International Journal of
Education, Management, and Technology

e-ISSN : 3026-5444
p-ISSN : 3026-4200
Index : Harvard, Boston, Sydney University, Dimensions, Lens, Scilit, Semantic, Google, etc

https://doi.org/10.58578/IJEMT.v2i3.3861

Production of Nutritional and Functional Jam from Cayenne Pepper

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Article Info:

Submitted:	Revised:	Accepted:	Published:
Sep 1, 2024	Sep 14, 2024	Sep 18, 2024	Sep 21, 2024

Abstract

Cayenne peppers are high in nutritional value, antioxidant properties but highly perishable like any other fresh fruits and vegetables. Fresh pepper is highly perishable and deteriorates within a few days after harvest without proper storage or preservation measures. The economic importance of Cayenne peppers is remarkable. In addition, their perishability is high and their added-value is low. Thus, it is important to find ways to improve their shelf life and add value to the crop. Therefore, there is need to study the processing of cayenne pepper into value added product such as Jam. Fresh cayenne peppers was sorted, washed, sliced into smaller sizes and homogenized. The homogenized pulp was heated, sweetners, pectin was added and jam was produced. The produced jam was subjected to physiochemical, texture and sensory evaluation. All data obtained was subjected to statistical analysis using Analysis of variance ANOVA. The results showed that the physiochemical composition of cayenne pepper ranged from 12.76 to 12.89 °Brix, 121.28 to 122.11 mg/100g; 2.85 to 2.49mg/100g; 0.31 to 0.39%; 47.35 to 49.17%; 97.67 to 111.67 for total soluble solid (TSS), vitamin C, carotenoid, total titrable acidity, DPPH and phenolic, respectively. The texture ranged from 0.27 to 3.93; 0.78 to 0.94; 1.56 to 9.11; 0.29 to 1.54; 0.38 to 0.89; 0.15 to 0.36; 0.42 to 1.11; 0.01 to 0.03; 15.18 to 15.25 for Hardness, springiness, adhesiveness, cohesiveness, chewiness, fracturability, gumminess, energy to peak and springiness, respectively. Yoruba pepper jam with date were well accepted among the samples in terms of all the attributes (colour, aroma, firmness, gelatinous, taste, mouthfeel and overall acceptability), followed by hausa pepper jam with date, yoruba pepper jam with sugar and hausa pepper jam with sugar. It could be deduced from the results that the present study that production of jam using different sweeteners (date and sugar) and from different varieties of cayenne pepper (Yoruba and Hausa) has great potentials. Yoruba cayenne pepper had better TSS, vitamin C, carotenoids, TTA and total phenol. All the sensory attributes indicated that the jam blends were well acceptable to the consumers especially the colour, aroma, firmness, gelatinous, taste, mouthfeel and overall acceptability but cayenne Hausa (sugar and date) had the best sensory attributes but yoruba pepper jam with date were well accepted among the samples in terms of all the attributes (colour, aroma, firmness, gelatinous, taste, mouthfeel and overall acceptability), followed by hausa pepper jam with date, yoruba pepper jam with sugar and hausa pepper jam with sugar. Processing of cayenne pepper into jam using different sweeteners will help in reducing post-harvest losses of the pepper and also enhance the utilization potential of the pepper.

Keywords: Cayenne Pepper, Jam Production, Sensory Evaluation, Physiochemical Analysis, Consumer Acceptability

INTRODUCTION

Pepper is an important crop not only because of its economic importance but also for the nutritional value of its fruits being a major source of natural colour and antioxidant compounds (Howard *et al.,* 2004). The intake of these compounds in food is an important health protecting factor that have been recognized as being beneficial for prevention of widespread human diseases, such as cancer and cardiovascular diseases (Brainley, 2000). Peppers are widely used in food products such as sauces, meats, jellies, cakes, chocolates, and sweets due to their spicy and pungent flavour caused by the presence of capsaicin (Carvalho *et al.*, 2006). Besides being used as a spice, peppers also have a preservative effect because they are rich in capsaicin exhibiting high antioxidant and antimicrobial properties (Reifschneider, 2000).

Cayenne is a member of the genus *Capsicum* and other species of this genus include Tabasco peppers, African peppers, Mexican chili peppers, bell peppers, pimentos, paprika, and bird peppers. Cayenne is often referred to as chili, which is the Aztec name for cayenne pepper. The name cayenne is derived from a Tupi word, "kyinha." The cayenne plant produces long red peppers and grows to a height of 2–6 ft. (0.5–2 m). The plant is native to tropical areas of America and is cultivated throughout the world in tropic and subtropics' climate zones. Cayenne (*Capsicum frutescens*) is a stimulating herb that is well known for its pungent taste and smell. It is a popular spice used in many different regional styles of cooking, but it has also been used medicinally for thousands of years. The main medicinal properties of cayenne are derived from capsaicin which gives peppers their heat. In addition to adding heat to the pepper, capsaicin acts to relieve pain and reduce platelet stickiness. Cayenne contains vitamins C and E and carotenoids. It has anti-inflammatory, antioxidant, anti-septic, diuretic, analgesic, expectorant, and diaphoretic properties.

