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Quality Attributes of Jams and Marmalades Produced from Some Selected Tropical Fruits

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Abstract

Some selected tropical fruits such as mango, cashew apple, pineapple, guava, lemon, and sour-sop were processed and their pectin strength evaluated. These processed fruit samples were used in the production of jams and marmalades to study the physicochemical and sensory qualities of the products to ascertain their suitability and acceptability. The result showed that lemon (L) have high pectin strength, mango (M) and guava (G) have medium while pineapple (P), cashew apple (CA) and sour-sop (SS) have weak pectin strength. The proximate result revealed that moisture content of the jam samples ranged from 23.29%-45.21% for PJ and GJ, ash 0.19 MJ-0.82% SSJ, protein 0.20 PJ-0.73% SSJ, crude fat 0.02 LJ-0.44% CAJ and carbohydrate 53.64%-74.87% for samples GJ and PJ, respectively. Results for the proximate analysis of marmalades showed that moisture content ranged from 24.92%-49.02%, ash 0.24%-0.62%, protein 0.28%-0.86%, fat 0.08%-0.22%, and carbohydrate 50.03%-74.19%. Physical properties of the jam samples were 0.36 pa.S-2.57pa.S for viscosity, 2.30-2.75 for pH, sugar 52.80%-721% and total titratable acidity 2.60%-4.63% while that of marmalade samples were 0.17 pa.S-2.21pa.S for viscosity, pH 2.40-2.95, sugar 44.00-68.20°Brix and total titratable acidity 1.83%-3.54%. The results for sensory scores of the fruit jams showed that all the samples were acceptable by the consumers. Although, mango, pineapple, and cashew apple marmalade recorded the highest acceptability scores. Therefore, nutritious acceptable jams and marmalades can be produced using some Nigerian tropical fruits; hence, reducing their annual wastage.

Keywords: Tropical fruits; Jams; Marmalades; Proximate physical; Sensory properties; Postharvest losses

Introduction

Nutritional loss of vitamins, antioxidants, and health-promoting substances or decreased market value occurs in fresh fruits in a large percentage on a daily bases mostly in developing countries. Quality deterioration starts as soon as it is harvested and continues until consumed or finally rotten if not consumed or preserved. How these fruits can be preserved or transformed into value-added products are of paramount importance. It has been reported that about 40%-50% of fruits produced in developing countries are lost before they can be consumed due to the high rate of bruising, water loss and subsequent decay during post-harvest handling [1,2]. Approximately, one-third of all fresh fruits are lost before it reaches the consumers [3]. Another estimate suggests that about 30%-40% of total fruits produced are lost between harvest and final consumption [4]. These changes in fresh fruits cannot be stopped but can be slowed down within certain limits of factors responsible for such deterioration or by converting most of the fruits into conserves and preserves such as jams, marmalades, jellies and candies that can enhance its shelf life and their availability [4].

Edible fruits have been propagated with the movement of human and animals in a symbiotic relationship as a means for seed dispersal and nutrition. Humans and animals are dependent on fruits as a source of nutritional nourishment. Aptly put, fruits normally mean the fleshy seed and associated structures of a plant that is sweet and edible in the raw form such as apples, bananas, lemons, guava, oranges, pineapple among others. Fruits account for a substantial fraction of the world's agricultural output and some such as apples and pomegranate have acquired extensive cultural and symbolic meanings.

Fruits are good sources of minerals and vitamins especially ascorbic acid, sulfur, phosphorus, iron, calcium and other essential minerals and vitamins which are found in a good number of fruits [5]. Fresh fruits are high in water, minerals, vitamins, and fiber which contribute extensively to the general well being of humans and animals. The regular intake of fruits reduces the risk of several diseases and functional depreciation associated with aging [6].

Nigeria is blessed with favorable and adequate climate and humidity which enhances the abundant yield of fruits. These tropical fruits are grown industrially by local farmers or naturally spread by animals or birds. Apart from the growing profile of fruits as an important source of vitamins and minerals; among the low and middle-income earners, fruits are seen as nutritional nourishment for the elderly, expectant, lactating mothers and children. The increased acceptance and consumption of fruits has led to its high demand. However, due to the short shelf life of fruits and post-harvest losses encountered by fruits processors, handlers and sellers, fruit availability and nutrient quality have been adversely affected.

