QUALITY EVALUATION OF JAM PRODUCED FROM MATURED OVERRIPE PLANTAIN (*MUSA PARADISIACA*) DURING STORAGE

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Abstract
Conversion of food waste, caused by lack of adequate postharvest storage medium, into value added product is a good approach in ensuring food and nutrition security; such waste include overripe plantain with low market/economic value. This study evaluated the physico-chemical properties of jam produced from three ratios of 50:50, 45:55 and 40:60pulpof overripe plantain to sugar. The parameters determined were moisture, pH, ash, titratable acidity, vitamins A and C, total viable count and sensory attributes such as taste, appearance, spreadability and overall acceptability. Samples were stored for 2 months and analyses were done at 0, 1 and 2 months. Moisture content ranged from 18.18 to 45.45% and pH ranged from 3.47 to 3.99. Values obtained for Ash and titratable acidity ranged from 0.32 to 0.44% and 1.13 to 3.95%, respectively. There were no bacteria in freshly prepared jam samples and values obtained in storage were within acceptable limits. Significant amount of vitamins A (11.29-14.44 mg/100 g) and C (3.01-3.17 mg/100 g) were obtained in all samples; however values decreased as storage period progressed. The sensory evaluation showed 50:50 plantain pulp to sugar ratio was the most preferred in terms of spread-ability and overall acceptability. Overripe plantain can be used in production of jam to reduce post harvest losses and ensure food and nutrition security.

Keywords: Postharvest losses; overripe fruits; plantain; jam; physico-chemical properties

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1. INTRODUCTION

Post harvest losses of agricultural produce are major bottleneck to food and nutrition security in developing countries especially Nigeria. Plantain (*Musa paradisiaca*) is a major starchy staple in the Sub-Saharan Africa with lots of postharvest issues due to its climacteric nature. It is highly nutritious as it is rich in vitamins and minerals (Mohapatra *et al*., 2010). Plantain is an important source of carbohydrates in humid tropical Africa and contained 35% carbohydrate, 0.2 to 0.5% fats, 1.2% protein, and 0.8% ash (International Institute for Banana and Plantain, 2008). In terms of gross value of production, it is one of the most important fruits in the developing world.

Plantain has diversity of minerals; it is high in potassium, low in sodium (17 mg/100 g) and fat (0.1%) making it suitable to control blood pressure (Mohapatra *et al*., 2010). Plantain is usually harvested green after maturity and it begins to ripe at postharvest storage. The ripening process of the fruit level involves several biochemical pathways like degradation of starch to sugar, change in the peel and pulp colour and cell wall changes. As plantain ripens, starch is converted to sugar and within a short period of time, plantain becomes overripe and this leads to spoilage and waste (International Institute for Banana and Plantain, 2008).Good postharvest management is crucial when producing plantain for market. Poor handling of plantain can lead to problems such as uneven ripening that can decrease the value of plantain (Mebraetie, 2015). Overripe and injured fruits are discarded at the stage of harvesting. A major problem of plantain is that it is highly perishable, at ambient tropical temperatures; plantain has an average market life of 1-10 days. The difficulties associated with the short storage life of plantain are worsened by the marketing system. The environment within the market is also not

suited for long-term storage. A combination of factors such as high perishability, ambient temperatures and poor marketing conditions leads to loss in plantain quality and ultimately to post harvest losses (USAID 2012).

Conversion of food waste to value added product is a good approach in ensuring food security in Nigeria. Instead of discarding the overripe plantain, value added product such as jam can be produced to minimize losses and boost plantain marketers' economy. In south western Nigeria, a local product called *dodo-ikire* has been developed as value added product which reduces tendencies of overripe plantain wastage (Kayode *et al*., 2013). Besides this local product, the potential of overripe plantain in jam production also deserves practical investigation. Jam is produced from various fruits, its consumption has increased over the years and its market is expanding (Okudu *et al*., 2017). This work is aimed at evaluating the quality attributes of jam produced from overripe plantain during storage.

2. MATERIALS AND METHODS

This research was carried out in Food Science and Engineering Laboratory, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Preparation of jam from matured overripe plantain

Matured plantain (*Musa paradisiaca*) fruits free from defects were purchased from Araada Market in Ogbomoso, Nigeria and stored on a shelf at 25±2°C, 85% Relative Humidity (RH) till they became overripe. Overripe plantain fingers were sorted, washed with distilled water and peeled. The peeled plantain was sliced and blended with sugar in ratio 50:50, 45:55 and 40:60 of plantain to sugar. For each of the plantain pulp to sugar sample, jam was produced using open kettle method described by Okudu *et al*. (2017). Plantain was made into pulp (1316 g) using a Kenwood blender and boiled in 400 ml water; 16.3 g of pectin was added to the batch while stirring rapidly. Sugar was added gradually and it was boiled down to 68° Brix. Citric acid solution was added and the mixture was heated until it set (Figure 1).

