yam variety which presented very low brown index (7.78) in the sample without additives. Hence, the additives contributed to producing the light brown colour of *amala* resulting from mailard reaction, regarded by local processor to be of higher quality, as against the very light grey or very light brown colour that would have resulted.

The a\* coordinate ranged from +2.33 to +3.13 for the *elubo* (Figure 1), with the *elubo* samples without additive and with *ewe abafe* insignificantly different from each other, but different from the remaining samples. The positive values observed for all the samples showed that they tend towards red than green, however, sample with *ewe okan* had the highest a\* value, tending more towards red than others. For the *amala* samples, there were significant ( $p < 0.05$ ) differences in the a\* values, ranging from 3.49 to 6.08, which tended towards red than green. Moreover, the *amala* samples had higher a\* than the *elubo* samples (Figure 1.0), as the *amala* samples were darker as shown by low L\*

values, resulting from the chemical reactions that occurred in the course of reconstitution.

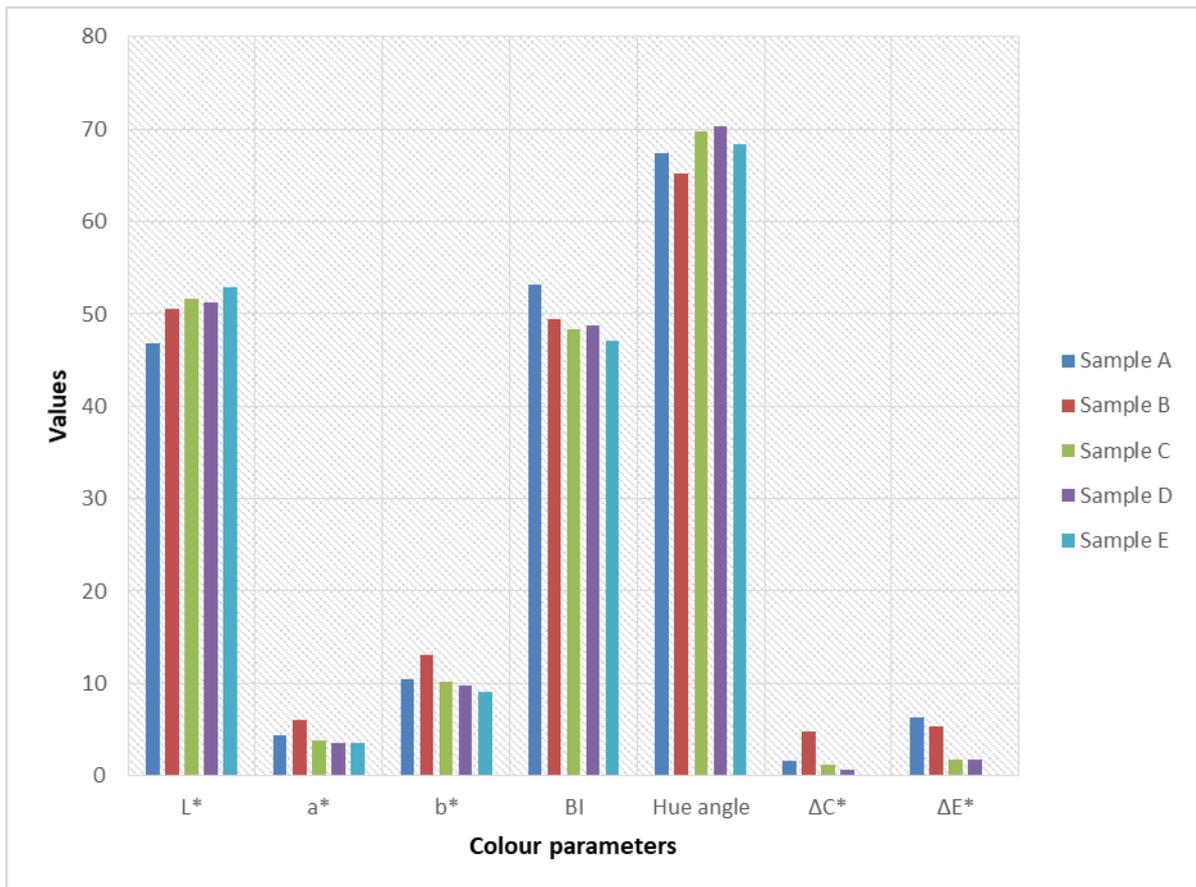
The blue-yellow indicator shown by the  $b^*$  parameter ranged from 11.92 to 13.68 for the flour samples and 9.04 to 13.12 for the *amala* samples, varying significantly ( $p < 0.05$ ). The result showed that the flour sample and *elubo* sample without additive had the lowest values for both, indicating movement towards yellow, farther from blue, which was an indication of the lightness or whiteness of these samples, related to the results of  $L^*$  values. Hence, sample without additives was lighter in appearance. The colour variations observed in the *elubo* and *amala* samples could be linked to the composition of the phytochemicals present in the indigenous additives.