Hence, there is a need to reduce the number of fruits wasted yearly by farmers and sellers by converting some of these fruits into preserve such as jams and marmalades. Therefore, the aim of this study was to process some selected tropical fruits, evaluate its pectin strength and to produce jams and marmalades from the processed fruit materials and to analyze the physicochemical and sensory properties of the products to ascertain its nutritional benefits and acceptability.

Materials and Method

Collection of materials

Materials used for these study included mature fresh cashew apple

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(*Anacardium occidentale*), mango (*Mangniferia indica*), guava (*Psidium guajava*), pineapple (*Ananas comosus*), lemon (*Citrus limon*), sour-sop (*Annona muricata*) and sugar. Mango (M), Pineapple (P), sour-sop (SS) Guava (G) and Lemon (L) were purchased from fruit garden market at D-line while Sugar (SG) was procured from Next Time Supermarket in Port Harcourt, Rivers State. Cashew Apple (C) was purchased from Uturu, Okigwe, Abia State, all in Nigeria. All these materials were transported to the Department of Food Science and Technology Laboratory, Rivers State University, Port Harcourt, Nigeria. All reagent used for this study were of analytical grade and obtained from the same Laboratory.

Methods

Extraction of pectin: Mature lemon was selected and washed thoroughly to remove dirt, rinds were peeled off and the pith (white part) was also peeled. The citrus peel pith was chopped into thin slices of about 2-3 mm thick and the juice was extracted using juice extractor (Iloytron, 23438, UK). One kilogram (1 kg) of the chopped peel pith, 80 ml of the extracted lemon and 1400 ml of distilled water were measured using a kitchen scale (Hana the big boss, made in China). All were poured into a non-stick pot and heated at 100°C for 5 min. After which, the temperature was reduced to simmer at about 95°C for an extra 15 min. The mixture was removed from heat and poured into a double folded muslin cloth and pressed adequately to extract the pectin. The extracted pectin was stored in a well tight labeled plastic container and kept in a deep freezer to prevent deterioration until required. Flow chart showing the pectin extraction process is presented in Figure 1.

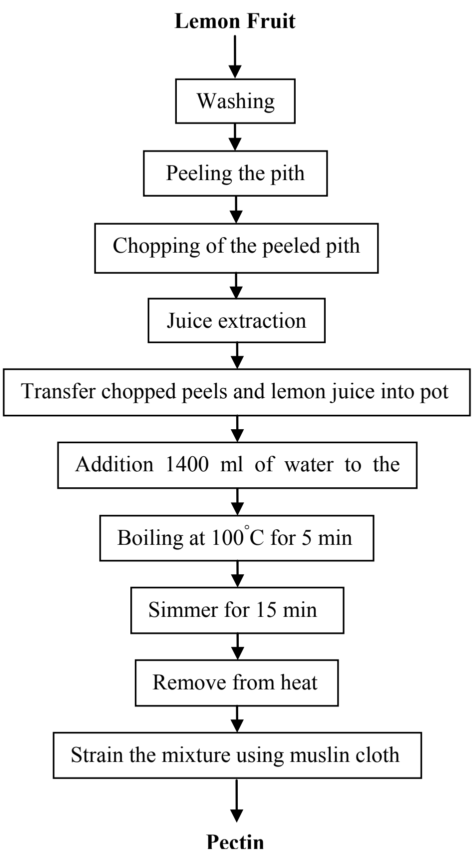

Figure 1: Flow chart showing pectin extraction process.

Evaluation of pectin strength using an alcohol test: Five milliliters (5 ml) of the sample extract was placed in a test tube and cooled to room temperature (28 ± 2°C). The test tube was then held in a tilted position and 10 ml of alcohol poured to the side of the tube until the alcohol was in contact with the sample extract. The test-tube was allowed to stand undisturbed for about 1 to 2 min. The test tube was closed with thumb and tilted slowly till the content reached the thumb. During this process, pectin strength was determined by examining the reactions of the extract in the test tube appropriately (Figure 2). Movement of one large clot in the test tube, visibility of two small clots and numbers of tiny clots was an indication of high, medium and weak pectin strengths, respectively [7].

