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Physicochemical, Sensory Properties and Bacteria Load of Jam Produced from Squash (*Cucurbita*) Fruit

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Abstract

Squash fruit (*Cucurbita*) jam was prepared from varying compositions of squash fruit and sugar with pineapple jam used as control. The blends were 300:300, 300:360; 300: 420, 300: 480 grams of squash fruit and sugar respectively and 300:300grams of pineapple and sugar for the control. The proximate composition of the squash jam had moisture content ranging between 13.98-35.86%, ash 0.34-0.49%, protein 2.54-5.13% and carbohydrate 59.50-83.50% respectively. The physicochemical properties of the jam had 3.35-3.75 for pH, 60-80°brix for sugar, 64.15-86.43mg/L total solid and 0.0011-0.0022% vitamin C respectively. Total titratable acidity (TTA) ranged between 2.59-3.78%, while viscosity values ranged between 13.62-21.29pas. The pH, sugar (°brix), total solid, vitamin C, titratable acidity and viscosity were significantly different ((P <0.05) among the blends. The microbiological properties showed the total bacterial count for squash jam stored for four weeks. The heterotrophic count result ranged from 0-30 x 10^6cfu/ml and 0-2.0 x 10^6cfu/ml for week zero and week one, 0-3.1 x 10^7cfu/ml and 0-7.2 x 10^7cfu/ml for week two and week three respectively. The sensory properties for the jam produced from squash ranged from 4.45-8.25 and from 5.25-7.75 for color and aroma, 4.75-7.35 and 5.25-7.65 for taste and texture and 4.90-8.05 and 4.55 – 7.95 for spreadability and general acceptability respectively. The color, aroma, taste, texture, spreadability and general acceptability increased significantly (P<0.05) with increase in sugar substitution. The result indicated that the jam sample with 300g: 300g (1:1) squash to sugar competed favorably in the sensory attributed.

Keywords: Squash Fruits; Jam; Microbiological; Physicochemical; Sensory

Introduction

Jams are one of the most popular food products because of their low cost, all year long availability and organoleptic properties [1]. It is a product made from whole fruit that is cut into pieces or crushed, heated with water and sugar to activate the pectin before storing in containers. It is usually made from pulp and juice of one fruit rather than a combination of several fruits and it is soft, having a texture of a thick puree with at least 65^{0}Brix [2]. Codex Alimentarus Commission [3], defined jam as a product brought to a suitable consistency and made from whole fruit or pieces of fruit which can be concentrated or unconcentrated fruit pulp or fruit puree of one or more kinds of fruit which is mixed with food materials with sweetening properties with or without the addition of water FAO [4]. Jam can be made from fruits with high pectin content like apples, strawberry, citrus fruits and quinces whereas jam made from low pectin fruits like squash are combined with other high pectin fruits like citrus fruits [5].

Squash fruit *(cucurbita)* is a genus of herbaceous vines in the gourd family known as *cucurbita* which originated from Southern Mexico. It can be grouped as summer type or winter type depending on the season it is grown. The fruit has a color ranging from green, ash, and orange with interior flesh usually yellow or orange in color. Squash can be cooked, baked or sliced into chips depending on the type of squash used. Winter squash require a longer cooking time than summer squash because of its hard and thick skin. Prior to cooking, the squash is washed, cut into different parts and baked or boiled depending on one's choice.

Squash fruit is beneficial to health as it contains negligible fat and no cholesterol. It also helps in reducing high blood pressure because of its magnesium and potassium content, as well as aids in weight loss due to its low calories and promotes the colon function because of its abundant fiber content thereby boosting digestion process and reducing constipation [6]. It is rich with vitamins, crude protein, several dietary mineral and antioxidant like beta carotene, folate, and tryptophan. Despite these nutritional attributes, there is little or no information on its use in the production of jam or any related preserves which has resulted to the low usage and high post-harvest losses/wastage of squash fruits in the communities where they are cultivated.