The calculated colour parameters of *elubo* and *amala*: hue angle, delta chroma ( $\Delta C$ ) and total difference ( $\Delta E$ ) were also shown in Figure 1 and 2. The hue angle, which was a measure of how individual perceived the colour varied significantly for both *elubo* and *amala*, ranging from 76.48 to 79.41 and 65.16 to 70.28 respectively. The colour difference, shown by  $\Delta C$  and  $\Delta E$  were measures for comparing colour or measuring differences between the target and the control sample [27]. The results (Figure 1 and 2) showed that the  $\Delta C$  and  $\Delta E$  were significantly different ( $P < 0.05$ ) for *elubo*, which ranged from 0.57 to 1.87 and 4.66 to 16.87; and *amala* which ranged from 0.71 to 4.79 and 1.72 to 6.34 respectively. Samples with *popooro oka* and *ewe okan* had the highest total difference ( $\Delta E$ ) for *elubo* and *amala* respectively. This showed that samples A (with *ewe okan*) and B (with *popooka*) had higher disparity from the control sample (with no additives), reflecting the intensity of the effects of these two additives on the colour.



**Figure 1: Colour parameters of *elubo***

\*Sample A- Sample with *Ewe Okan*, Sample B- Sample with *Popooka*,  
Sample C- Sample with *Omikan*, Sample D- Sample with *Ewe Abafe*, sample  
E- Sample with no additive



**Figure 2: Colour parameters of *amala***

\*Note: Sample A- Sample with *Ewe Okan*, Sample B- Sample with *Popooka*, Sample C- Sample with *Omikan*, Sample D- Sample with *Ewe Abafe*, sample E- Sample with no additive

### Chemical properties

The chemical properties of the fermented yam flours were as presented in Table 2. The protein content of *elubo* samples ranged from 4.35 to 5.02% (Table 2), as *elubo* with *omikan* was significantly highest in protein. *Elubo* with *ewe abafe* and *popooka*, as well as *ewe okan* and without additive were not significantly different ( $P \geq 0.05$ ) from each other. The results of the fermented yam flours were similar to previous observations of protein content for yam flour by Ojokoh and Gabriel [28] (4.28 – 6.11 %), but higher than those reported by Oyeyiola *et al.* [29] (1.80 %) and Jimoh *et al.* [30] (1.53 %) for *Dioscorea rotundata*. The moisture content of the *elubo* samples ranged from 8.77 to 10.49%, which is believed to be within range for longer storage life, as it contained moisture content of less than 12% [31]. This is similar to the report of Ojokoh and Gabriel [28] (7.28 - 9.10%). Moreover, longer shelf life would be guaranteed if storage was avoided at high humidity of more than 70% [32].

The crude fat of the samples, which ranged from 0.18 to 0.22 %, showed that the samples with additives had significantly slightly higher content than the sample without. Moreover, yam and its products generally have low fat content. The fat content was lower than those of *elubo* reported by Ojokoh and Gabriel [28] (0.95 –

1.01%) and in range with that reported by Oyeyiola *et al.* [29] (0.2 – 0.3 %) and Karim *et al.* [33] (0.34 %). Ash content, which represented the inorganic proportion of the fermented yam flours varied significantly within the range of 0.89 – 2.13%. The flour without additive had the lowest ash content of 0.89 % and the flour fermented with *omikan* had the highest value of 2.13%. The additives could be said to have significant contributory effect on the mineral contents, as the samples with additives were significantly higher in ash content. Moreover, it has been reported that the plants of some of these extracts contain significant amount of ash, ranging from 5.34 % for guinea corn stem - *popooro oka* [9] 4.9 % for *Bauhinia specie - ewe abafe* [34] and 1.25 % for fermented maize [35].