Procedure for jam and marmalade production: Various fruits used for the study were selected, washed thoroughly to remove dirt and peeled. The pulp was cut into the section and deseeded and the cut pulp was placed in a blender (Sumeet Food Processor, Model A) and blended separately until smooth puree was obtained. The recipe such as fruit puree, sugar, distilled water; citric acid and pectin were measured and set aside. The ceramic plate was placed in the freezer prior to jam production. The fruit puree and distilled water were placed in a non-stick pot and heated 100°C for 5 min. The temperature was reduced to simmer, sugar, citric acid, and pectin were added sequentially. In between each addition, the substance was stirred continuously using a laboratory stirrer (model JKL 2145, REMI Motors, India) for 5 min intervals. After which, the cold test was done using the cold plate to determine the extent of the gelation. When the jam was fully set, it was removed from the heat, then fill in a jar bottle and store in ambient temperature (28 ± 2°C). The difference between the ingredient used for the jam and marmalade is that 20% of fruit peels were added to that of marmalade during its production process. Recipe formulation for jam and marmalade is presented in Table 1 while fruits used, pectin, jam, and marmalade are shown in Figures 3-6.

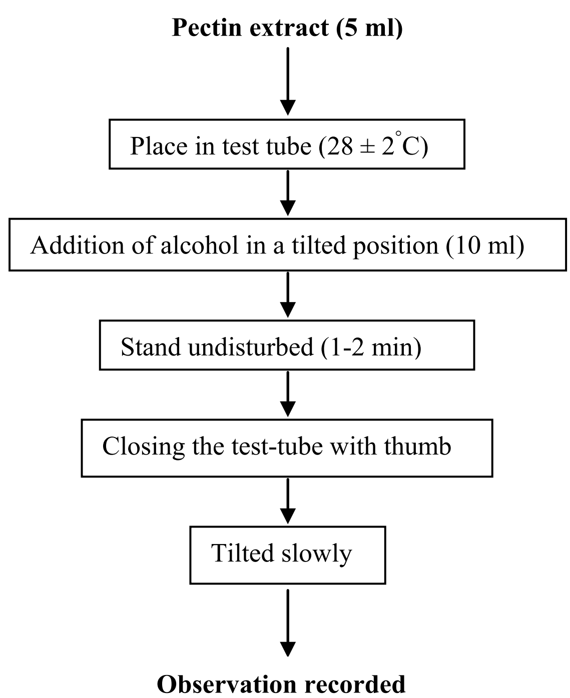

Figure 2: Flow chart showing pectin strength evaluation.

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	Samples (%) per 300 g					
Ingredients	**A**	**B**	**C**	**D**	**E**	**F**
Cashew apple (C)	300	0	0	0	0	0
Mango (M)	0	300	0	0	0	0
Guave (G)	0	0	300	0	0	0
Pineapple (PA)	0	0	0	300	0	0
Lemon (L)	0	0	0	0	300	0
Sour-Sop (SS)	0	0	0	0	0	300
Sugar (SG)	200	200	200	200	200	200
Citric acid (CA)	10	10	10	10	10	10
Pectin (PT)	10	10	10	10	10	10
Distilled water (DW)	200	200	200	200	200	200

Table 1: Recipe Formulation for jam and marmalade.

Figure 3: Fruits used.

Figure 4: Lemon pectin.

Proximate analysis of jam and marmalade: Proximate compositions of jam and marmalade were determined using the AOAC [8] standard method. For moisture content, hot air oven (Thermo Scientific-UT 6200, Germany) was used to dry 2 g sample weight to a constant weight at 105 ± 2°C for 3 hr-5 hr and the moisture content was calculated after placing the sample in a desiccator to cool for about

Figure 5: Fruits puree.

Figure 6: Jam and Marmalade.

