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*Full Length Research Paper*

# Influence of processing methods on the sensory acceptability of products from selected hybrid plantains (*Musa* species *AAB*) cultivars

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**High-yielding and disease-resistant hybrid plant cultivars recently developed by breeders need evaluation for end-use. This study evaluated the influence of processing methods on the sensory acceptability of products (plantain chips, fried ripe plantains called "dodo" in Nigeria, boiled unripe and ripe plantains, and "amala," a dough, as it is called in Nigeria when unripe and ripe plantain flour is reconstituted in hot water) from selected hybrid plantain cultivars. Pita 26, Pita 27, Mbi egome, and Agbagba landrace cultivars were studied. Plantain pulps were subjected to frying (170°C for 2 min), boiling (100°C for 15 min), and drying (65°C for 48 h) at unripe and ripe stages before analyses. These food items were subjected to sensory evaluation. The panel of 20 people evaluated samples for texture, taste, flavor, appearance, color, stretchability, moldability, mouthfeel, and overall preference on a 9-point hedonic scale. The sensory studies showed statistically significant differences (P<0.05) between products and processing methods significantly affected the cultivars' sensory parameters and essential minerals and vitamins. Products from the Mbi egome cultivar were adjudged acceptable in terms of overall quality, followed by the Agbagba local landrace cultivar. The data in this study have shown that hybrid plantains have the potential to be used industrially.**

**Key words:** Consumers acceptability, value added products, hybrid plantain, organoleptic.

## INTRODUCTION

Plantains are staple food crops in the tropics especially in West and Central Africa (Adenitan et al., 2022). Nigeria produces over 2.11 million metric tons of plantain annually and consumed as a staple food (Anajekwu et al., 2020). Most plantain producers are small-scale farmers from developing countries who grow them mainly

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for consumption and sale in local markets. But as more people in developing countries move to cities, plantains are becoming a cash crop. This means that farmers in rural areas will be able to profit from them, which will aid in reducing poverty in developing countries (Oluwagbenga et al., 2020). Nigerian food processors have been able to make more money from adding value to plantains (Ubi et al., 2016).

In the unripe stage, the nutritional composition of plantain showed that starch is the predominant carbohydrate in the crop which makes it an important source of energy (Ogechi et al., 2017). Additionally, plantains are a good source of vital nutrients like carotene (pro-vitamin A), vitamin C, and other nutrients that should be consumed daily according to the National Research Council's Food and Nutrition Board. Plantains are high in potassium and low in sodium (17 mg/100 g) and fat (0.1%) making it recommended to control blood pressure and suitable for persons who are salt intolerant (Borges et al., 2020). All stages of the fruit (green to ripe) are used as a source of food in one form or the other. The mature unripe and ripe fruits are consumed boiled, steamed, baked, pounded, roasted, or sliced and fried into chips.

Plantains are highly perishable, and significant post-harvest losses are unavoidable from farm gate to market, resulting in food insecurity. Post-harvest losses are caused by poor handling, insufficient storage and transportation, and pest and disease infestation of fresh fruits (Lamptey et al., 2019). Postharvest losses are also exacerbated by a lack of postharvest and marketing infrastructure, such as packaging, cold storage, prepackage and distribution, postharvest treatment and washing facilities. Processing unripe plantains into chips and flour, and ripe plantains into fried snacks like 'dodo' are two common indigenous methods of reducing post-harvest losses and increasing income for processors (Oluwagbenga et al., 2020).

To reduce post-harvest losses of plantain and improve on food security, the International Institute of Tropical Agriculture, IITA have developed new hybrid plantain varieties which have been reported to have a high yield and disease resistant ability (Eriksson et al., 2018; Tenkouano et al., 2019). The adoption rate of the new hybrids plantain by farmers is limited and literature is scarce on their utilization for the production of value-added products.

Processing methods are an excellent way to extend the shelf life of foods, change their structure, appearance, and nutritional composition, and make them more appealing to consumers. Consumers expect foods to have a longer shelf life while also improving in quality and naturalness (Du et al., 2019). However, nutritional and bioactive ingredients are lost in food during processing such as drying, frying, and boiling. It is necessary to investigate the impact of processing methods on plantains to improve their quality and sensory properties while preserving their natural values as much as possible. Furthermore, these new hybrid plantains must be evaluated for their suitability for acceptable traditional plantain products in terms of sensory characteristics and quality. The sensory quality and acceptability of the products made from the new hybrid plantain will determine their adoption. There is a scarcity of data on the sensory and acceptability of traditional plantain-based products using these new hybrids with superior agronomic traits. The objective of this study focuses on the influence of processing methods on utilization of new hybrid plantains and organoleptic characterization of the value-added products made from them.

## MATERIALS AND METHODS

### Study area

The study was conducted in Nigeria. The selected hybrid plantain cultivars were harvested from the International Institute of Tropical Agriculture (IITA) research farm, in Ibadan, Oyo State.