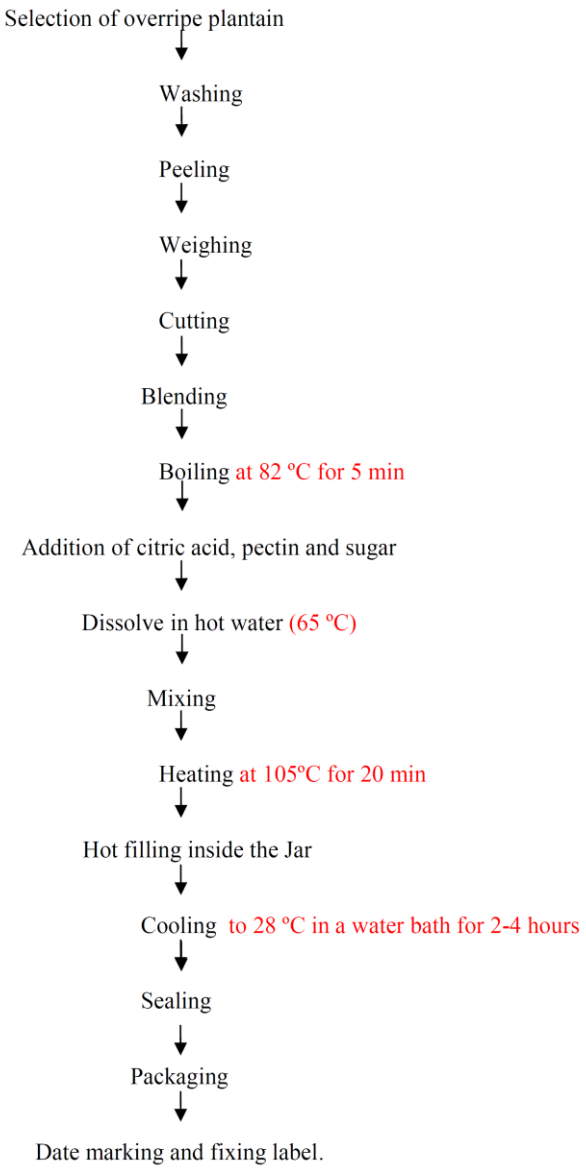

Figure 1: Flowchart for the production of jam from overripe plantain

The produced jam samples were separately hot filled into a sterilized jar, sealed, inverted, packaged, labelled and stored at ambient (28±2°C) temperature for 2 months and taken for analysis at 0, 1 and 2 months.

Physicochemical analysis

All physicochemical analyses were carried out according to the official methods of Association of Official Analytical Chemists (AOAC, 2012).

Moisture content was estimated using oven drying method. The pH values were measured using a Jenway Model P107 pH meter. Titratable acidity was determined by titrating the diluted jam sample with 0.1 N NaOH solution till a permanent pink colour appeared. Ash content was estimated using dry ashing method in a muffle furnace at 550°C. Total soluble solids were measured at 20°C using an Abbe refractometer. Ascorbic acid was determined using the 2, 6-dichlorophenol indophenol dye titration method. Vitamin A, vitamin C and total sugars were estimated using the methods of AOAC (2012).

Determination of total viable count

Total Viable Count (TVC) was done according to the method described by Nour *et al*. (2011). Plate count agar was used for enumeration of bacteria. Well homogenized samples were serially diluted with 0.1 % peptone water up to 10 ml and transferred aseptically into sterile Petri dishes. About 15 ml of sterilized Nutrient Agar was added to each plate. The plates were rotated and the media were allowed to solidify. The plates were inverted and incubated for 48 h. The TVC (cfu/ml) was determined using a colony counter.

Sensory attributes. Sensory attributes of jam were evaluated and a commercial brand was used as control. The evaluation was conducted by 40 semi-trained panellists. The produced jam samples were coded and served in a white disposable plastic cups. The jam sample was assessed for colour, aroma, taste, spreadability and overall acceptability using 9-point hedonic scale according to the method of Akinwande *et al*. (2014). The coded samples were served to panellists who evaluated it for each sensorial parameter based on their degree of likeness using 9 point hedonic scale with 9 = like extremely, 5 = neither like nor dislike and 1= dislike extremely.