15 min. The fat content was determined using the Soxhlet solvent extraction method. Petroleum ether was used in a Soxhlet apparatus (Gerhardt Soxtherm SE-416, Germany) to extract fat from a known weight of the sample. Two grams of the sample labeled A were weighed into the extraction thimble and the thimble was blocked with cotton wool. It was then placed back in the Soxhlet apparatus fitted with a weighed flat bottom flask (B) which was filled to about three-quarter of its volume with petroleum ether with a boiling point of 40°C to 60°C. The extraction was carried out for a period of 4 h to 8 h after which complete extraction was done. Crude protein was determined using the micro-Kjeldahl method and each sample's percentage protein calculated by multiplying their nitrogen value by the factor of 6.25 and the ash content determined as a percentage of the sample weight while total carbohydrate content was estimated by difference.

Analysis of physical properties: Physical properties such as pH, total titratable acidity, total sugar (°Brix) and viscosity of the jam and marmalade were determined using the standard method of Analytical Chemist [8].

Sensory evaluation: The sensory evaluation of the jam and marmalade were carried out using a panel of 20 persons comprising of students and staff of the Department of Food Science and Technology and Home Science and Management, Rivers State University. The samples were assessed on a 9-point hedonic scale with 1 representing dislike extremely and 9 like extremely. The samples were presented in a random pattern and the parameters evaluated included; texture, flavor, taste, appearance, spreadability and general acceptability. A glass of water was presented to each panelist for rinsing of mouth in between each evaluation in accordance with Iwe [9] method.

Statistical analysis: Statistical analysis was conducted in duplicate and mean values reported using Analysis of Variance (ANOVA), Microsoft Excel spreadsheet, version 20.1, the year 2011 and separation of the mean values were carried out using the Least Significant difference (LSD) test at 5% level of significance.

Results and Discussion

Pectin strength

This study revealed that lemon has high pectin strength, mango and guava have medium while cashew apple, pineapple, and sour-sop have weak pectin strength as presented in Table 2. This finding is in agreement with the observation of Baker [10] who reported high pectin strength for lemon. Beda et al. [11] equally reported mango and guava with medium pectin strength. Emelike et al. [7] also reported weak pectin strength for pineapple and cashew apple fruits. Past research studies had linked pectin strength to rich or low fiber sources of fruits [12]. Consumption of these fruits in fresh, jam and marmalade form may add to the dietary fiber needs of the populace irrespective of the pectin strength.

Proximate compositions of jam and marmalade samples

The proximate analysis divulged that moisture content of the jam and marmalade samples ranged from 23.29%-45.21% and 24.92%-49.02% with Guava recording the highest and pineapple the lowest in both jam and marmalade as presented in Tables 3 and 4. The high moisture content observed in this study for guava jam and marmalade is comparable to that reported by Correa et al. [13] and Aina et al. [14] also reported 30% for pineapple jam. These are equally within the range observed in this study. There was no significant different ($p<0.05$) between samples SSJ and GJ, MJ and SSJ while significant difference exists among other jam samples. In terms of the marmalade, there was no significant difference between samples MM and GM, MM and CAM, LM and SSM while sample PM had significant different to others. It has been reported by Eke-Ejiofor and Owuno [15] that moisture has a great impact on the shelf life of products. Ashage and Adeleke [16] also stated that the moisture content of any food material is a measure of its shelf life.

The ash content of food materials gives an indication of the mineral composition of the food sample which is very important in many biochemical reactions. The ash content of the jam samples ranged between 0.19%-0.82% with MJ and SSJ recording significantly lower and higher values, respectively. Values for marmalade samples ranged from 0.24% to 0.62% with MM and CAM recording significantly higher ($p>0.05$) values and LM significantly lower ($p<0.05$) value. Ebere et al. [17] equally reported an increase in cash value of cookies produced with cashew apple fiber incorporation. This is evident that cashew apple is embedded with a high amount of ash and hence, good quality mineral compositions. The difference in ash content between mango jam and mango marmalade could be associated with the addition of fruit peels to the marmalade samples. The value observed for SSJ is higher than the findings of Kang who reported 0.37% ash for sour-sop jam and lower to that reported by Aina et al. [14] with the value 5.10% for pineapple jam. This might be attributed to the ratio of composition of the fruit pulps. Tarwar et al. [18] also reported 0.3% ash in guava jam which is in agreement with the one observed here with the value of 0.38%.