Therefore, producing and evaluating jam from squash fruit will help to improve the value of underutilized squash (*Cucurbita*) fruit, diversify the use of the fruit by providing variety in the number of available jam products, promote cultivation and increase market for both fruit and value added product.

Materials and Methods

Materials

Collection of Materials: Squash fruit was purchased from Afor Nnobi Market in Anambra State. Sugar was bought from Mile 3 Market in Port Harcourt, Rivers State. The unripe oranges and lemons were gotten from the Rivers State University demonstration farm, Nkpolu Oroworukwo, Port Harcourt, Nigeria.

Chemicals: All the chemicals and equipment used in the analysis were of analytical grade and were obtained from the Biochemistry Laboratory, Department of Food Science and Technology, Rivers State University, Nkpolu, Oroworukwo. Port Harcourt. Nigeria.

Methods

Preparation of Pectin: Eight (8) unripe oranges were sorted, washed and peeled. The mesocarp of the peels which is high in pectin were collected and used to prepare pectin according to the method described by Eke-Ejiofor & Owuno [7] (Figure 1&2, Table 1).

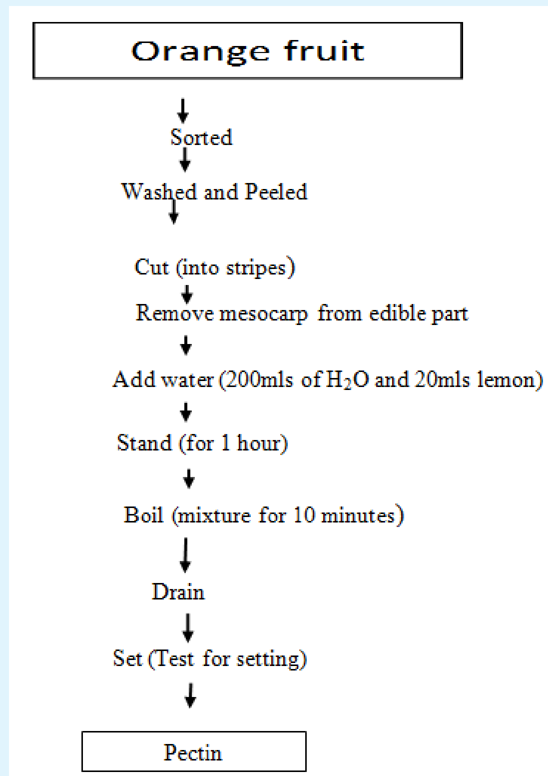

Figure 1: Extraction for pectin [7].

Ingredient	Samples				
	A	B	C	D	E
Pineapple Fruit (g)	300	0	0	**0**	**0**
Squash fruit (g)	0	300	300	300	300
Water (ml)	350	350	350	350	350
Sugar (g)	300	300	360	420	480
Citric acid (g)	18	18	18	18	18
Pectin (ml)	20	20	20	20	20

Table 1: Recipe for Production of Squash Fruit Jam/Pineapple Jam.

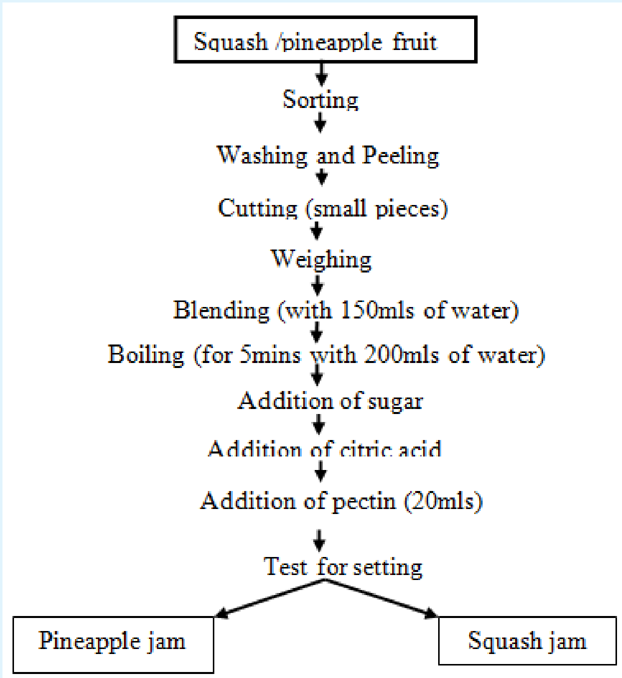

Figure 2: Production of Pineapple Jam [8].