Cayenne pepper is a member of hot pepper which belongs to the Solanaceous family, and it is commonly used as ingredient in the preparation of soups, sauces, stew probably because it contains essential nutrients and vitamins such as A, E and C. It is called "sombo or bawa" and usually consumed as fresh, dried or processed (Alegbejo, 1999; Denton and Olufolaji, 2000; Grubben and El-Tahir, 2004). Nigeria is the largest producer of pepper in Africa, accounting for about 50% of total world production. More recent estimates indicate that Nigeria produced about 700000 metrics tons of pepper from a total land area of about 77, 000 hectares (Zin *et al.,* 2006). Nigeria pepper is in high demand abroad because of its pungency and good flavor.

Statement of the Problem

Cayenne peppers are high in nutritional value, antioxidant properties but highly perishable like any other fresh fruits and vegetables. Fresh pepper is highly perishable and deteriorates within a few days after harvest without proper storage or preservation measures. The economic importance of Cayenne peppers is remarkable. In addition, their perishability is high and their added-value is low. Thus, it is important to find ways to improve their shelf life and add value to the crop.

Justification

Fruit and Vegetable preservation is the process of treating and handling food to stop or slow down spoilage but allows for the fruit to be stored over a long period of time. Using fruit to make jam as a method of preservation involves boiling, adding of sugar and sealing, yet maintaining nutritional value, texture and flavor. Value addition is one of the ways of creating awareness of the health benefits importance and usefulness of cayenne pepper. Cayenne peppers have been reported to have nutritional value, antimicrobial and anti-oxidative properties. These properties give them potentials to be used as functional food products. Processing into value added products such as Jam will also reduce postharvest losses and make it nutrients more available for the populace.

Aim and Objectives

This project is aimed at processing of cayenne pepper into jam and determining the quality attributes of the jam samples.

i. To determine the physical, physio-chemical and chemical properties of commonly consumed varieties of cayenne pepper.
ii. To determine the mineral profile, carotenoid and antioxidative properties of commonly consumed varieties of cayenne pepper in Nigeria.
iii. To determine the physico-chemical and sensory properties of jam produced form different varieties of cayenne pepper

MATERIALS AND METHODS

Freshly harvested cayenne pepper within the same dimension (width, length and breadth) and in very good conditions was purchased at Odo-oba market, Ogbomoso, Oyo state in Western Nigeria. All chemicals used was of analytical grade

Production of Cayenne Pepper Jam

Jam was produced as described by Oladapo (2014) as shown in Fig 3.1. Fresh cayenne peppers (was sorted, separated from the stems, washed, sliced into smaller sizes and homogenized with water (1:1 w/w) for about five (5) minute in a food-processor (Philips do Brash, São Paulo, Brazil). The homogenized pulp was heated in an aluminum pan at 70 °C for 10 minutes under direct fire to concentrate the aqueous extraction of pepper solids. The °Brix of the juice was determined using a refractometer. Sweeteners (date and sugar) were mixed with the diluted juice and the solution transferred to an aluminum kettle and evaporated at atmospheric pressure (91.325 Pa a Cuntiba, Brazil) under direct fire. The formulations that was used for the jam production is as shown in Table 1.

Analyses

Determination of the Physiochemical Properties

`pH

The pH of the fresh cayenne pepper and the jam samples was determined using pH meter (Jenway pH meter).

Cayenne pepper
↓
Sorting
↓
Washing
↓
Grinding
↓
Homogenizing (1/1 in water)
↓
Addition of ingredients (sugar/date and pectin)
↓
Evaporation
↓
Hot filling into cans
↓
Cayenne pepper jam

Figure 1: Flow-chart for the production of cayenne pepper jam. Source: Oladapo (2014).

Table 1: Cayenne pepper jam formulation

Ingredients	Sweeteners (date and sugar)
Juice pepper (g)	**500**
Water (ml)	**70**
Pectin (g)	**15**
°Brix	**65°C**

Source: Reis *et al.* (2009)

Soluble solid

The total soluble solid content of the fresh cayenne pepper and the jam samples was determined using the air oven method. Aluminum dishes was washed; dried in the oven for 10 min and kept in the desiccator to cool, after which their weights were taken.