Crude protein values of the jam samples ranged between 0.20%-0.73% with SSJ recording the highest and PJ the lowest. That of marmalade samples ranged from 0.28%-0.86% with CAM recording

Fruit extract	Pectin strength
Lemon	High
Mango	Medium
Guava	Medium
Pineapple	Weak
Cashew apple	Weak
Sour-sop	Weak

Table 2: Pectin strengths of some selected fruits.

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
PJ	23.41 ± 0.46^{e}	0.57 ± 0.02^{b}	0.20 ± 0.00^{c}	0.08 ± 0.00^{e}	75.87 ± 0.48^{a}
MJ	39.41 ± 0.84^{bc}	0.19 ± 0.00^{c}	0.46 ± 0.00^{b}	0.18 ± 0.00^{d}	64.77 ± 0.23^{bc}
CAJ	27.92 ± 1.88^{d}	0.56 ± 0.02^{b}	0.29 ± 0.12^{c}	0.44 ± 0.00^{a}	70.80 ± 1.78^{b}
LJ	38.67 ± 0.35^{c}	0.39 ± 0.01^{b}	0.31 ± 0.20^{c}	0.02 ± 0.00^{f}	60.62 ± 1.98^{d}
SSJ	42.39 ± 0.35^{ab}	0.82 ± 0.20^{a}	0.73 ± 0.08^{a}	0.26 ± 0.00^{c}	55.81 ± 0.06^{d}
GJ	45.21 ± 0.35^{a}	0.38 ± 0.00^{b}	0.40 ± 0.11^{c}	0.38 ± 0.00^{b}	53.64 ± 0.75^{d}
LSD	3.33	0.22	0.20	0.00	4.06

Values in the same column having different superscript are significantly different at 5% level of probability ($p<0.05$), ± standard deviation of duplicate determination
Key: PJ: Pineapple Jam; MJ: Mango Jam; CAJ: Cashew Apple Jam; LJ: Lemon Jam; SSJ: Sour-sop Jam; GJ: Guava Jam

Table 3: Proximate compositions of the jam samples.

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
PM	24.92 ± 2.83^{d}	0.37 ± 0.00^{b}	0.30 ± 0.00^{d}	0.22 ± 0.00^{a}	74.19 ± 2.83^{a}
MM	46.17 ± 0.01^{ab}	0.62 ± 0.00^{a}	0.70 ± 0.11^{ab}	0.18 ± 0.00^{b}	52.34 ± 0.10^{c}
CAM	44.21 ± 0.49^{b}	0.57 ± 0.00^{a}	0.28 ± 0.18^{d}	0.08 ± 0.00^{d}	54.86 ± 0.68^{c}
LM	39.65 ± 1.08^{c}	0.24 ± 0.07^{c}	0.54 ± 0.00^{bc}	0.14 ± 0.00^{c}	60.31 ± 0.86^{b}
SSM	38.23 ± 0.91^{c}	0.43 ± 0.06^{b}	0.86 ± 0.00^{a}	0.18 ± 0.00^{b}	60.31 ± 0.86^{b}
GM	49.02 ± 0.91^{a}	0.45 ± 0.06^{b}	0.43 ± 0.00^{cd}	0.08 ± 0.00^{d}	50.03 ± 0.84^{d}
LSD	3.63	0.09	0.20	0.00	3.58

Values in the same column having different superscript are significantly different at 5% level of probability ($p<0.05$), ± standard deviation of duplicate determination
Key: PM: Pineapple Marmalade; MM: Mango Marmalade; CAM: Cashew Apple Marmalade; LM: Lemon Marmalade; SSM: Sour-Sop Marmalade; GM: Guava Marmalade

Table 4: Proximate compositions of the marmalade samples.

the lowest compared to SSM which has significantly (p>0.05) highest value. The highest protein values observed in this study for sour-sop jam and marmalade is in agreement with the work of Akimolafe and Ajayi [19] who also reported high protein value for sour-sop jam. This might be attributed to the high protein content of the sour-sop fruit with a value of 15.62% as compared to other fruits [19]. Results showed that PJ, CAJ, LJ, and GJ were not significantly (p<0.05) different from each other while significant differences exist between MJ and SSJ samples. Results showed that samples PM, CAM and GM had crude protein values that are not significantly (p>0.05) different from each other while LM and SSM were significantly different. Protein values of 0.22% and 0.26% for guava and pineapple jams, respectively reported by Homi [20] and Olugbenga et al. [21] are within the ranges observed in this study for these fruits.