There was no significant effect of additives on the crude fibre content (Table 2), as it varied from 1.47 – 1.67 %; the samples with *ewe okan*, *omikan* and without additives were not significantly ( $P \geq 0.05$ ) different from each other as well as between those with *popooka* and *ewe abafe*. The sample with no additive had the highest crude fibre content, while the sample fermented with *popooka* had the lowest crude fibre content. The crude fibre contents were similar to previous observations of 1.23 to 1.38 % [28] for *D. rotundata* yam flour samples. The pH of the flour samples ranged from 4.87 to 5.83, with the sample having *omikan* as the additive having the lowest pH value, significantly different from other samples. The lower pH was as a result of the higher acidity content of *omikan* (fermented maize water) obtained from the acidic fermentation process during the processing of *ogi* from maize grains, accompanied by drop in the pH from about 6.5 to 3.9 as reported by Nwokoro and Chukwu [36]. The starch and sugar contents of the samples ranged from 45.28 to 47.76% and 3.67 to 3.97% respectively (Table 2). The starch content of sample with *ewe abafe* was significantly higher than others, while the sugar content of sample with *ewe abafe* and *omikan* were significantly higher, which could impact significant pleasant taste to the resulting *amala*. The sample without additive showed significantly lowest starch and sugar content. Higher contents of starch (69.75 and 73.06%) and sugar (4.43 and 5.74%) have been reported by Jonathan *et al.* [4] for *elubo* stored for varying durations, as well as starch content (59.74-70.30%) of *elubo* from Nigerian and Ugandan yellow fleshed potato reported by Fetuga *et al.* [37].

### Sensory evaluation

The sensory properties results of the *amala* are presented in Table 3. The results showed that some of the additives had significant effect on the sensory properties than others. The result indicated that there was significant difference between the appearance of the *amala* with *omikan* and *amala* from other additives; and there was no significant difference between that of *ewe okan* and *popooka*, as well as *ewe abafe* and the *amala* without additive. *Amala* with *omikan* was the least preferred in terms of appearance, followed by *popooka*, *ewe okan*, without additive and then *ewe abafe*. This implied that the acceptability of *amala* in terms of appearance was not by how white/light or how brown it was, when related to the result of the CIE tristimulus scale observed for *amala* without additive having the lightest or whitest colour ( $L^*$  and  $b^*$  axis). However, it was determined by a pre-set image of colour that was traditionally believed to be the quality appearance for *amala*, as the most preferred in terms of appearance was not the lightest nor darkest reported by the  $L^*$  values.



The sample with *popooka* was the least preferred in terms of taste and aroma, while sample with *omikan* and without additive were the most acceptable respectively (Table 3). The preferred taste of the sample with *omikan*, could be attributed to the pleasant sour taste of *omikan* resulting to the low pH of its *elubo*, as well as the higher sugar content of the *elubo*. In terms of mouldability, smoothness and overall acceptability, sample without additives was the most preferred, while sample with *popooka* was the least preferred for smoothness and overall acceptability. Hence, the different types of additives had varying effects on the different sensory attributes of the food product.

## CONCLUSION

The study showed that indigenous additives had mild effect on the chemical properties of *elubo*. The effect of the additives was more significant on the sensory properties and colour parameters of *elubo* and *amala*. The additives had varying effects on the sensory properties. The implication of the additive on the colour attributes ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $\Delta C$  and  $\Delta E$ ) of the *elubo* and *amala* was that the components of the indigenous additives (with the exception of *omikan*) contributed to the reduced lightness or whiteness, as these components had colour pigments that diffused into the flour samples during preparation, with *popooka* and *ewe abafe* having more pronounced effects. Hence, the use of additives in the processing of *elubo* by traditional processors served the role of altering the colour of *elubo* and appearance of the resulting *amala*, including impact on some of the sensory attributes. Therefore, the use of additive could be concluded to be relative, depending on individual's perception of quality.

**Declaration of Interest:** The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.



**Table 1: List of indigenous Additives for fermented yam flour processing**

S/N	Indigenous name	English name	Botanical name of the plant
1	<i>Ewe Okan</i> or <i>ewe olosan</i>	Green Heart leaf	<i>Cyclicodiscus gabunensis harms</i> [Fabaceae]
2	<i>Poporo oka</i> or <i>popooka</i>	Guinea corn stem	<i>Sorghum bicolor</i>
3	<i>Omikan</i> or <i>omidun</i>	Fermented corn ( <i>Zea mays</i> ) water	-
4	<i>Ewe Abafe</i>	Camel's foot leaf or monkey bread leaf	<i>Bauhinia specie</i>