Titrable Acidity

About 10 ml of the samples was pipetted into an Erlenmeyer flask with 2 drops of phenolphthalein added. This was titrated using 0.1 NaOH until a faint pink colour appears. The titer value was noted and used to calculate

Total Titrable Acidity (TTA) which was expressed as Percentage Lactic Acid.

% Lactic acid = A × 0.009 × 100/V;

Where A = ml of 0.1NaOH required for the titration;

and V = ml of sample taken for the test.

The acidity was calculated as lactic acid using the equation:

Volume of base used x Normality of NaOH N x 9

Volume of Sample used average titer

Reducing sugar

Reducing sugar was analyzed according to the method as described by AOAC (2010). Ten grams of jam sample was mixed in a beaker with 100 ml warm water. The mixture was stirred until the soluble matter was dissolved. They were then filtered through Whatman filter paper No. 4 and then distilled water was added to make final volume of 250 ml. The solution was transferred to burette and titrated against the 10ml Fehling's solution in conical flask containing 4-5 drops of methylene blue indicator till brick red color appeared. The reading on burette was noted and calculation was made according to following formula: Reducing sugar % = Factor (4.95) X dilution (250) X 2.5 Titre X wt of sample X 10

Non-reducing sugar

Non-reducing sugar was estimated by difference using following formula: non-reducing sugar (%) = Total sugar (%) - reducing sugar (%)

Chemical composition

Moisture content

About 5 g of the sample was weighed into a moisture dish and dried in hot air oven at 100 ℃ for 1 h. It was then cooled in a desiccator and weighed. It was then returned into the oven and the process was repeated until a constant weight was obtained (AOAC, 2010).

$$\% \, Moisture\ content = \frac{(\text{Initial weight}) - (Final\ weight)}{weight\ of\ sample} \, X\ 100$$

Total Carotenoid

Spectrophotometric determination of carotenoid content was carried out by using Spectrophotometer (UV-VIS SPECORD Analytik Jena, Germany) as described by Alda *et al.* (2009). Lycopene in the fresh and dried tomatoes samples was extracted by adding 8.0 ml of the mixture of hexane–acetone–ethanol (2:1:1, v/v/v) wrapped with aluminum foil to exclude light. Tubes was capped and vortexed immediately, and then incubate out of bright light. The mixture was extracted at room temperature for 30 min. This extract was reconstituted with 10 mL distilled water on a vortex mixer for 1 min. The sample was allowed to stand for 10 min so as to allow phases to separate and all air bubbles to disappear. The cuvette was rinsed with the upper layer from one of the blank samples, then using hexane as a blank to zero at 503 nm determine the A503 of the upper layers of the lycopene samples. Lycopene levels in the hexane extracts was calculate as follows: Where: The molecular weight of lycopene = 537g/mole, the volume of mixed solvent = 8 ml, the volume ratio of the upper layer to the mixed solvent = 0.55, the weight of added tomato = 1.0 g, the extinction coefficient for lycopene in hexane = 172 mM-1, The Spectrophotometer at 503nm = A503.

Vitamin C

The vitamin C present in the samples was extracted with 20% trichloroacetic acid and thereafter determined by titrimetric method using 2,6-dichlorophenol indophenol dye as described by Sadasivam and Manickam (1996).

Determination of Antioxidative properties

Total phenol

Total phenol content was determined using Folin-ciocalteau method as described by Roesler *et al.* (2006). The total phenol content of the sample was determined by mixing 0.5ml aliquot of freshly prepared sample extract with equal volume of water, 0.5 ml Folin-Ciocalteu's reagent, and 2.5 ml of saturated solution of sodium carbonate (Na_2C0_3). The absorbance was measured after 40 min at 725 nm (Singleton *et al.,* 1999). Total phenol content was extrapolated from the standard curve using the absorbance values and expressed as garlic acid equivalents (GAE / 100 g).

Texture profile

Cutting tests and compression tests was performed with Stable Micro System TA-XT2 Texture Analyzer. The cutting speed was 0.1 mm/s and the speed of the probe was 1.0 mm/s before and after the measurement at the cutting test. The cutting force was measured and the specific cutting force was calculated from the ratio of the maximum cutting force to the cutting diameter at the cutting method. At the compression tests the penetration speed was 0.2 mm/s with different probes depending on the material of the tested sample. However, the speed of the probe was 1.0 mm/s before and after the measurement (compression and decompression), respectively. The maximum compression force and the deformation was determined according to the character of the tested material (Kaszab *et al.*, 2011).

The results of the tests performed with the texture analyzer was recorded and evaluated by the Texture Expert 1.22 software.