The crude fat content of the jam samples ranged from 0.02%-0.44% with CAJ recording the highest and LJ the lowest with a significant difference among all the jam samples. Marmalade samples had fat values which ranged from 0.08%-0.22% with PM recording the significantly highest value as against CAM and GM with significantly lowest values compared to other samples. The crude fat content of the jam and marmalade samples were lower than 3.40% for pineapple jam and higher compared to 0.02% sour-sop jam [14]. This could be attributed to the ratio of composition of the fruit pulps. The fat content of 0.09% in guava jam was observed by Tarwar et al. [18]. This value is in comparison with the value of GM observed in this study. This is an indication that the fat content of the produced GM is in a minute quantity; hence, suitable for health conscious individuals.

The carbohydrate content of the jam samples ranged from 53.64%-75.87% with GJ recording the lowest and PJ with significantly highest (p>0.05) value. The carbohydrate values for the marmalade samples ranged from 50.03%-74.19% with PM and GM recording significantly highest and lowest values, respectively. The carbohydrate content of the pineapple jam and marmalade were high as compared to other fruits and this might be attributed to the carbohydrate content of pineapple 16.05% as compared to other fruits such as guava 15.43%, mango 15.93% and sour-sop 12.66% [22]. Jam samples with low carbohydrate content might be ideal for diabetic and hypertensive patients requiring low sugar diets. Morton [23] also reported that the total carbohydrates in guava fruits ranged between 9.5% and 10%. Carbohydrate content of the fruit jam and marmalade samples were similar with the findings of Aina et al. [14] and Homi [20] for pineapple and guava jams with the values of 58.6% and a range of 63.73%-70.98%, respectively.

Processing of jam and marmalade results in moisture reduction and thus the concentration of food [24]. This statement is evident with the occurrence in this present study.

Physical properties of the jam and marmalade samples

Physical properties of the produced jam and marmalade samples are presented in Tables 5 and 6, respectively. The result showed that values for viscosity ranged from 0.36 pa.S-2.57 pa.S with significantly lowest and highest values for SSJ and CAJ samples, consecutively while that of marmalade ranged from 0.17 pa.S-2.21 pa.S with MM recording the lowest and PM the highest, significantly (p<0.05). Viscosity depends upon the pectin concentration of the fruits and temperature used in the production process. One of the most important parameters that have an effect on viscosity is temperature [21]. This study showed that sugar type is important for pectin solution and it is reported that sucrose formed the most rigid gels that give a better texture to product [25]. Sucrose increases the viscosity of pectin solutions. Changes in the viscosity of jam and marmalade samples were due to the presence of the added sugar and sugar inherent in fruits and this is in agreement with the statement of Jaranmond and Endan [26].

Sugar content is an important parameter in the production of jams and marmalades. Pineapple jam and marmalade had significantly highest sugar content with the values 72.10°Brix and 68.2°Brix and this may be attributed to the natural sugar level present in the fruit. All the jam samples had sugar contents significantly (p<0.05) different from each other except MJ and LJ samples. In terms of the marmalades, there was no significant (p<0.05) different in the sugar levels of samples MM, LM, and SSM, as well as CAM and GM samples.

pH values for the jam and marmalade samples were slightly lower

Samples	Viscosity (pa.S)	Sugar (°Brix)	pH	Titratable Acidity (%)
PJ	2.31 ± 0.00^{ab}	72.10 ± 0.71^{a}	2.75 ± 0.21^{a}	3.35 ± 0.06^{b}
MJ	2.22 ± 0.20^{bc}	55.00 ± 0.00^{d}	2.45 ± 0.07^{abc}	2.78 ± 0.00^{d}
CAJ	2.57 ± 0.18^{a}	66.00 ± 0.00^{b}	2.30 ± 0.14^{c}	3.31 ± 0.00^{b}
LJ	1.96 ± 0.06^{c}	54.50 ± 0.31^{d}	2.35 ± 0.07^{c}	4.63 ± 0.05^{a}
SSJ	0.36 ± 0.06^{d}	63.80 ± 0.00^{c}	2.70 ± 0.00^{ab}	3.01 ± 0.03^{c}
GJ	2.19 ± 0.04^{c}	52.80 ± 0.00^{e}	2.40 ± 0.00^{bc}	2.60 ± 0.01^{e}
LSD	0.23	0.94	0.31	0.07