Statistical analysis

Data (Mean values of three individual replicates) were analyzed using Statistical Package for the Social Sciences (SPSS, 2006) version 15 software (SPSS Inc., Chicago, IL, USA). Data obtained were subjected to analysis of variance (ANOVA) and means separated with Duncan multiple range test at a significance level of $p < 0.05$.

3. RESULTS AND DISCUSSION

Physicochemical properties of jam

The moisture content of all samples ranged from 27.83- 45.45% (Figure 2).

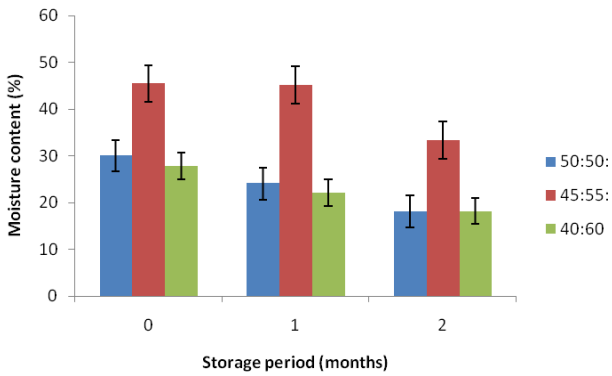

Figure 2: Moisture content of jam produced from overripe plantain
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar

Sample prepared from 45:55 of overripe plantain to sugar had the highest value and differed significantly ($p<0.05$) from other samples while the least value was observed in sample prepared from 50:50 plantain to sugar. The moisture contents obtained in this study were within the range (33 to 34%) reported for pineapple jam (Ashaye and Adeleke, 2009) except for jam made from 45:55 plantain to sugar which had 45.45%. The moisture content of foods can be used as an indicator of its shelf life (Fellows, 2000). High moisture content in jam samples will make it susceptible to microbial spoilage and has a great impact on the shelf life of jam (Eke-Ejiofor and Owuno, 2013). Sample produced from 45:55 plantain to sugar had the highest moisture content at the end of the second month which might make it more susceptible to microbial spoilage and hence reduce shelf life.

The pH ranged from 3.76 - 3.99 (Table 1). pH decreased with increase in duration of storage. The significantly highest value was obtained

from jam produced from 40:60 plantain to sugar sample while the least was obtained from jam produced from 45:55 plantain to sugar. The pH of jam obtained agreed with the one reported by Mohammad *et al*. (2008) when diet jam was developed from apple obtained from Swat. The pH of jam is an important factor to obtain optimum gel formation which should not be less than 3.0 (Mohd Naeem *et al*., 2017).

Table 1: Physico-chemical attributes of overripe plantain jam during storage

Sample	Storage period (months)		
	0	1	2
pH			
50:50	3.80±0.01^{b}	3.76±0.01^{b}	3.74±0.01^{b}
45:55	3.76±0.00^{a}	3.74±0.01^{c}	3.70±0.01^{a}
40:60	3.99±0.01^{c}	3.98±0.01^{a}	3.96±0.01^{c}
TTA (%)			
50:50	2.54±0.00^{b}	3.38±0.00^{c}	3.95±0.00^{c}
45:55	2.82±0.00^{c}	2.86±0.04^{b}	3.66±0.00^{b}
40:60	1.13±0.00^{a}	3.54±0.00^{a}	2.86±0.00^{a}
Sugar g/100g			
50:50	68.33±0.00^{b}	58.13±0.00^{b}	58.13±0.00^{b}
45:55	58.13±0.00^{c}	48.11±0.00^{a}	48.14±0.00^{a}
40:60	58.13±0.00^{a}	48.14±0.00^{a}	48.14±0.00^{a}
Brix			
50:50	70±0.00^{a}	70±0.00^{a}	71±0.00^{a}
45:55	68±0.00^{b}	68±0.00^{b}	65±0.05^{b}
40:60	70±0.00^{a}	69±0.10^{ab}	70±0.00^{a}

Means with the same superscript along the column are not significantly ($p \geq 0.05$)
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar

The result obtained from all the samples in this study did not fall below pH of 3.0 and the advantage of this is that none of the samples produced formed hard gel. As storage period increased, the pH of each samples decreased; this was due to increased acidity. Changes in pH are directly related to change in acidity of jam sample (Hussain *et al*., 2008).