Sensory Evaluation

The jam samples were subjected to sensory evaluation using 50 semi trained panelist. The jam was served with random coded plates. It was rated on a 9 point hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely) for different parameters

Statistical Analysis

All data obtained was subjected to statistical analysis using Analysis of variance ANOVA and Duncan multiple comparison test to test significant differences between means $p<0.05$. Data analysis was done using Statistical Package for Social Science SPSS version 20.0 (SPSS, 1993).

RESULTS AND DISCUSSION

Physiochemical Composition of Pepper

The physiochemical composition of cayenne pepper is shown in Table 4.1. The total soluble solid (TSS) of the cayenne pepper ranged from 12.76 to 12.89 °Brix with Hausa cayenne pepper having the lowest value while Yoruba cayenne pepper had the highest value. The differences that were registered in the values of TSS could be due to differences between the used cultivars. A similar result of TSS was reported by Tzortzakis *et al.* (2012) at fruits of pepper cv. Oregon, in assessing the effects of municipal solid waste compost (MSWC) mixed with soil, in different ratios, without fertigation. Also a lower value of 4.26 °Brix was reported by Aminifard *et al.* (2013) in fruits of sweet pepper cv. And 4.6 °Brix was observed by by Chassy *et al.* (2006) in fruits of bell peppers. No significant different was recorded between samples at $p< 0.05$.

The vitamin C content of the cayenne pepper ranged from 121.28 to 122.11 mg/100g with Hausa cayenne pepper having the lowest value while Yoruba cayenne pepper had the highest value. This implies that the intake of Yoruba cayenne pepper may take care of vitamin C deficiency related aliment like scurvy (Edem and Miranda, 2011). This is lower to the result obtained on vitamin C content (12.50±0.82- 27.29±0.94) mg/100g of some selected vegetables like *Oha, Ukazi, Nchuanwu* and *Uziza* as reported by Chinma *et al.* (2007). Vitamin C is involved in protein metabolism, collagen synthesis and an important physiological antioxidant (Li and Schellhorn, 2007; Jacob *et al.*, 2002). It also plays an important role in immune function, improves absorption of non-heme iron and participates in biosynthesis of glucocorticoids (Gershoff, 1993). No significant difference was recorded between the samples at $p< 0.05$.

Table 2: Physiochemical Composition of the Cayenne Pepper

Sample	TSS	Vitamin C	Caroteniods	TTA	DPPH	Total phenol
A	12.76±0.09 [a]	121.28±0.45 [a]	2.49±0.06 [b]	0.31±0.01 [b]	49.17±2.89 [a]	97.67±5.85 [b]
B	12.89±0.08 [a]	122.11±0.10 [a]	2.85±0.13 [a]	0.39±0.01 [a]	47.35±1.54 [b]	111.67±7.23 [a]

Means with different superscripts are significantly different ($p < 0.05$).

Sample A= Cayenne hausa pepper

Sample B= Cayenne yoruba pepper

The carotenoid content of the cayenne pepper ranged from 2.85 to 2.49mg/100g with Hausa cayenne pepper having the lowest value while Yoruba cayenne pepper had the highest value. This implies that the pepper contains a considerable amount of carotenoids which can light against diseases like age- related muscular degenerative disease, hypercholesterolemia, cardiovascular disease, hypertension, diabetics and onset of cancer occurrence in human being (Menottetali *et al*., 2019). Likewise, Lee *et al.* (2012) showed that carotenoid destruction in red peppers was greatly affected by water activity and storage temperature and reported that carotenoid stability in red peppers was improved by lowering the storage temperature. Carotenoids are fairly stable in their natural environment, but become sensitive to light and temperature and are readily decomposed during some food processing operations (Perez-Galvez*et al*., 2009).

The results are in line with the findings of Schweiggert *et al.* (2007) that total carotenoid concentration during four months' storage at ambient temperature dropped by 9.6% and 16.7% in chili and 38.8% and 39.7% in paprika powders with and without illumination, respectively. Similarly, variation or loss of carotenoids during foods processing, e.g., peeling, as well as storage, occurs through geometric isomerization and enzymatic or non-enzymatic oxidation (Rodriguez-Amaya, 2003). It has been reported that the loss of the carotenoid fraction during storage correlates with the development of prooxidative processes in paprika (Perez-Galvez*et al*., 2003). Significant different observed in all the samples ($p > 0.05$).

The total titrable acidity of the pepper ranged from 0.31 to 0.39% with Hausa cayenne pepper having the lowest value while Yoruba cayenne pepper had the highest value. This pattern of acidity (%) might be due to formation of organic acids by ascorbic acid degradation and de-esterification of protein molecules. These findings were in accordance with results obtained by Prasad and Mail (2006) and Shakir *et al.* (2008) in apple and pear mixed fruit jam. Significant differences were observed in all the samples ($p > 0.05$). Significant different observed in all the samples ($p > 0.05$).