Four plantain varieties were evaluated in this study which are PITA 26 and PITA 27, Mbi egome and Agbagba landrace (control) (Figure 1). The cultivars used in this study was selected based on their availability in the period of study, morphological difference and also due to limited literature on their utilization. Table 1 presents the morphological differences that exist between the plantain cultivars used in this study. The selected plantain cultivars were divided into two batches; a batch was processed at the matured green (stage 1) and the other at ripe yellow (allowed to ripen after harvesting to stage 5). The ripening stages of the fruits were determined following (Bhuiyan et al., 2020) ripening chart. The food products evaluated are fried unripe plantain (plantain chips), fried ripe (“dodo”), boiled unripe plantain, boiled ripe plantain and plantain flour (“amala”) produced from both unripe and ripe plantain cultivars. The sensory evaluation room of the food and nutrition science laboratory of IITA was used for this study. The sensory room was well illuminated, and the booths were well-partitioned to avoid distraction or interference by other panelists. All other analyses were carried out in duplicates at the Food and Nutrition Sciences Laboratory of IITA, Ibadan, Oyo State.

### Frying of plantain fingers

Unripe and ripe plantain bunches were separated into individual fingers, washed, peeled, and then sliced longitudinally into small round slices (2 mm thickness) with the aid of a sterile stainless-steel kitchen knife and fried in vegetable oil (specific gravity of 0.92 $g/cm^3$) for 2 min at 170°C. After frying, it was cooled and packaged in a polyethylene bag for further analysis at 30±2°C (Adeyanju et al., 2016).

### Boiling of plantain fingers

Fingers of plantain were selected randomly from each set (unripe and ripe) and cut into a cooking pot containing 2 L of water each and then cooked for 15 min at 100°C. The peel of the plantain was not removed to prevent the leaching of nutrients into the boiling water during cooking. After the boiling, each set of plantain was drained out of hot water and cooled for 10 min before the peels were removed (Ajiboye and Shodehinde, 2022).

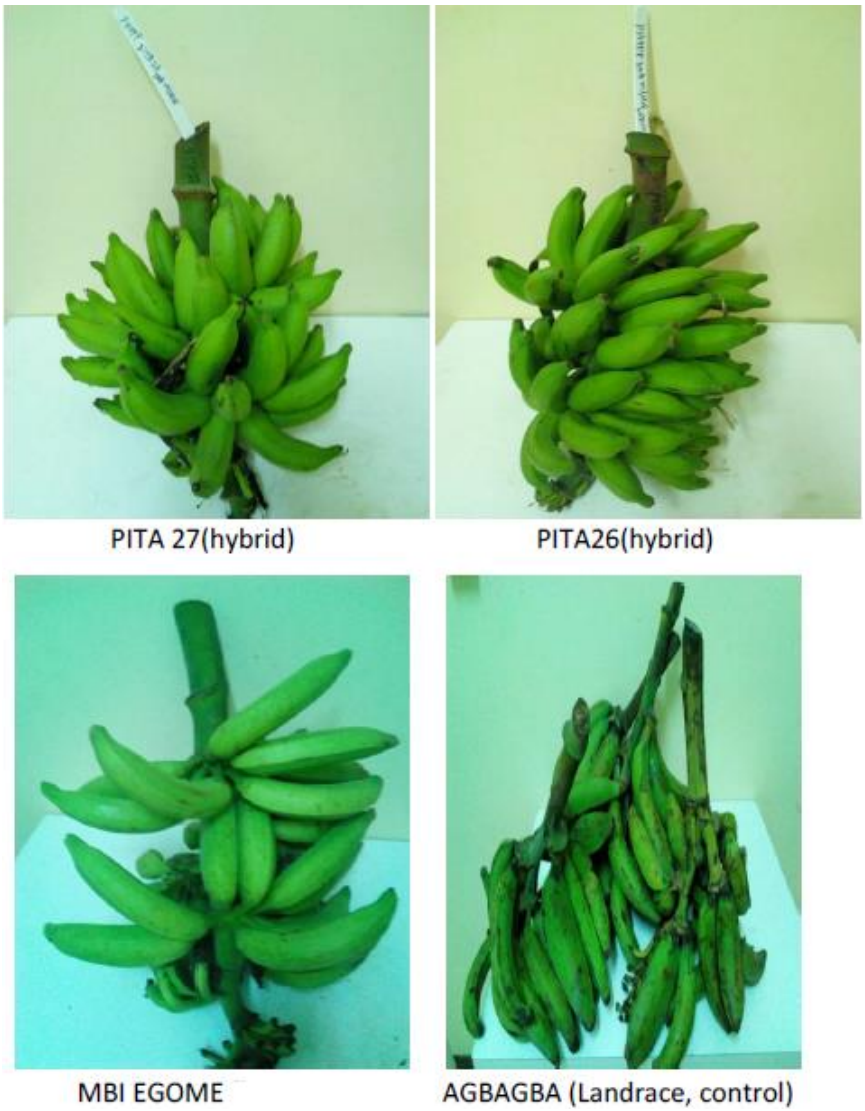



**Figure 1.** Four plantain varieties used for the study
Source: Authors

**Table 1.** Morphological differences between the cultivars used for the study.

| Cultivars | Bunch type/family grouping | Stature type | Source | Response to black sigatoka disease |
|---|---|---|---|---|
| Pita 26 | Hybrid | Small | Nigeria | Resistant |
| Pita 27 | Hybrid | Small | Nigeria | Resistant |
| Mbi Egome | French horn | Medium | Nigeria | Less susceptible |
| Agbagba | False horn | Medium | Nigeria | Susceptible |

Source: Brown et al. (2017).