Three fresh matured medium sized squash fruits (300g) were sorted and washed, peeled and cut into small equal pieces. The fruit was boiled with 200ml of water for 20 minutes, allowed to cool and blended into a fine and consistent paste. Sugar of varying quantities were added to the different samples and further heated for 10 minutes. 18g of citric acid was added each into the cooked slurries and boil further for 5 minutes while stirring. Finally, 20mls of pectin was added to the respective mixtures and allowed to boil for 2 minutes with continuous stirring to prevent burning. The mixture was removed from heat and tested for setting using a previously chilled plate, with a hot spoonful of the jam poured into the cold plate and a finger used to push through the jam on the plate. A wrinkle without flow back of jam was used to confirm that jam was set. The tested jam was transferred into a sterilized bottle and stored for further analysis.

Sensory Evaluation: The sensory attributes of the squash jam was determined by using simple hedonic test described by Munoz [9], with twenty (20) semi -trained member panel that were neither sick nor allergic to the raw material, comprising of students of the Department of Food Science and Technology, Rivers State University. A nine 9-point hedonic scale was used where 1 and 9 represented dislike extremely and like extremely respectively. The attributes that were evaluated include color, aroma, taste, texture (mouth feel), spread ability, and general acceptability.

Chemical analysis

Proximate Analysis: The moisture, ash, and crude protein content of jam samples were determined according to AOAC [10] while carbohydrate was determined by difference.

Physicochemical Properties: The sugar content of the jam was determined using digital sugar refractometer (ATC, China), while the viscosity of the jam was determined with the aid of a rotary digital viscometer (NDJ 85, China). pH was measured using pH meter (TS 625, UK) as described by Onwuka [11] while total titratable acidity (TTA) of the sample were determined using volumetric analysis method.

Microbiological Analysis: Squash jam and control were subjected to microbiological analysis after three weeks of storage at room temperature using Lynne Mclands Borough's method.

Statistical Analysis: All analysis was carried out in duplicate. Values obtained were subjected to analysis of variance (ANOVA) using Microsoft excel spreadsheet and the difference in mean significance using LSD test which was defined at ($p<0.05$).

Results

Proximate Composition of Squash Jam

(Table 2) shows the result for proximate composition of jam from Squash fruit (*Cucurbita*). Moisture content of the squash Jam ranged from 13.98-35.86% with Sample B (300g: 300g) recording the highest value and Sample E (300g: 480g) recording the lowest value. The result of the present study is close to that reported for roselle jam with moisture content ranging between 33-34% [12]. Results showed that the moisture content of the samples were significantly different ($p<0.05$) from each other and increased with the addition of sugar. The high moisture content in the present study made the samples susceptible to mould growth. Frazier & Westoff [13] stated that the moisture content of any food is an index of its water activity and it is used as a measure of stability and susceptibility to microbial contamination [14].

Ash content ranged from 0.34-0.49% with Sample B (300g: 300g) having the highest value, and Sample A (control) having the lowest value. This result falls within the range (0.15-0.49%) reported by Eke-Ejiofor & Owuno [7] for pineapple/jackfruit jam and Kansci, et al. [15] for mango jam respectively. There was no significant difference (p>0.05) in ash between the samples. The values obtained were relatively low which indicates low mineral content in the jam as the proportion of ash contents is a reflection of the mineral contents present in the food material.

Protein content ranged from 2.54 -5.13% with Sample C (300g: 360g) having the highest value and Sample E (300g: 480g) having the lowest value. The protein content in this study is higher than the findings of Eke- Eke-Ejiofor & Owuno [7] for jackfruit (0.19g/100g) and pineapple (0.46g/100g) jam. The trend in this study is expected as increase in sugar content reduced the available protein. There was a significant difference (p≤0.05) between sample E (300g: 480g) and the others.