Values in the same column having different superscript are significantly different at 5% level of probability (p<0.05), ± standard deviation of duplicate determination
Key: PJ: Pineapple Jam; MJ: Mango Jam; CAJ: Cashew Apple Jam; LJ: Lemon Jam; SSJ: Sour-Sop Jam; GJ: Guava Jam

Table 5: Physical properties of the jam samples.

Samples	Viscosity (pa.S)	Sugar (°Brix)	pH	Titratable Acidity (%)
PM	2.21 ± 0.16^{a}	68.20 ± 0.00^{a}	2.40 ± 0.00^{c}	3.54 ± 0.10^{a}
MM	0.17 ± 0.06^{c}	55.00 ± 0.00^{b}	2.65 ± 0.07^{b}	2.06 ± 0.01^{d}
CAM	1.65 ± 0.04^{b}	53.90 ± 0.00^{c}	2.50 ± 0.00^{c}	3.01 ± 0.14^{b}
LM	1.83 ± 0.33^{ab}	55.00 ± 0.00^{b}	2.70 ± 0.00^{b}	2.49 ± 0.10^{c}
SSM	1.83 ± 0.00^{ab}	55.00 ± 0.00^{b}	2.50 ± 0.00^{c}	1.83 ± 0.00^{e}
GM	1.95 ± 0.10^{ab}	44.00 ± 0.00^{c}	2.95 ± 0.07^{a}	1.95 ± 0.10^{e}
LSD	0.43	0.00	0.11	0.14

Values in the same column having different superscript are significantly different at 5% level of probability (p<0.05), ± standard deviation of duplicate determination
Key: PM: Pineapple Marmalade; MM: Mango Marmalade; CAM: Cashew Apple Marmalade; LM: Lemon Marmalade; SSM: Sour-Sop Marmalade; GM: Guava Marmalade

Table 6: Physical properties of the marmalade samples.

Samples	Colour	Taste	Flavor	Texture	Spreadability	Overall acceptability
PJ	6.30^{ab}	7.05^{a}	6.90^{a}	6.60^{a}	7.00^{a}	7.05^{ab}
MJ	7.20^{a}	7.30^{a}	7.10^{a}	7.00^{a}	6.95^{a}	7.80^{a}
CAJ	6.45^{ab}	7.10^{a}	6.85^{a}	6.65^{a}	7.30^{a}	7.45^{a}
LJ	5.55^{bc}	6.65^{a}	6.50^{a}	6.20^{a}	6.50^{a}	6.40^{bc}
SSJ	5.25^{c}	5.20^{b}	5.35^{b}	5.25^{b}	4.95^{b}	5.50^{c}
GJ	5.15^{c}	5.75^{b}	5.45^{b}	5.55^{b}	4.60^{b}	5.90^{c}
LSD	0.98	0.85	0.96	0.95	0.97	0.84

Values in the same column having different superscript are significantly different at 5% level of probability (p<0.05), ± standard deviation of duplicate determination
Key: PJ: Pineapple Jam; MJ: Mango Jam; CAJ: Cashew Apple Jam; LJ: Lemon Jam; SSJ: Sour-Sop Jam; GJ: Guava Jam

Table 7: Sensory parameters of the jam samples.