The DPPH content of the cayenne pepper ranged from 47.35 to 49.17% with Yoruba cayenne pepper having the lowest value while hausa cayenne pepper had the highest value. It is generally recognised that free radicals produced in the body are purely associated with etiology of cancers and other chronic diseases. Dietary antioxidants capable of scavenging free radicals can reduce the risks of cancer and chronic diseases (Duh*et al.*, 2019). Significant different observed in all the samples ($p > 0.05$).

The phenolic content of the cayenne pepper ranged from 97.67 to 111.67 with Hausa cayenne pepper having the lowest value while Yoruba cayenne pepper had the highest value. Phenols are one of the major groups of non-nutritive dietary components that have been associated with the inhibition of cancer, atheriosclerosis, as well as ameloriating age-related degenerative brain disorder (Chang *et al.*, 2002). Phenolic phytochemicals inhibit autoxidation of unsaturated lipids, thus preventing formation of oxidized low density lipoprotein (LDL) which has been associated with the incidence of cardiovascular diseases (Fang*et al.*, 2002; Xu*et al.*, 2007). Natural phenolic compounds are capable of decreasing oxygen concentration, intercepting singlet oxygen, preventing 1st – chain initiation by scavenging initial radicals such as hydroxy radicals, binding metal ion catalyst, decomposing primary products of oxidation to nonradical species, and breaking chains to prevent continued hydrogen abstraction from substances (Shahidi and Naczk, 2004). Significant difference were observed in all the samples ($p > 0.05$).

Physiochemical Composition of Jam

The physiochemical composition of jam from cayenne pepper is shown in Table 4.1. The pH of the jam ranged from 3.06 to 3.26 with hausa pepper jam with sugar having the lowest value while yoruba pepper jam with sugar had the highest value. The pH of the jam varies, this could be that the pH may have inhibited the growth and proliferation of the contaminants and this indicating an acidic condition that promotes yeast growth and some bacteria species (Endress *et al.,* 2005). The results is similar to the report of Harris *et al.,* (1991) who report that fruit and jam falls within the range of 3 – 5. The pH in the present study was slightly lower than that of jackfruit (Eke-Ejiofor and Owuno, 2013) and pineapple jam (Hanan *et al.,* 2012) which ranged from 4.8 to 6.3 in low calorie baladi rose petals jam. The pH of jam is an important factor to obtain optimum gel condition. The pH must not be too low (>3.5) since it could induce deterioration of sensory quality: glucose crystallization; granular texture; excessive acidic flavour; and exudation phenomenon (Besbes *et al*., 2009). No significant different was between samples at $p < 0.05$ except sample A.

The moisture contents of the jam ranged from 49.68 to 55.57% with yoruba pepper jam with date having the lowest value while hausa pepper jam with date had the highest value. Moisture has a great impact on the shelf life of products (Eke-Ejiofor and Owuno, 2013). Processing of jams resulted in water removal and thus concentration of food nutrients (Saka *et al*., 2007). Moisture and dry matter levels of any food material is a measure of the shelf life of the food (Ashaye and Adeleke, 2009). It is expected that the lower moisture will deter microbial proliferation. Moisture content is an indicator of shelf life stability; an increase in moisture content enhances microbial contamination and chemical reactions that could lead to a reduction in food quality and stability (Abioye *et al*., 2016). Significant different observed in all the samples ($p > 0.05$).

Table 3: Physiochemical Composition of Jam

Sample	pH	Moisture (%)	Ash (%)	TSS °Brix	Vitamin C (mg/100g)	TTA	Reducing sugar	Non reducing sugar	Total sugar
A	3.06 ± 0.03^{b}	50.09 ± 0.36^{c}	0.51 ± 0.02^{b}	65.34 ± 0.08^{c}	56.65 ± 0.23^{d}	0.55 ± 0.02^{b}	39.18 ± 0.27^{d}	20.07 ± 0.08^{b}	59.54 ± 0.10^{b}
B	3.25 ± 0.05^{a}	55.57 ± 0.19^{a}	0.61 ± 0.01^{a}	68.53 ± 0.07^{b}	60.27 ± 0.41^{c}	0.63 ± 0.00^{a}	39.75 ± 0.29^{c}	23.59 ± 0.10^{a}	63.12 ± 0.13^{a}
C	3.26 ± 0.03^{b}	54.83 ± 0.06^{b}	0.53 ± 0.01^{b}	70.35 ± 0.14^{a}	68.41 ± 0.09^{b}	0.51 ± 0.02^{c}	42.28 ± 0.28^{b}	11.63 ± 0.08^{c}	54.79 ± 0.63^{c}
D	3.08 ± 0.02^{a}	49.68 ± 0.11^{d}	0.51 ± 0.03^{b}	65.05 ± 0.26^{c}	72.90 ± 0.16^{a}	0.52 ± 0.01^{bc}	45.69 ± 0.23^{a}	9.27 ± 0.05^{d}	55.14 ± 0.04^{c}

Means with different superscripts are significantly different ($p < 0.05$).