**Production of plantain flour by drying**

Anajekwu et al. (2020) described the processing steps for making plantain flour. Plantain fruits (unripe and ripe) were removed from bunches, washed, and peeled by hand before being sliced (2 mm thickness) with a stainless-steel kitchen slicer, blanched at 80°C for 5 min, and dried in a cabinet drier at 65°C for 48 h. The dried slices were milled, sieved, sealed, and stored in a low-density

polyethylene bag for later use.

**Moisture content determination**

Moisture content was determined by the method described by AOAC (2005) method.

**Mineral analyses**

Five grams of each sample were gently heated over a Bunsen burner flame until the majority of the organic matter was destroyed. This was then heated in a muffle furnace for 5 h at 550°C until white-grey ash was obtained. The ash material was cooled. The ash material was treated with 20 mL of distilled water and 10 mL of dilute hydrochloric acid. This mixture was boiled, filtered into a 250-ml volumetric flask, thoroughly washed with hot water, cooled, and made up to volume. The mineral content of each sample was determined using an Atomic Absorption Spectrophotometer (PYE Unicon, UK, model SP9) (Adegunwa et al., 2017).

**Ascorbic acid (Vitamin C)**

Ascorbic acid was determined by dyestuff titration method as described by Adegunwa et al. (2017). 0.4/100 g oxalic acid was used to digest the sample (5 g). The aliquot was titrated against dyestuff that had previously been standardized by standard ascorbic acid solution, and the ascorbic acid content was calculated using the formula:

Vitamin C (mg/100 g) = Titre value × 0.606 × 100 / Weight of sample

**Total carotenes**

Total carotenoid was determined by method described by Adegunwa et al. (2017). 5 g of plantain flour was mixed with 2 ml of distilled water. It was then moved to mortar. A pestle was used to crush 50 ml of cold acetone and 2 g of cellite. Suction was used to filter the mixture through a Buchner funnel using filter paper (Watmann 90 mm). Small amounts of acetone were used to clean the mortar, pestle, and residue, and the washings were collected in the funnel. The crushing and filtration processes were repeated twice (until the residue is colorless). The total carotenoid content was extracted with petroleum ether and measured at 450 nm with a UV-VIS spectrophotometer. Total carotenoid content (TC spec) was calculated as follows:

$$TC\ (\mu g/g) = A \times \text{volume (ml)} \times DF \times 10^4 / A^{1\%}_{1cm} \times \text{sample weight (g)}$$

Where A= absorbance; DF= dilution factor, volume = total volume of extract (25 ml), and $A^{1\%}_{1cm}$ = absorption co-efficient of carotene in PE.

**Sensory evaluation of value-added products**

A 9-point hedonic scale with the ratings of: 9 = like extremely; 8 = like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much and 1 = Dislike extremely, as described by Nina et al. (2020) was used to compare the acceptability of plantain products. Twenty panelist composed of 10 males and 10 females were selected from the staff and graduate students at the International Institute of Tropical Agriculture (IITA), Ibadan and screened with respect to their interest and ability to different food sensory properties as described by Nina et al. (2020). Plantain chips, 'dodo', boiled unripe and boiled ripe plantain were evaluated for texture, taste, color, appearance, flavor, overall acceptability while 'amala' made from unripe and ripe flour was evaluated for texture, color, stretchability, mouldability, flavor, mouth feel and overall acceptability. The samples were served to panelist in a randomized manner with different codes. The means of the scores by the panelists were analyzed for significant differences between the respective samples.

**Statistical analysis**

The data obtained in the laboratory were subjected to analysis of variance (ANOVA) using the Statistical Analytical System (SAS) package (SAS 9.3 version) (2008), and the means were separated using Least Significant Difference (LSD). The significance test was done at the 5% probability level ($p < 0.05$).

## RESULTS AND DISCUSSION

### Moisture, minerals and vitamins content of the plantain cultivars at unripe and ripe stages

The moisture content, essential minerals and vitamins are presented in Figure 2. The moisture content of the unripe and ripe plantain of the different cultivars ranged from 56.69 to 69.38%. Moisture provides a measure of the water content and index of storage stability (Adegunwa et al., 2017). The vitamin C content varied between 5.49 and 10.25 mg/100 g. At the ripe and unripe stages, Pita 26 had the lowest and highest value, respectively. Carotene (pro-vitamin A) levels ranged between 1.71 and 19.77 g/g. At the unripe stage, Pita 26 had the lowest value, whereas Mbi egome had the highest value. The calcium content varied between 7.48 and 99 mg/kg. The ripe Agbagba cultivar had the highest calcium content, while the unripe Pita 27 cultivar had the lowest calcium content. Magnesium content ranged from 10.06 to 14.37 mg/kg, with ripe Mbi egome having the lowest value and unripe Agbagba having the highest. The potassium content varied between 94.37 and 184.45 mg/kg. At the ripe stage, Mbi egome had the lowest value, while Pita 26 had the highest value. Sodium content varied between 4.72 and 6.15 mg/kg. Mbi egome at ripe stage had the lowest value, while Agbagba at unripe stage had the highest value.