A significant decrease in pH was reported in apple and pear-mixed jam for a storage period of 3 months by Shakir *et al*. (2007) and also in grape fruit marmalade as reported by Ehsan *et al*.(2003). The decrease in pH agreed with the findings in this study. The decrease in pH may be attributed to formation of free acids and pectin hydrolysis (Muhammad *et al*., 2008). The result of total titratable acidity is shown in Table 1. The total titratable acidity of sample produced from 50:50, 45:55 and 40:60plantain to sugar ranged from 2.54 - 3.95%, 2.82 - 3.66%, 1.13 - 2.82%, respectively, at 0, 1 and 2 months storage period. The total titratable acid increased as storage period progressed. The significantly highest value (3.95%) was obtained from jam produced from 50:50 plantain to sugar, the least was obtained from jam produced from 40:60 plantain to sugar (1.13%). The highest value of acidity obtained in jam produced from 50:50 plantain to sugar sample will aid the preservation of quality of jam. Garcia-Martinez, Ruiz-Diaz, Martinez-Monzo, Camacho & Martinez-Navarreze (2002) stated that high acidity preserve quality and destroys fruit enzymes that can cause spoilage.

The result of ash content is shown in Figure 3.

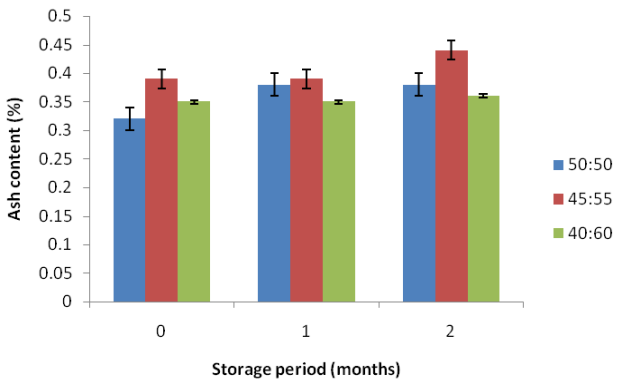

Figure 3: Ash content of jam produced from overripe plantain
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar

The ash content of sample 50:50, 45:55 and

40:60 prepared from overripe plantain pulp and sugar ranged from 0.32 - 0.38%, 0.39 - 0.44%, 0.35 - 0.36% for 0, 1, and 2 months, respectively. Significant higher value was obtained from sample prepared from 45:55 plantain to sugar (0.44%) and the least value was obtained from 40:60 plantain pulp to sugar (0.35%). Values obtained are higher than ash content of fruits jam in Malaysia market (0.12 g/100 g to 0.25 g/100 g) reported by (Mohd Naeem *et al*., 2017) but compared favourably with pineapple, jackfruit and mango jams (0.15–0.49 g/100 g) (Eke-Ejiofor and Owuno, 2013). The ash content provides an estimate of the quality of jam (Abdel *et al*., 2013).

The brix contents of freshly prepared jam obtained for all samples ranged from 68° to 70° brix (Table 1) similar to the value reported by Nour *et al*. (2011). However, at the end of storage period, the brix obtained for jam produced from 50:50, 45:55 and 40:60 plantain to sugar ratio were 71° brix, 55° brix and 70° brix respectively. A decrease in brix was observed in sample prepared with 45:55 plantain to sugar could be as a result of increased acidity during storage. The sugar contents of all the samples ranged from 58.13 – 68.33 g/100g, 48.14 – 58.13 g/100g and 48.14 – 58.13 g/100g for 50:50, 45:55 and 40:60 plantain pulp to sugar, respectively. The highest significant value was obtained from sample 50:50 plantain pulp to sugar (68.33 g/100g) while the least was obtained in 45:55 plantain pulp to sugar and sample 40:60 plantain pulp to sugar within the range (48.13 g/100g). There is a decrease in sugar content as the number of storage period increases. Nour *et al*. (2011) also reported decrease in sugar contents of Sudanese mango jam during storage. Sugar present in jam comprises of natural and added sugar which serves as a good agent for preservation of jam (Eke-Ejiofor and Owuno, 2013).

Vitamin A content differed significantly (Figure 4) for all samples (11.29 - 14.44 mg/100g).