Sample A= Hausa pepper jam with sugar

Sample B= Hausa pepper jam with date

Sample C= Yoruba pepper jam with sugar

Sample D= Yoruba pepper jam with date

The ash contents of the jam ranged from 0.51to 0.61 with Yoruba pepper jam with date having the lowest value while Hausa pepper jam with date had the highest value. Ash content of a food is a measure of the amount of mineral composition present in the food. They are necessary in combating infections and for other metabolic activities in infants and children. High ash content has been ascribed to high minerals which could increase the mineral content of the consumers and are good for the bones as reported by (Sharma and Chauhan, 2000). Ash contents are an indication of minerals that are contained in the flours. Flours reported in this study are comparable with the work of Odenigbo *et al.* (2013). No significant different was between samples at $p< 0.05$ except sample B.

The total soluble solid (TSS) contents of the jam ranged from 65.05 to 70.35 ^{o}Brix with yoruba pepper jam with date having the lowest value Yoruba pepper jam with sugar had the highest value. The total soluble solid (TSS) of jam is significantly influenced by the combined effect of stages of maturity and ripening conditions (Bates *et al.*, 2001). The content depends mostly on the percentage of solid materials dissolved in water in the jam. Jam blends or beverage with less than 7 ^{o}Brix are categorized as weak and watery, meaning that the total soluble solids are low (Kamarul *et al.*, 2016). The total (soluble and non-soluble) solids are used as indicators of the fruit jam content that ranged from 13.2 to 44.03% in the orange jam samples. The total solids of jam content are used in characterizing the quality of jam and other beverage products (Egbekun and Akubor, 2007; Adubofuor *et al.,* 2010). The stability which is an indication of the maturity of the fruits used might be part of the reason the jam was palatable and acceptable, as it can be deduced that reducing sugars are the main constituents of soluble solids. The total soluble solids are used in characterizing the quality of jam and other products (Egbekun and Akubor, 2007; Adubofuor *et al.,* 2010). This content is reasonably lower as compared to the findings of Hofi *et al.* (1994) who stated that jam should have total solids of between 15% and 16% and Muhammed *et al.* (2005) who reported a total solid of drink to 17.11%. No significant different was between samples at $p< 0.05$ except sample B and C.

The vitamin C content ranged from 56.65 to 72.90mg/100g with Hausa pepper jam with sugar having the lowest value and Yoruba pepper jam with date having the highest value. The variation may be due to leaching of the vitamin being water soluble and oxidation due to longer period and higher temperature of drying. This was in agreement with the works of Shi*et al.* (1999) and Famurewa (2010), they reported that drying of vegetable leads to some losses of ascorbic and sensory characteristics. It was added that more severe drying conditions in oven caused higher losses of ascorbic acid. The vitamin C content of food product reduces during processing and thermal treatments. Loss of vitamin C is accelerated by water loss (Barth and Zhuang, 2006) and its relative stability or degradation is highly dependent on temperature and commodity type (Klein, 2017). However, processing of pepper has been reported to have a very detrimental effect on their ascorbic acid content (Takeoka*et al.,* 2001; Toor and Savage, 2006). Ascorbic acid is one of the most thermolabile components of food products, fact also confirmed at tomato drying. The vitamin C content in foods also helps in absorption of iron from the food. Vitamin C is a strong water soluble antioxidant that helps the body develop resistance against infectious agents and scavenges harmful free radicals (Olapade and Ogunade (2014). Significant different observed in all the samples ($p > 0.05$).

The total titratable acidity of the jam ranged from 0.51 to 0.63 with Yoruba pepper jam with sugar having the lowest value and Hausa pepper jam with date having the highest value. The more acidic the juice, the less susceptible to bacterial action but the more susceptible to the action of yeasts and moulds (Jay, 2000). Moreover Anvoh *et al.* (2009) reported that fruit acids influence colour, flavour and gustative characteristics of the juice products. These results were similar to that reported by Braddock (2019) which had earlier reported on orange (0.7-0.8%) and grape fruits (1.1-1.3%) respectively. Its stability might be due to the stable concentration of the organic acid in the jam judging by the report of Fasoyiro *et al.* (2005) that says that increase in titratable acidity could be due to presence of preservatives, and in this work, no preservative was added to the juice produced. The results of the titratable acidity obtained in this study agreed with the findings of Okoye and Animalu (2009), Eissa *et al.* (2010). Standard range of acidity is (0.14 - 0.16) which the result obtained is higher than. The TTA of the jam could protect the beverage from the development of food spoilage organisms which would lead to increase shelf-life of the product. Food acids dictate the dominant microflora in foods and to a large extent will determine the shelf stability of the juice (Ezeama, 2007). The more acidic the jam, the less susceptible to bacterial action but the more susceptible to the action of yeasts and moulds (Jay, 2000). Significant different observed in all the samples ($p > 0.05$).