Analysis of variance showed that processing methods had a significant effect on the value-added products with regards to moisture, essential minerals and vitamins as shown in Figure 3. The moisture content that ranged from 4.06 to 69.28% where dried products recorded the least value (4.06%) followed by fried products (15.82%) and boiled products had the highest values (69.28%). The calcium content ranged from 6.51 to 9.66 mg/kg where dried product recorded the least value (6.51 mg/kg), followed by boiled products (8.37 mg/kg) and fried products recorded the highest value (9.66 mg/kg). Fried product recorded the highest value (22.93 mg/kg) for magnesium content, followed by dried products (16.94

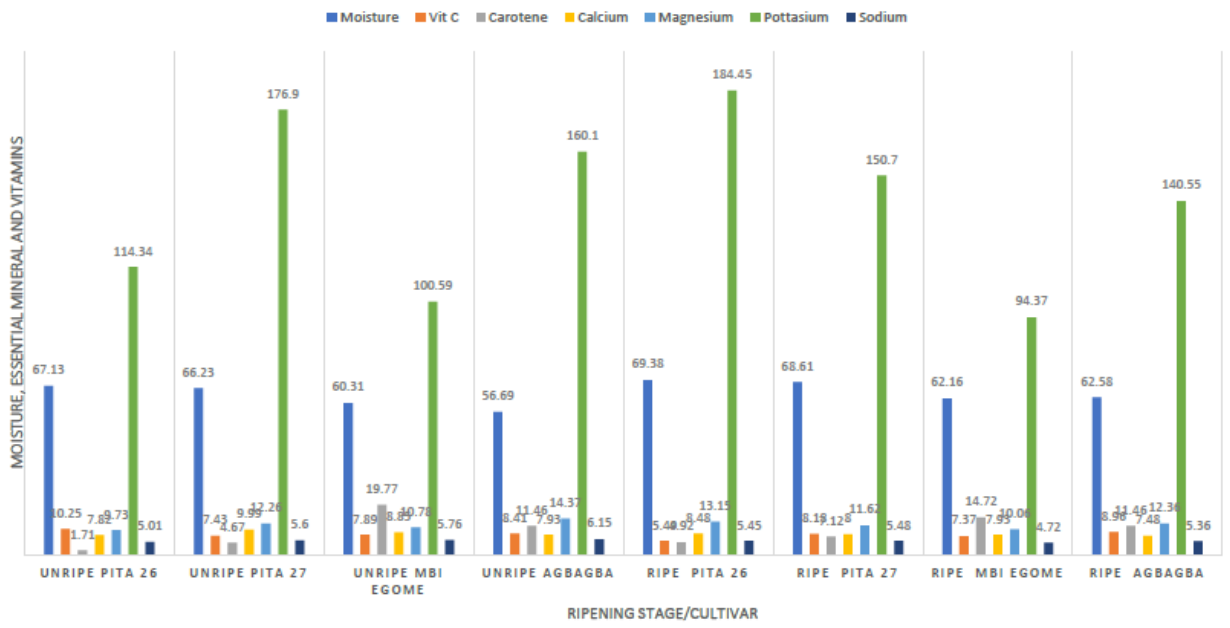



**Figure 2.** Graphical representation of the moisture (%), minerals (mg/kg), vitamin C (mg/100 g) and carotene (µg/g) of the raw plantain cultivars at different ripening stages.
Source: Authors