Samples	Colour	Taste	Flavour	Texture	Spreadability	Overall Acceptability
PM	7.05^{ab}	6.90^{a}	6.65^{ab}	6.60^{ab}	6.45^{bc}	7.15^{a}
MM	7.35^{a}	7.25^{a}	7.10^{a}	7.40^{a}	7.35^{ab}	7.50^{a}
CAM	4.85^{d}	5.90^{b}	5.85^{bc}	5.70^{bc}	6.00^{cd}	5.80^{b}
LM	6.35^{b}	7.20^{a}	6.90^{a}	7.25^{a}	7.90^{a}	7.60^{a}
SSM	5.20^{cd}	4.65^{c}	5.20^{c}	4.70^{d}	3.00^{e}	4.55^{c}
GM	5.50^{c}	7.00^{a}	6.15^{b}	5.40^{c}	5.35^{d}	6.25^{b}
LSD	0.96	0.83	0.79	0.85	0.89	0.84

Values in the same column having different superscript are significantly different at 5% level of probability (p<0.05), ± standard deviation of duplicate determination
Key: PM: Pineapple Marmalade; MM: Mango Marmalade; CAM: Cashew Apple Marmalade; LM: Lemon Marmalade; SSM: Sour-Sop Marmalade; GM: Guava Marmalade

Table 8: Sensory parameters of marmalade samples.

than the value of 3.95% reported by Fasogbo et al. [27] for pineapple jam. Pineapple jam and guava marmalade sample had the highest pH value. The pHs of all the jam and marmalade samples are within the acidic pH range and thus, are desirable for the inhibition of bacterial growth [28]. This range of pH could be associated with the natural pH value of the selected fruits and high level of sugar content in the products. There is a natural phenomenon of sugar being used to restrain the growth of microbes and therefore reduce food spoilage to the barest minimum which science has proven right. This is in agreement with the statement of Aina and Adesina [29] that high values for pH and sugar are recommended to hinder microbial growth and maintain keeping quality.

Total Titratable acidity of the jam samples ranged from 2.60%-4.63% with GJ recording the lowest and LJ the highest while that of marmalade samples ranged from 1.83%-3.54% with PM recording the highest and SSM the lowest, significantly. The values for jam samples are higher and that of marmalade are within the range of 1.18% reported by Fasogbo et al. [27] which could be attributed to the ratio of the composition.

Sensory properties of the fruit jam and marmalade samples

The sensory score for the color of the jam samples ranged from 5.15-7.20 with GJ as least preferred and MJ as most preferred while marmalade samples ranged from 4.85-7.35 with MM as most preferred and CAM as least preferred, significantly as shown in Tables 7 and 8, respectively. Taste and flavor of the jam samples ranged from 5.20-7.30 and 5.35-7.10 while marmalade samples ranged from 4.65-7.25 and 5.35-7.10, respectively. Texture and spreadability of the jam samples ranged from 5.25-7.00 for samples SSJ and MJ and 4.60-7.00 for samples GJ and PJ, respectively. Texture and spreadability of the marmalade samples ranged from 4.70 (sample SSM)-7.40 (sample MM), 3.00 (SSM sample)-7.90 (LM sample), respectively. Overall acceptability of the jam samples ranged from 5.50-7.80 and MJ was rated most preferred while SSJ was least preferred. Overall acceptability of the marmalade samples ranged from 4.55-7.60 for samples overall acceptability LM and SSM as the most and least preferred, consecutively. The recorded sensory scores is an indication that the fruit jam samples were highly acceptable by the consumers except for those produced from sour-sop and guava which had the least preference scores compare to other samples. But the fact that their overall acceptability is beyond 5.50 on a 9-point hedonic scales revealed that they were equally acceptable by the panelists. A similar trend was also observed in the case of marmalade having the least overall acceptability score of 4.55 for the sour-sop sample. The high sensory values of these jams and marmalades could be due to the color, flavor, and texture of these fruits which is transferred to the final products on processing. Olugbenga et al. [21] also reported the same trend for banana, pineapple and watermelon jam blends in which pineapple jam recorded the best overall sensory acceptability due to the arrays of color and taste which this fruit supplies. Othman [30] stated that pineapple and mango fruits are an excellent source of vitamins and minerals and supply a range of sensory characteristics which enhances their eating attractiveness.

Conclusion

This study revealed that acceptable jams and marmalades can be produced from abundant Nigerian tropical fruits with intact nutritional and structural compositions. This will not only reduce the wastage of these fruits, but it will also serve as a means of income generation in the country instead of the usual outflow of the fund in the purchase of strawberry jam and marmalade.

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