The reducing sugar of the jam ranged from 39.18 to 45.69 with hausa pepper jam with sugar having the lowest value and Yoruba pepper jam with date having the highest value. The results are in agreement with the findings of the Besbes*et al.* (2009), furthermore, Pearson (2016) reported that the increase in reducing sugars content in date jam compared with the raw material could be explained by a partial hydrolysis of sucrose (initial and added) during cooking. These reducing sugars are essentially glucose and fructose (Al-Hooti*et al.*, 1995). Significant different observed in all the samples ($p > 0.05$).

The non-reducing Sugar of the jam ranged from 9.27 to 23.59 with yoruba pepper jam with date having the lowest value and Hausa pepper jam with date had the highest value. The results are supported by the Chefteland Cheftel (2016) they investigated that the non-reducing sugars, which have more affinity for water than sucrose, could contribute to the reduction of the jam crystallization phenomenon. The sugar fraction of pepper was essentially formed by non-reducing sugars. This could be attributed to a higher invertase activity. It is worth noting that sugar fraction of the majority of date cultivars was dominated by the reducing sugars (Barreveld, 2013).Significant different observed in all the samples ($p > 0.05$).

The total sugar of the jam ranged from 55.14 to 63.12 with Yoruba pepper jam with sugar having the lowest value and Hausa pepper jam with date having the highest value. The results revealed that the highest total sugar was recorded during the storage period. Our result are in agreement with the findings of Besbes *et al.* (2009) they reported high content of sucrose and low reducing sugar content. The total (reducing and non-reducing) sugars to a large extent determine the sweetness of juices and beverages. It could be used for masking the astringency derived from organic acids (Anvoh *et al.*, 2009; Adeola and Aworh, 2010). When compared with the recommended dietary allowances (RDA) of 130 g/day (El-Sheikha *et al.,* 2010), for total sugars, the orange juice samples will contribute to the average 15.40%. Wardlaw (2004) reported that frequent consumption of sugar sweetened beverages may be associated with larger weight gain and increased risk of type 2 diabetes. No significant different was between samples at $p < 0.05$ except sample A and B.

Texture Measurement of Jam

The texture measurement of the jam produced is as shown in Table 4.3. The texture ranged from 0.27 to 3.93; 0.78 to 0.94; 1.56 to 9.11; 0.29 to 1.54; 0.38 to 0.89; 0.15 to 0.36; 0.42 to

1.11; 0.01 to 0.03; 15.18 to 15.25 for Hardness, springiness, adhesiveness, cohesiveness, chewiness, fracturability, gumminess, energy to peak and springiness, respectively. Similar kind of results was reported by Sindumath and Amutha (2014) for coconut-based jam, Hussain and Shakir (2010) for apricot and apple jam and Vidhya and Narain (2011) for wood apple fruit preserve. Hardness is the height of the force peak of the first compression cycle (Bourne 2002). Springiness, or elasticity, is the rate at which the compressed sample returned to its original height after the deforming force was removed

Table 4: Texture Measurement of Jam

Sample	Hardness	Springiness	Adhesiveness	Cohesiveness	Chewiness	Fracturability	Gumminess	Energy to peak	Springiness
A	3.93 ± 0.19^{a}	0.78 ± 0.06^{b}	9.11 ± 2.82^{a}	0.29 ± 0.17^{b}	0.89 ± 0.52^{a}	2.88 ± 0.12^{a}	1.11 ± 0.62^{a}	0.03 ± 0.00^{a}	15.18 ± 0.03^{b}
B	0.27 ± 0.03^{c}	0.88 ± 0.05^{a}	1.56 ± 0.07^{b}	1.54 ± 0.82^{a}	0.38 ± 0.25^{a}	0.15 ± 0.02^{b}	0.42 ± 0.27^{a}	0.02 ± 0.00^{c}	15.29 ± 0.08^{a}
C	3.93 ± 0.19^{a}	0.78 ± 0.06^{b}	9.11 ± 2.82^{a}	0.29 ± 0.17^{b}	0.89 ± 0.05^{a}	2.88 ± 0.02^{a}	1.11 ± 0.62^{a}	0.03 ± 0.00^{a}	15.19 ± 0.03^{b}
D	0.68 ± 0.03^{b}	0.94 ± 0.01^{a}	3.48 ± 0.22^{b}	0.87 ± 0.02^{ab}	0.56 ± 0.02^{a}	0.36 ± 0.14^{b}	0.59 ± 0.02^{a}	0.01 ± 0.06^{b}	15.25 ± 0.00^{ab}

Means with different superscripts are significantly different ($p < 0.05$).