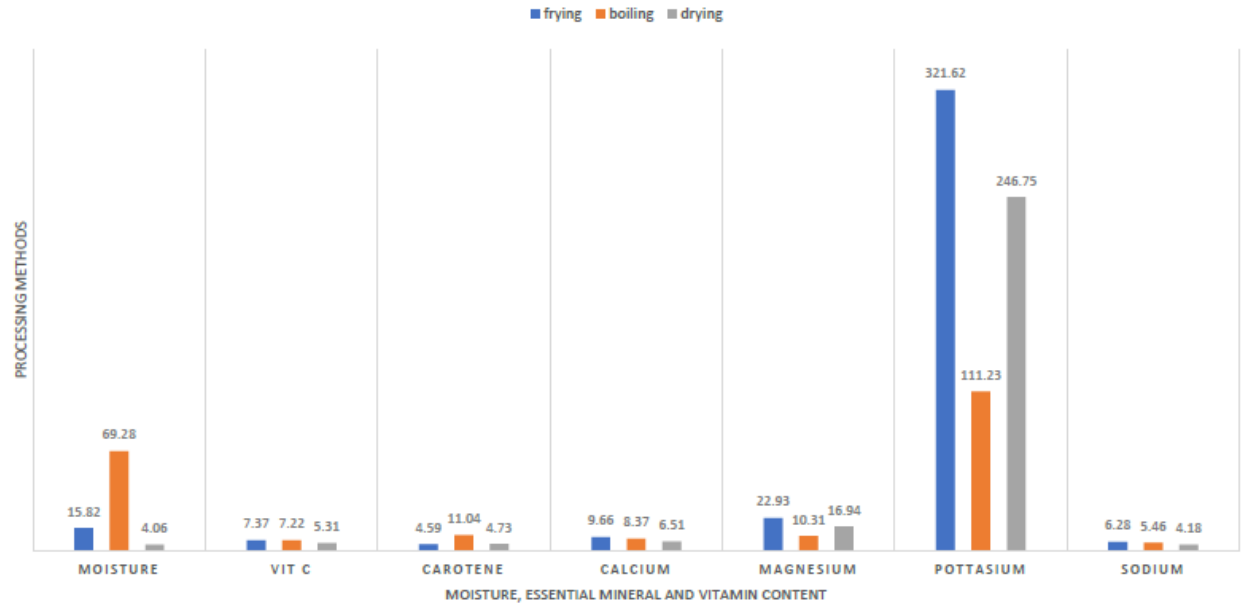



**Figure 3.** Graphical representation of effect of processing methods on the moisture (%), minerals (mg/kg), vitamin C (mg/100 g) and carotene (µg/g) of the plantain cultivars.
Source: Authors

mg/kg) and boiled products (10.31 mg/kg). Fried products showed highest value (321.62 mg/kg) for potassium content, boiled products (111.23 mg/kg) and dried products recorded the least value. Sodium content showed high value (6.28 mg/kg) in fried products, 5.46 mg/kg for boiled products and least value (4.18 mg/kg) for dried products. Generally, fried products recorded the highest values for essential minerals, and this may be due to the composition of the frying oil. Vitamin C showed high value for (7.37 mg/100 g) for fried products, 7.22

**Table 2.** Sensory evaluation of plantain chips and "dodo" from hybrid plantain cultivars.

| Sample | Cultivar | Texture | Taste | Colour | Appearance | Flavor | Overall acceptability |
|---|---|---|---|---|---|---|---|
| Fried unripe (Plantain chips) | PITA 26 | 6.09$^{b}$ | 5.38$^{b}$ | 5.76$^{b}$ | 5.67$^{a}$ | 5.57$^{b}$ | 5.67$^{b}$ |
| | PITA 27 | 4.19$^{a}$ | 3.52$^{a}$ | 5.00$^{a}$ | 5.14$^{a}$ | 4.38$^{a}$ | 4.43$^{a}$ |
| | MBI EGOME | 7.86$^{d}$ | 7.43$^{c}$ | 7.76$^{c}$ | 7.86$^{b}$ | 7.05$^{c}$ | 7.76$^{c}$ |
| | AGBAGBA | 7.00$^{c}$ | 7.29$^{c}$ | 7.62$^{c}$ | 7.67$^{b}$ | 6.86$^{c}$ | 7.38$^{c}$ |
| Fried ripe plantain ('Dodo') | PITA 26 | 5.25$^{a}$ | 5.50$^{a}$ | 5.15$^{b}$ | 5.40$^{c}$ | 5.15$^{a}$ | 5.40$^{a}$ |
| | PITA 27 | 5.85$^{c}$ | 7.00$^{d}$ | 5.10$^{a}$ | 4.70$^{a}$ | 6.70$^{d}$ | 6.10$^{c}$ |
| | MBI EGOME | 6.25$^{d}$ | 6.50$^{b}$ | 6.60$^{d}$ | 6.25$^{d}$ | 6.30$^{c}$ | 6.50$^{d}$ |
| | AGBAGBA | 5.30$^{b}$ | 6.70$^{c}$ | 5.75$^{c}$ | 5.15$^{b}$ | 6.15$^{b}$ | 5.85$^{b}$ |

Means followed by different superscript within a column indicate a significant difference ($p<0.05$).
Source: Authors

mg/100 g for boiled products and least value (5.31 mg/100 g) for dried products. Carotene (Pro-vitamin A) content was high in boiled product with 11.04 µg/g, followed by 4.73 µg/g for dried products and 4.59 µg/g for fried products. Boiling retains the carotene of plantain in a study by Adegunwa et al. (2017).

**Plantain chips (fried unripe plantain)**

The results of the effect of processing method on sensory evaluation of plantain chips are presented in Table 2. There was a significant difference ($P<0.05$) for all sensory parameters. Frying as a processing method showed a significant effect on the sensory parameters of the cultivars at different ripening stages.

The response of the panelist on texture ranged from 4.19 to 7.89. Mbi egome recorded the highest texture and Pita 27 had the least texture. Generally, the panelists scores indicated that the plantains chips from Mbi egome had a very hard to good texture. Textural attribute denotes the freshness and high quality of a food product (Ajani et al., 2020). Nina et al. (2020) reported similar score for texture (6.20-6.55) for plantain chips while Onwudiwe and Obue (2019) reported higher score for texture (8.4) for fried plantain chips.

Taste ranged from 3.52 to 7.43. Mbi egome had the highest taste value while Pita 27 recorded the least taste. The significant difference ($P<0.05$) in taste quality of the plantain chips can be linked to the total soluble solids and pH difference of the plantain cultivars. However, taste is mainly a balance between sugar and acid content. Nina et al. (2020) reported similar score for taste (6.30-6.45) while Onwudiwe and Obue (2019) reported 8.4 score for taste of fried chips which is higher compared to this study.