Total available carbohydrate content ranged from 59.50-83.50% with Sample E (300g: 480g) having the highest value and Sample B (300g: 300g) the lowest value. Carbohydrate content increased with an increase in the level of sugar inclusion and showed significant difference (p<0.05) between sample E and B, which could be attributed to the ratio of squash fruits to sugar in sample E. Carbohydrate provide readily accessible energy for physical performance and regulate nerve tissue transmission. Therefore squash jam would be a good source of carbohydrate as well as energy.

Sample (g)	Moisture Content (%)	Ash (%)	Protein (%)	Carbohydrate (%)
A	14.49±0.01^{d}	0.34±0.07^{a}	4.72±0.61^{a}	80.50±0.71^{ab}
B	35.86±1.05^{a}	0.49±0.01^{a}	4.34±0.00^{a}	59.50±0.71^{d}
C	26.83±1.81^{b}	0.39±0.00^{a}	5.13±0.00^{a}	67.50±0.71^{cd}
D	18.27±1.10^{c}	0.44±0.06^{a}	4.55±-0.30^{a}	77.00±1.41^{bc}
E	13.98±0.77^{d}	0.47±0.01^{a}	2.54±0.00^{b}	83.50±0.71^{a}
LSD	0.846	0.0428	0.3041	2.915

Table 2: Proximate Composition (%) of Squash Jam.
Means with the same superscripts on the same column are not significantly different (P<0.05)
Key:
A (Control) = Pineapple (1): Sugar (1)
B = Squash (1): sugar (1)
C = Squash (1): sugar (1.2)
D = Squash (1): sugar (1.4)
E = Squash (1): sugar (1.6)

Physicochemical Properties of Squash Jam

(Table 3) shows the result of physicochemical properties of squash jam such as pH, sugar (ºbrix), total solid, vitamin C, titratable acidity and viscosity. pH content of samples ranged from 3.35-3.75 with Samples E(300g:480g) having the highest value and Sample A (control) having the lowest value. There was no significant difference (p<0.05) between the control sample A and sample E (300g: 480g) in terms of pH. The pH of jam is an important factor to obtain optimum gel condition. High acidity prevents the growth of food poisoning bacteria and also helps maintain the colour and flavor of most fruits. The pH in the present study is slightly higher than that reported by Eke-Ejiofor & Owuno [7] on jackfruit jam. Long-term storage stability of fruit preparation is achieved through a combination of thermal processing, control of water activity and pH.

The sugar content measured in (⁰Brix) ranged from 60.00-80.00 with samples A (300g: 300g), C (300g: 360g), and E (300g: 480g) having the highest sugar content, while samples B and D (300g: 300g) (300g: 420g) have the least sugar content respectively. This is expected as sugar content is a function of its quantity, which could also, serves as preservative in jam. In support of the present study, Ayub [16] stated that one of the most important constituent of fruit is sugar which functions as a sweetener and as a natural food preservative. Reducing the amount of sugar in the production of preserves will upset the balance of fruit, sugar and pectin needed to ensure the jam or jelly sets. The five samples with different formulations were significantly different at (p<0.05) which played a role in gel formation to retard the microbial growth. James [17] reported that 60 ºbrix is recommended for proper gel formation. Sugars are the most important constituents of fruits as well as preserves and are essential factors for the flavor of such foods.

Total solid ranged from 64.15 – 86.43% with sample B (300g: 300g) having the lowest value and Sample E (300g: 480g) the highest value. The total solids, present in the squash jam showed that samples A, B, C, D and E were significantly different from each other at (p<0.05). The total solids increased with an increase in the concentration of sugar.