Sample A= Hausa pepper jam with sugar

Sample B= Hausa pepper jam with date

Sample C= Yoruba pepper jam with sugar

Sample D= Yoruba pepper jam with date

(Tang *et al.*, 1999). Adhesiveness is the negative force area of the first bite, or the work necessary to pull the molars away from the food (Bourne 2002). Cohesiveness is the ratio of positive force areas under the first and second compression, where the second is divided by the first (Bourne 2002). This shows the strength of the internal bonds of the food (Rosenthal 1999).Chewiness is the energy required to chew a solid food until it is ready for swallowing. It is determined as the product of hardness, cohesiveness, and springiness (Bourne 2002).

Sensory Evaluation of Jam

The sensory evaluation of the jam produced is as shown in Table 4.4. All sensory attributes indicated that the jam blends were acceptable to the consumers especially the colour, aroma, firmness, gelatinous, taste, mouth feel and overall acceptability. Hausa pepper jam with sugar were well accepted among the samples in terms of all the attributes (colour, aroma, firmness, gelatinous, taste, mouth feel and overall acceptability), followed by Hausa pepper jam with date, Yoruba pepper jam with sugar and Yoruba pepper jam with date. The colour is an important sensory attribute on which the consumer preference depends. There was no significance ($p \geq 0.05$) difference in the panelist's preference. The high score of samples could be as a result of the appealing colour, flavour and texture (Othman, 2011). The evaluation is in accordance with the reports of Sindumathi and Amutha (2014) in case of coconut-based jam, Rajkumar *et al.* (2018) in case of rose petal jam and Gagan and Aditya (2018) for rose petal jam.

Table 5: Sensory Evaluation of Jam

Sample	Colour	Aroma	Firmness	Gelation	Taste	Mouth feel	Overall acceptability
A	8.23 ± 0.68^{a}	7.00 ± 1.31^{a}	7.60 ± 1.16^{a}	7.50 ± 1.19^{a}	7.47 ± 1.54^{a}	6.93 ± 1.28^{a}	7.87 ± 0.73^{a}
B	6.47 ± 1.41^{bc}	5.80 ± 1.83^{b}	6.53 ± 1.69^{bc}	6.33 ± 1.86^{b}	6.30 ± 1.41^{b}	6.27 ± 1.57^{ab}	7.03 ± 1.18^{b}
C	7.23 ± 2.39^{b}	6.13 ± 2.16^{ab}	7.10 ± 1.21^{ab}	6.77 ± 1.22^{ab}	5.90 ± 2.34^{b}	6.20 ± 1.98^{ab}	6.87 ± 1.67^{b}
D	6.37 ± 1.21^{c}	6.17 ± 1.51^{ab}	6.33 ± 1.12^{c}	6.33 ± 1.52^{b}	5.53 ± 1.81^{b}	5.43 ± 1.35^{b}	6.47 ± 1.16^{b}

Means with different superscripts are significantly different ($p < 0.05$).

Sample A= Hausa pepper jam with sugar

Sample B= Hausa pepper jam with date

Sample C= Yoruba pepper jam with sugar

Sample D= Yoruba pepper jam with date

CONCLUSION

It could be deduced from the results obtained from the present study that production of jam from the commonly grown varieties of cayenne pepper using different sweeteners (date and sugar) is possible and have great potentials. Yoruba cayenne pepper had better TSS, vitamin C, carotenoids, TTA and total phenol. Physiochemical composition and the texture of the jam samples indicated that the sweeteners had significant effect on the composition. All the sensory attributes indicated that the jam blends were well acceptable to the consumers especially the colour, aroma, firmness, gelatinous, taste, mouth feel and overall acceptability but cayenne Hausa (sugar and date) had the best sensory attributes but Yoruba pepper jam with date were well accepted among the samples in terms of all the attributes (colour, aroma, firmness, gelatinous, taste, mouth feel and overall acceptability).

Processing of cayenne pepper into jam using different sweeteners will help in reducing post-harvest losses of the pepper and also enhance the utilization potential of the pepper. It also encourages the preservation of this pepper due to the seasonality which makes them available during its season and uncommon during offseason.

Recommendation

Studies should be conducted on production of more value added products from cayenne pepper as a functional food ingredients and there should be increase on the awareness of the potentials.

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