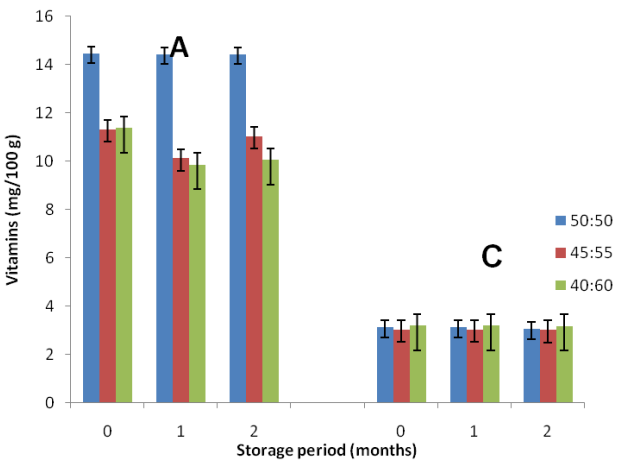

Figure 4: Vitamins A (A) and C (C) contents of jam during storage
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar

Jam prepared from 50:50plantain to sugar had significantly higher values (14.44 mg/100 g) than others. This could be due to higher proportion of plantain used. Vitamin A is important for growth and development and for the maintenance of the immune system and good vision. Vitamin C contents of all samples ranged from 2.99 - 3.17 mg/100g (Figure 4). The values obtained from this study agree with the findings of Jawaheer *et al*. (2003) and Mohd Naeem *et al*., 2017). Despite the processing and storage conditions of overripe plantain in jam production, somelevels of vitamin C were retained in this study. Exposure of food items to high temperature has been identified as a factor that can destroy ascorbic acid (Johnson*et al*., 2013). Over ripening of fruits can also affect the ascorbic acid of plantain and fruits.

Sensory Evaluation. All the produced jam samples compared favourably with the commercial sample when evaluated for sensory attributes (Table 2). Spreadability and overall acceptability were rated highest in sample prepared from 50:50 plantain to sugar while jam produced from 45:55 plantain to sugar was the least preferred. The recommended ratio for jam making is at least 40% fruit content and with a minimum soluble solid content of 45°brix (Eke-Ejioforand Owuno, 2013).

Table 2: Sensory evaluation of jam

Attributes	Colour	Taste	Aroma	Spreadability	Acceptability
50:50	6.45±1.97^{b}	6.03±2.29^{b}	6.04±2.05^{b}	6.03±2.05^{b}	7.2±1.37^{b}
45:45	5.37±2.23^{a}	5.04±2.14^{a}	4.91±2.20^{a}	4.94±2.23^{a}	5.64±1.92^{a}
40:60	6.18±2.36^{b}	6.05±2.06^{b}	6.0-8±2.13^{b}	5.69±2.16^{b}	6.98±1.41^{b}
Control	6.27±2.37^{b}	6.16±1.92^{b}	6.10±2.07^{b}	6.07±2.14^{b}	7.01±1.38^{b}

Means with the same superscript along the column are not significantly ($p \leq 0.05$)
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar

Since jam produced from 50:50 plantain to sugar in terms of overall acceptability to sugar gave the best result; jam can be produced from this ratio

Microbial properties

The total viable count in jam samples is shown in Table 3.

Table 3: Microbial load of overripe plantain jam during storage

Sample	Total viable count (cfu/ml)		
	Storage (months)		
	0	1	2
50:50	Nil	4.0 ×10^{3a}	5.0×10^{3a}
45:55	Nil	2.1×10^{3b}	1.0×10^{3b}
40:60	Nil	2.1×10^{3b}	1.0×10^{3b}

Means with the same superscript along the column are not significantly ($p \leq 0.05$)
50:50: Percentage of plantain pulp and sugar
45:55: Percentage of plantain pulp and sugar
40:60: Percentage of plantain pulp and sugar
Nil- zero or no count

There was no count in the fresh samples however values increased as storage period progressed. All the results of the bacterial counts from the stored jam analyzed were within the acceptable limit. According to the International Commission on Microbiological Specification of Foods (1986), the acceptable limit of mesophilic aerobic bacteria in food products should not exceed a maximum of 10^{3}cfu/ml. Tasnim*et al.* (2010) reported processed juice samples contained the load of viable bacteria within the acceptable limit in the average of 10^{3}cfu/ml.

4. CONCLUSION

This study shows the prospects of overripe plantain in the production of quality jam. The attributes studied were within the recommended limit for good jam production. Rather than discarding them, this commodity can be sold to food industry which will use these overripe plantains to manufacture jam and in return serves as source of income to farmers. Of all the three experimented plantain: sugar mixes, blending overripe plantain in 50:50 was most preferred by panellists and it is therefore recommended for production of jam.

Conflict of interest

The authors declare that there is no conflict of interest regarding this publication.

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