Color of the chips is important in the assessment of consumer acceptability and a quality parameter of fried snacks which is related to the perception of consumers (Ajani et al., 2020). There was color variation among the evaluated plantains chips which ranged from 5.00 to 7.76 where Mbi egome had the highest score and Pita 27 had the least value. Agbagba plantain chips (control) also had a high value for color while Pita 27 and Pita 26 showed least value for color, which may be due to the slice sticking problem observed in the fruit pulps. Slices sticking together during frying had a great influence on homogeneous product processing efficiency. Generally, all the samples in this study had a golden yellow color which is the characteristics color of plantain chips (Ajani et al., 2020). Control of the frying temperature and time is important to the color of plantain chips because increase in these parameters will reduce the color intensity of the plantain chips (Adeyanju et al., 2016). Onwudiwe and Obue (2019) reported 8.1 score for color for fried chips compared to this study.

Appearance is considered as one of the attributes critically assessed by consumers and often forms the basis for their selection or rejection of products. Appearance ranged from 5.14 to 7.86. Mbi egome had the highest appearance value while Pita 27 had the least. Panelists also scored high value of 7.67 for Agbagba plantain chips. Appearance affects the visual perception of consumers. The primary reason for the popularity of fried foods may be the characteristics like soft, juicy interior as well as thick and crispy outer crust. Nina et al. (2020) reported similar result range for appearance (6.25-7.40) for plantain chips.

Flavor is an important sensory quality that affects smell perception of consumers. It ranged from 4.38 to 7.05 where Mbi egome had the highest value and Pita 27 had least. Onwudiwe and Obue (2019) reported 8.4 score for flavor for plantain chips which is a higher value compared to that in this study. Nina et al. (2020) also reported similar result for flavor (6.20-6.55) for plantain chips. The overall acceptability ranged from 4.43 to 7.76. Mbi egome had the highest overall acceptability, followed by Agbagba while Pita 27 had the least value. Similar score (6.20-6.55) was reported by Nina et al. (2020). Plantain chips processed from Mbi egome cultivar had the highest

**Table 3.** Sensory evaluation of boiled unripe and ripe hybrid plantain cultivars.

| Sample | Cultivar | Texture | Taste | Colour | Appearance | Flavour | Overall acceptability |
|---|---|---|---|---|---|---|---|
| Boiled Unripe Plantain | PITA 26 | 6.02$^{b}$ | 5.22$^{b}$ | 5.82$^{b}$ | 5.27$^{b}$ | 5.52$^{b}$ | 5.63$^{b}$ |
| | PITA 27 | 4.20$^{a}$ | 4.07$^{a}$ | 5.02$^{a}$ | 5.04$^{a}$ | 4.48$^{a}$ | 4.32$^{a}$ |
| | MBI EGOME | 7.82$^{d}$ | 7.54$^{d}$ | 7.92$^{d}$ | 7.96$^{d}$ | 7.35$^{d}$ | 7.82$^{d}$ |
| | AGBAGBA | 7.20$^{c}$ | 7.21$^{c}$ | 7.73$^{c}$ | 7.22$^{c}$ | 6.90$^{c}$ | 7.20$^{c}$ |
| Boiled Ripe Plantain | PITA 26 | 5.20$^{a}$ | 5.51$^{a}$ | 5.16$^{b}$ | 5.42$^{c}$ | 5.06$^{a}$ | 5.56$^{a}$ |
| | PITA 27 | 5.80$^{c}$ | 6.60$^{b}$ | 5.12$^{a}$ | 4.72$^{a}$ | 6.02$^{b}$ | 6.12$^{c}$ |
| | MBI EGOME | 6.95$^{d}$ | 6.65$^{c}$ | 6.68$^{d}$ | 6.75$^{d}$ | 6.38$^{d}$ | 6.75$^{d}$ |
| | AGBAGBA | 5.52$^{b}$ | 6.72$^{d}$ | 5.70c | 5.07$^{b}$ | 6.25$^{c}$ | 5.80$^{b}$ |

Means followed by different superscript within a column indicate a significant difference ($p<0.05$).
Source: Authors.

acceptability, indicating that the cultivar was the best for value addition into plantain chips.

Plantain chips made from Pita 26 and Pita 27 cultivars showed significantly low overall acceptability for value addition as plantain chips and as such are not recommended for value addition as plantain chips. In Nigeria, the production and marketing of plantain chips was formally done by females. Recently, it has been overtaken by many jobless male youths who now venture in this as real time agribusiness since plantain chips are generally eaten as snack food at any time (Ubi et al., 2016).

**"Dodo" (fried ripe plantain)**

The result showed a significant difference ($P<0.05$) in the sensory parameter as presented in Table 2. Frying as a processing method showed a significant effect on the sensory parameters considered for 'dodo'. 'Dodo' is a high demand value added product for customers in social events, restaurants and fast food services (Oluwagbenga et al., 2020). The texture ranged from 5.25 to 6.25 where Mbi egome had the highest value while Pita 26 had least value. Pita 27 also scores a high value of 5.85 for texture compared to Agbagba which is the control. Texture, color and oil content are the main quality parameters of fried products (Oyedeji et al., 2017).