Vitamin C content ranged from 0.0011 - 0.0022mg/100g with sample A (control) having the highest value and Sample C (300g: 360g) having the lowest value. The low vitamin C values may be attributed to the heat processing method involved in the production, which could damage the vitamin Uckiah, et al. [18]. There was no significant difference (p<0.05) among the samples in vitamin C. The naturally occurring anti-oxidants decreased significantly during heating as reported by Anise, et al. [19], which also is integral in biochemical process in human body.

The result showed that by increasing the level of sugar in the jam formulation, vitamin C content was slightly decreased.

Titratable acidity ranged from 2.59 -3.78% with sample B having the highest value and Sample E having the lowest. All the samples were significantly different (p<0.05.) from each other. The values obtained showed that increase in sugar concentrations decreased the total acidity of the samples. Acidity gives imperative effects on the gelation property of pectin [20].

Viscosity of the jam ranged from 13.62 – 21.29Pa.s with Sample B (300g: 300g) having the highest value and Samples E (300g: 480g) with the lowest value. Viscosity of the jam showed significant different (p<0.05) between the samples. Viscosity depends upon factors like pectin concentration since pectin helps to increase the viscosity of the jam as well as the raw material (fruits) used.

Sample (g)	pH	Sugar (ºbrix)	Total Solid (%)	Vitamin C Mg/100g	Vitamin C Mg/100g	Viscosity (pa.s)
A(Control)	3.35±0.00e	80.00±0.00c	85.50±0.01a	0.0022±0.000a	3.78±0.11b	21.29±0.07a
B	3.65±0.00c	60.00±0.00e	64.15±1.05d	0.0018±0.000b	2.97±0.01a	17.32±0.23c
C	3.55±0.00d	60.00±0.00d	73.17±0.81c	0.0011±0.0000e	3.32±0.01c	19.15±0.22b
D	3.65±0.00b	80.00±0.00b	81.73±1.10b	0.0016±0.0000c	3.25±0.01d	14.34±0.22d
E	3.75±0.00a	80.00±0.00a	86.43±0.77a	0.0012±0.000d	2.59±0.01e	13.62±0.04e
LSD Value	0	0	0.846	0	0.0141	0.178

Table 3: Physicochemical Composition of Squash Jam.
Means with the same superscripts on the same column are not significantly (P<0.05) different.

Key:

A (Control) = Pineapple (1): Sugar (1)
B = Sugar (1): squash (1)
C = Sugar (1): squash (1.2)
D = Sugar (1): squash (1.4)
E = Sugar (1): squash (1.6)

Bacterial Count for Squash Jam

(Table 4) shows the total bacterial count (cfu/ml) of squash jam stored for three weeks. The bacterial count for week zero ranged from 1.0x10^{6}cfu/ml -4.0x10^{6}cfu/ml with Sample B (300g: 300g) having the highest count and Sample C (300g: 480g) with the lowest count. There was no growth on sample A (control) and D (300g: 420g) in week zero. Week one had total bacteria count ranging from 1.0x10^{6}cfu/ml- 2.0x10^{6}cfu/ml with Sample C (300g: 360g) and sample D (300g: 420g) having the highest count and sample B (300g: 300g) the lowest count with no observable growth in sample A. Week two result showed count ranging from 1.2x10^{6}cfu/ml -3.1x10^{6}cfu/ml with sample A (control) having the highest count and sample D (300g:420g) the lowest count, with no growth in samples B and E. The presence of bacteria in the first two week of storage, in samples C and D may be attributed to contaminants from the storing container or environmental condition. Week three results showed count ranging from 4.0x10^{6}cfu/ml -7.2x10^{6}cfu/ml with sample C (300g: 360g) having the highest count and sample D (300g: 420g) the lowest count. The bacterial count for squash jam, stored for three weeks showed high heterotrophic count. Results showed an increase in bacterial count as the storage time increased, but with a significant decrease in heterotrophic bacterial as the ratio of squash to sugar addition increased.