**Table 2: Chemical properties of *Elubo* samples fermented with and without additives**

Properties	Sample A	Sample B	Sample C	Sample D	Sample E
Crude protein (%)	4.66±0.14 <sup>b</sup>	4.35±0.21 <sup>a</sup>	5.02±0.14 <sup>c</sup>	4.48±0.07 <sup>a</sup>	4.73±0.07 <sup>b</sup>
Moisture content (%)	10.49±0.25 <sup>d</sup>	9.12±0.29 <sup>b</sup>	9.6±0.23 <sup>c</sup>	8.77±0.18 <sup>a</sup>	10.49±0.14 <sup>d</sup>
Crude fat (%)	0.21±0.07 <sup>b</sup>	0.21±0.14 <sup>b</sup>	0.21±0.07 <sup>b</sup>	0.22±0.07 <sup>b</sup>	0.18±0.14 <sup>a</sup>
Ash (%)	1.23±0.12 <sup>c</sup>	1.26±0.07 <sup>d</sup>	2.13±0.44 <sup>e</sup>	1.18±0.28 <sup>b</sup>	0.89±0.10 <sup>a</sup>
Crude fiber (%)	1.66±0.35 <sup>b</sup>	1.47±0.14 <sup>a</sup>	1.71±0.14 <sup>b</sup>	1.51±0.21 <sup>a</sup>	1.67±0.21 <sup>b</sup>
pH	5.47±0.11 <sup>bc</sup>	5.83±0.11 <sup>c</sup>	4.87±0.06 <sup>a</sup>	5.57±0.06 <sup>bc</sup>	5.80±0.10 <sup>b</sup>
Starch (%)	45.38±0.02 <sup>b</sup>	46.07±0.01 <sup>c</sup>	46.44±0.01 <sup>d</sup>	47.76±0.15 <sup>e</sup>	45.28±0.39 <sup>a</sup>
Sugar (%)	3.85±0.01 <sup>b</sup>	3.83±0.01 <sup>b</sup>	3.97±0.03 <sup>c</sup>	3.97±0.01 <sup>c</sup>	3.67±0.02 <sup>a</sup>

\*Means with the same superscript within the same row are not significantly different ( $P \geq 0.05$ ). Sample A- *Elubo* with Ewe Okan, Sample B- *Elubo* with Popooka, Sample C- *Elubo* with Omikan, Sample D- *Elubo* with Ewe Abafe, sample E- *Elubo* with no additive

**Table 3: Sensory evaluation properties of *amala* with and without indigenous additives**

Sample	Appearance	Taste	Aroma	Mouldability	Smoothness	Overall acceptability
A	4.70±0.82 <sup>b</sup>	4.55±0.85 <sup>b</sup>	4.58±1.47 <sup>b</sup>	4.85±1.61 <sup>b</sup>	8.03±0.70 <sup>d</sup>	6.30±0.82 <sup>c</sup>
B	4.63±1.3 <sup>b</sup>	3.98±1.42 <sup>a</sup>	3.85±0.77 <sup>a</sup>	4.38±2.68 <sup>b</sup>	5.40±2.76 <sup>a</sup>	4.50±1.24 <sup>a</sup>
C	3.10±2.9 <sup>a</sup>	7.10±1.00 <sup>d</sup>	5.00±0.00 <sup>c</sup>	2.70±2.00 <sup>a</sup>	7.30±0.96 <sup>c</sup>	5.63±0.49 <sup>b</sup>
D	5.85±1.3 <sup>c</sup>	4.03±1.19 <sup>a</sup>	4.85±0.86 <sup>b/c</sup>	3.95±1.82 <sup>b</sup>	6.30±0.47 <sup>b</sup>	5.45±0.50 <sup>b</sup>
E	5.55±0.50 <sup>c</sup>	5.55±0.90 <sup>c</sup>	6.58±0.50 <sup>d</sup>	7.03±1.42 <sup>c</sup>	8.33±0.47 <sup>d</sup>	6.63±0.49 <sup>c</sup>

9- Point hedonic score system: 9=Like extremely, 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 and 1=Dislike extremely

\*Means with the same superscript within the same column are not significantly different ( $P \geq 0.05$ ).

Sample A- *Elubo* with Ewe Okan, Sample B- *Elubo* with Popooka, Sample C- *Elubo* with Omikan, Sample D- *Elubo* with Ewe Afafe, sample E- *Elubo* with no additive (Control sample)

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