Taste is a very important sensory parameter that influence consumer acceptability. Taste ranged from 5.50 to 7.00. Pita 27 had the highest value and Pita 26 recorded the least value.

Color ranged from 5.10 to 6.60. Mbi egome had the highest while Pita 27 had the least value.

Appearance ranged from 4.70 to 6.25 where Mbi egome had the highest value while Pita 27 recorded the least value.

Flavor ranged from 5.15 to 6.70. Pita 27 scored the highest value while Pita 26 has the least value. Frying is one of the major value addition processes for plantain which results in products with a unique flavor-texture combination (Oyedeji et al., 2017).

The overall acceptability ranged from 5.40 to 6.50. Panelists scored Mbi egome the highest value for overall acceptability, thus is the best for 'Dodo' value addition which is always in high demand in this agro-ecology in the mornings and evenings in homes (Ubi et al., 2016). A high proportion of the cultivars scored significantly high acceptability for this value added product and thus were also best for 'Dodo' value addition which is always on a high demand in all parts of Nigeria and can be eaten with porridge beans and meat (Ubi et al., 2016). More income is derived from the value-added plantain as dodo by fast food restaurants and food catering services.

**Boiled unripe plantain**

Table 3 shows the effect of processing method on sensory evaluation of boiled unripe plantain of the selected cultivars. There was a significant difference ($P<0.05$) for all parameters studied. Boiling as a processing method showed a significant effect on the sensory parameters of the cultivars at different ripening stages.

The texture ranged from 4.20 to 7.82, taste 4.07 to 7.54, color 5.02 to 7.92, appearance 5.04 to 7.96, flavor 4.48 to 7.35, and overall acceptability 4.32 to 7.82. Mbi egome scored the highest value while Pita 27 recorded the lease value for all sensory parameters studied. Agbagba (control) also scored high values for the sensory qualities. Onwudiwe and Obue (2019) reported similar sensory quality results of texture 7.6, taste 7.5, color 7.1, flavor 7.1 and overall acceptability score of 7.4 for boiled unripe plantain. The panelists accepted boiled unripe plantain from Mbi egome cultivar as best compared to other cultivars. Gunasekaran et al. (2020) reported that boiled unripe plantain contributed to the

**Table 4.** Sensory evaluation of unripe plantain flour ("amala") from hybrid plantain cultivars.

| Sample | Cultivar | Texture | Colour | Stretch ability | Mould ability | Flavour | Mouth feel | Overall acceptability |
|---|---|---|---|---|---|---|---|---|
| Unripe plantain flour | PITA 26 | 6.52$^{b}$ | 5.52$^{b}$ | 5.67$^{b}$ | 4.78$^{a}$ | 5.63$^{b}$ | 4.27$^{a}$ | 5.77$^{b}$ |
| | PITA 27 | 5.07$^{a}$ | 4.68$^{a}$ | 5.05$^{a}$ | 5.27$^{b}$ | 4.42$^{a}$ | 4.52$^{b}$ | 4.32$^{a}$ |
| | MBI EGOME | 8.60$^{d}$ | 8.06$^{d}$ | 7.62$^{d}$ | 7.82$^{d}$ | 7.38$^{d}$ | 7.88$^{d}$ | 7.80$^{d}$ |
| | AGBAGBA | 7.53$^{c}$ | 7.20$^{c}$ | 6.88$^{c}$ | 6.75$^{c}$ | 6.95$^{c}$ | 7.27$^{c}$ | 7.07$^{c}$ |
| Ripe plantain flour | PITA 26 | 3.44$^{a}$ | 3.68$^{a}$ | 3.90$^{a}$ | 3.56$^{a}$ | 3.21$^{a}$ | 3.82$^{a}$ | 3.17$^{a}$ |
| | PITA 27 | 3.22$^{a}$ | 3.50$^{a}$ | 3.77$^{a}$ | 3.40$^{a}$ | 3.02$^{a}$ | 3.33$^{a}$ | 3.01$^{a}$ |
| | MBI EGOME | 5.09$^{c}$ | 5.12$^{c}$ | 5.65$^{c}$ | 5.21$^{c}$ | 6.52$^{c}$ | 5.23$^{b}$ | 5.35$^{c}$ |
| | AGBAGBA | 4.06$^{b}$ | 4.50$^{b}$ | 4.86$^{b}$ | 4.63$^{b}$ | 4.28$^{b}$ | 4.54$^{c}$ | 4.16$^{b}$ |

Means followed by different superscript within a column indicate a significant difference ($p<0.05$).
Source: Authors.

recovery in children with acute watery diarrhoea. Resistant starch played a major role in prevention or cure of diarrhoea.

Resistant starch constitute about 83.7% of unripe plantain which is refractory to enzyme hydrolysis in the small intestine, and passes to the colon unaltered where it is acted upon by the normal commensals to produce short chain fatty acids, which are the primary mediators of the beneficial activity (Gunasekaran et al., 2020). Boiled unripe plantain is used for the preparation of unripe plantain porridge which an important delicacy in Nigeria and West Africa.