Sample	Week Zero (cfu/ml)	Week One (cfu/ml)	Week Two (cfu/ml)	Week three (cfu/ml)
A	NG	NG	$3.1x10^6$	$7.0x10^6$
B	NG	NG	1.0×10^6	3.0×10^6
C	$1.0x10^6$	$1.6x10^6$	$2.0x10^6$	$7.2x10^6$
D	NG	$1.2x10^6$	$2.0x10^6$	$4.0x10^6$
E	NG	NG	$1.0x10^6$	$2.0x10^6$

Table 4: Bacterial Count of Squash Jam in storage for three (3) weeks.

Key:

A (Control) = Pineapple (1): Sugar (1)
B = Sugar (1): squash (1)
C = Sugar (1): squash (1.2)
D = Sugar (1): squash (1.4)
E = Sugar (1): squash (1.6)
NG = No Growth

Sensory Evaluation of Squash Jam

Table 5 shows the sensory evaluation result of squash and pineapple jam samples. Sensory evaluation is one of the determinants of a consumer's choice of product. Jam color ranged from 4.45-8.25points with the control having the least value and squash jam having the highest value. The high color values of squash jam could be attributed to the carotenoid pigment in the raw fruit. Color is one of the most important quality parameters of jams. It is closely related to the perception and reception of the product [21].

Aroma of jam ranged from 5.25 – 7.75points with sample B (300g: 300g) having the highest and sample A (control) the lowest among the five samples , while taste ranged from 4.75 -7.35points with sample D (300g: 420g) having the highest rating and sample A (the control) having the lowest. This is expected as increase in sugar content increased sweetness.

Texture ranged from 5.25 -7.65 with Sample B (300g: 300g) having the highest rating and Sample A (control) having the least rating. Texture significantly affects the final assessment of the product. Poor texture can make a product unacceptable to the consumer, even if it tastes good. This parameter is influenced by the degree of fruit freshness, the sweetener and the gelling agent Spread ability ranged from 4.90 – 8.05pts with sample B (300g: 300g) having the highest rating and sample A (control) having the lowest value. General acceptability ranged from 4.55- 7.95 with sample B (300g: 300g) having the highest rating and sample A (the control) having the lowest as well.

	Color	Aroma	Taste	Texture	Spreadibility	General Acceptability
A	$4.45±2.67^c$	$5.25±2.45^b$	$4.75 ± 2.49^c$	$5.25 ±2.65^b$	$4.90 ± 2.58^b$	$4.55 ± 2.37^c$
B	$8.25±1.29^a$	$7.75±1.40^a$	$7.35±2.16^a$	$7.65±1.39^a$	$8.05±1.32^a$	$7.95±1.31^a$
C	$5.80±2.44^{bc}$	$5.80±2.19^b$	$5.30±1.97^{bc}$	$6.20±1.94^{ab}$	$5.80±2.46^b$	$6.45±1.88^b$
D	$7.60±1.46^{ab}$	$6.33±2.10^{ab}$	$6.75±1.94^{ab}$	$6.25±1.97^{ab}$	$6.30±2.20^{ab}$	$6.65±2.18^b$
E	$6.60±2.11^{ab}$	$6.35±2.41^{ab}$	$6.50±2.35^{abc}$	$6.05±2.35^{ab}$	$5.75±2.45^b$	$6.25±1.65^b$
LSD Value	2.071	2.157	2.194	2.003	2.243	1.917

Table 5: Sensory Composition result of Squash Jam.

Means with the same superscripts on the same column are not significantly different (P≤0.05)

Key:

A (Control) = Pineapple (1): Sugar (1)
B = Sugar (1): squash (1)
C = Sugar (1): squash (1.2)
D = Sugar (1): squash (1.4)
E = Sugar (1): squash (1.6)

Conclusion

Production of jam from underutilized Squash fruits (*curcubita*) with different ratio of sugar were generally accepted by the sensory panelist with sample B produced from ratio of squash to sugar (300g: 300g) being the most preferred. The proximate and physiochemical composition results showed sample B as the most preferred among the five samples. Microbiological analysis showed that some level of microbial activity was inhibited with an increase in the ratio of sugar inclusion. Optimal utilization of squash for jam production would reduce post-harvest as well as waste disposal challenges.

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