Unripe plantain porridge is used to control diarrhoea in Nigeria (Ayinde et al., 2017). Ayinde et al. (2017) reported in a study that most people living in urban areas regularly consume boiled ripe plantain compared to rural dwellers.

## Boiled ripe plantain

Effect of processing method on sensory evaluation of boiled ripe plantain is represented in Table 3. There was a significant difference ($P<0.05$) for all parameters studied. Processing method showed a significant effect on the texture, taste, color, appearance and overall acceptability of boiled ripe plantain. Texture ranged from 6.20 to 6.95 and flavor ranged from 5.06 to 6.38. Mbi egome had the highest value while Pita 26 had the lease value for both texture and flavor qualities. Taste ranged from 5.51 to 6.72 where Agbagba had the highest value and Pita 26 recorded the least. Color ranged from 5.12 to 6.68 and appearance ranged from 4.72 to 6.75. Mbi egome had the highest value while Pita 27 recorded the least value for color and appearance qualities. Mbi egome recorded the highest value 6.75 for the overall acceptability while Pita 26 recorded least value of 5.56. Ayinde et al. (2017) reported that most people living in rural areas regularly consume boiled ripe plantain compared to urban dwellers.

## Unripe plantain flour reconstituted dough ('Amala")

Table 4 shows the sensory evaluation results of the 'amala' samples from selected hybrid plantain cultivars. There was a significant difference ($P<0.05$) for all the sensory parameters. Drying as a processing method showed a significant effect ($p<0.05$) on the sensory parameters of the cultivars at different ripening stages.

The 'amala' samples made from Pita 27 and to some extent Pita 26 were rated lowly by the test panelists. The panelists on the other hand, seemed to have rated the 'amala' samples from Mbi egome and Agbagba highly in combined scoring for texture, color, stretchability, mouldability, flavor, mouthfeel, and overall acceptability. Texture ranged from 5.07 to 8.60, color 4.68 to 8.06, stretchability 5.05 to 7.62, mouldability 4.78 to 7.82, flavor 4.42 to 7.38, mouthfeel 4.27 to 7.88 and overall acceptability 4.32 to 7.80. The panelist score 'amala' made from Mbi egome highest overall acceptability for all sensory quality. The 'amala' sample from Agbagba cultivar (local landrace) was rated higher than the hybrid plantain cultivars except Mbi egome for all sensory parameters. Babalola and Taiwo (2019) reported appearance (4.47-6.93), texture (4.33-7.13), taste (4.60-6.93) and flavor (4.93-6.80) for reconstituted dough of cardaba banana and plantain flour which is like the results recorded in this study. Texture is first important factor before 'mouth feeling' in consumers' acceptability of "fufu" like pounded yam and 'amala' in Nigeria. From this study, the panelist scored high for texture than mouthfeel for all the cultivars. Generally, the cultivars used for this study (from the scores of the panelists) could also be used in the production and preparation of 'amala' in Nigeria. The food called 'amala' in Nigeria, is always eaten with a source which is considered rich in

protein (Ubi et al., 2016). It is a staple food in certain regions in Nigeria.

### Ripe plantain flour reconstituted dough (‘Amala”)

The results of the sensory evaluation of dough reconstituted from ripe plantain flours from selected hybrid plantain cultivars are presented in Table 4.

The texture of ‘amala’ from ripe Pita 26 and Pita 27 flour was less preferred (3.44 and 3.22) to the texture of ‘amala’ from ripe Mbi egome and Agbagba flour (5.09 and 4.06), respectively. Pita 26 and Pita 27 samples scored lower marks (3.68 and 3.50, respectively) in color compared to Mbi egome and Agbagba that scored higher marks (5.12 and 4.50) from the panelist. Stretchability ranged from 3.77 to 5.65, mouldability 3.40 to 5.21 and mouthfeel 3.33 to 5.23. Mbi egome sample recorded the highest mark while Pita 27 had the least score for stretchability, mouldability and mouthfeel. It was observed that ‘amala’ produced from flours of Mbi egome and Agbagba samples had better flavor than those from Pita 26 and Pita 27 flour samples. The overall acceptability ranged from 3.01 to 5.35. The panelists score Mbi egome the highest for overall acceptability percentage while Pita 27 has the least mark.

## Conclusion

The sensory properties of the value-added products (plantain chips, "dodo," boiled unripe and ripe plantains, unripe and ripe plantain flour reconstituted dough "amala") demonstrated that hybrid plantains cultivars have the potential to be processed into value-added products, thereby providing food security, enhancing livelihoods, improving nutritional status, and social well-being of the populace. The sensory parameters studied were significantly affected by processing methods such as frying, boiling, and drying. Mbi egome cultivar products were deemed acceptable in terms of overall quality, followed by Agbagba local landrace cultivar products. The findings of this study show that hybrid plantains (Mbi egome cultivar) have the potential for industrial exploitation through processing into snacks and food items suitable for consumption at home and in fast food service systems.

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## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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