Foods and Raw Materials, 2021, vol. 9, no. 1
E-ISSN 2310-9599
ISSN 2308-4057
Research Article
Open Access
https://doi.org/10.21603/2308-4057-2021-1-192-200
Available online at http:jfrm.ru/en

Functional and sensory properties of jam with different proportions of pineapple, cucumber, and *Jatropha* leaf

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Received February 05, 2021; Accepted in revised form February 18, 2021; Published online April 15, 2021

Abstract:
Introduction. Fruits and vegetables are vital for healthy food consumption. Conservation is the only option to prolong their shelf life. Nigeria is currently experiencing an increase in production of fruit jams that incorporate vegetables. Cucumbers, *Jatropha tanjorensis* L. leaf, and pineapples have a lot of health benefits, which makes them very promising for jam making. The present research featured the effect of cucumber, pineapple, and *Jatropha* leaf in different proportions on the functional and sensory properties of composite jam.
Study objects and methods. The technology of jam making followed standard procedures. Pineapple jam without cucumbers and *Jatropha* leaf served as control (pineapple:cucumber:*Jatropha* leaf = 100:0:0). The experimental jam samples had increasing amounts of *Jatropha* leaf (J), decreasing amounts of pineapple pulps (P), and a constant amount of cucumber (C), i.e. P:C:J = 85:10:5, 80:10:10, 75:10:15, and 70:10:20. The functional analysis involved chemical and proximate aspects, whereas the sensory evaluation involved appearance, aroma, taste, spreadability, and overall liking.
Results and discussion. The experimental samples showed a significant difference ($P < 0.05$) in vitamins, minerals, total titratable acidity, pH, Brix, and total soluble solids. The control sample (P:C:J = 100:0:0) had significantly lower ($P < 0.05$) contents of moisture, protein, ash, fat, and fiber than the experimental ones. However, the pH and total titratable acidity of the experimental samples 85:10:5 and 80:10:10 appeared to be quite similar ($P > 0.05$). Compared to the control sample, the sensory properties of the experimental samples differed significantly ($P < 0.05$) by appearance, aroma, and spreadability but were of similar ($P > 0.05$) taste and overall liking.
Conclusion. The obtained functional and sensory data proved that the new pineapple jam with cucumber and *Jatropha* leaf is a promising functional product.

Keywords: Composite jam, fruits, vegetables, quality characteristics, sensory properties, proximate analysis

Please cite this article in press as: Ogori AF, Amove J, Evi-Parker P, Sardo G, Okpala COR, Bono G, et al. Functional and sensory properties of jam with different proportions of pineapple, cucumber, and *Jatropha* leaf. Foods and Raw Materials. 2021;9(1):192–200. https://doi.org/10.21603/2308-4057-2021-1-192-200.

INTRODUCTION

Nowadays, fruits and vegetables are increasingly vital for healthy food consumption. Not only are they highly recommended aspects of health-promoting diets, but they also contain minerals, phytochemicals, and vitamins [1–3]. Public awareness of the beneficial properties of fruits and vegetables continues to increase due to recommendations of dieticians and physicians, educational programs, and media [3, 4]. However, poor availability and considerable post-harvest losses challenge both consumption and processing of fruits and vegetables [3]. Moreover, fruits and vegetables are not always accessible at the same time due to peculiarities of location and seasonality [3].

For long-term consumer benefits, robust harvesting of fruits and vegetables requires effective and efficient storage facilities and techniques. To preserve their freshness for a long period of time, they have to be transformed into a more stable product able to retain the initial nutritional and mineral contents [3]. Jam is an effective method of product conversion as it retains health and nutritional benefits of the raw material, especially of seasonal products [3]. Jams exist in diverse forms, e.g. chutney, fruit butter, jelly, marmalade, fruit spread, etc. [5]. To make jams, fruits and vegetables have to be cut, crushed, and/or ground until they reach required consistency [6]. Jam making includes the following major steps: thermal processing, adding sugar for pectin activation, mix formation, and packaging. Pectin helps to preserve the raw material as it substantiates the gelling agent, sugar or honey [6, 7].

Cucumbers (*Cucumis sativus* L.) possess a considerable therapeutic potential. They are an excellent source of beta-carotene, manganese, phytochemicals (alkanoids, flavonoids, tannins, phlabotannins, steroids, and saponins), and vitamin C [3, 8, 9]. Cucumbers possess anti-bacterial, antifungal, cytotoxic, antacid, but carminative properties [10], with ample amounts of water and little calories, fat, cholesterol, and sodium [11]. Cucumbers are reported to demonstrate such useful attributes as antioxidant activity, blood pressure and body weight management, cancer prevention, cholesterol reduction, and diabetes control [12].

Despite being widely cultivated in various parts of Nigeria, *Jatropha tanjorensis* still remains an exotic plant of *Euphobiacea* family [13]. In Nigeria, people call it “*Hospital is too far*”. Due to their high water content, its leaves are a popular ingredient for vegetable soup with a mild, soothing taste. This dish is especially popular in the southwestern regions, where the plant is used to treat cardiovascular ailments, anemia, i.e. as a hematinic agent, and diabetes, given its hypoglycaemic properties [14–16]. Indeed, the anti-oxidant mechanism of *J. tanjorensis* gives it preventive and protective capacity to exert some anti-anemic potential [17, 18]. A phytochemical analysis of *J. tanjorensis* leaf extract revealed terpenoids, saponins, cardiac glycosides, flavonoids, and tannins [19]. Due to its antioxidant properties, *J. tanjorensis* leaf could effectively ameliorate oxidative stress, if administered in the right doses. However, its excessive consumption may impair bioavailability due to the high phytate content [20].

As for pineapple (*Ananas comusus* L. Merr.), this tropical/sub-tropical fruit can be consumed fresh, cooked, or juiced [21, 22]. Pineapple fruit comprise many individual berries that fuse around a central core [23]. Despite being highly perishable and seasonal, pineapples contain carbohydrates, calcium, crude fiber, potassium, vitamin C, water, and various minerals, which can contribute to a balanced nutrition. Ripe pineapples contain citric acid, malic acid, vitamins A and B, sugar, protein digesting enzyme, and bromelin [21]. Pineapple pulp is a complex multicomponent system, but insoluble solids can make it look opalescent or turbid [24].

When combined, the above-mentioned health benefits of cucumber, pineapple, and *J. tanjorensis* leaf should be very promising for jam making [3, 8–11, 14–18, 21]. In fact, pineapple combinations with other products proved quite successful [3, 25]. Pineapple pulp provides both sweet taste and succulent effect when incorporated into confectionary products [25]. In addition, fruit and vegetable mixes are gaining more and more popularity in the Nigerian cuisine, especially in the east of the country. The cucumber, pineapple, and *Jatropha* leaf composite jam appears to be part of local diet, which has not been reported in scientific literature, to the best of our knowledge. Considering the rapidly growing population of Nigeria, the functional role of fruits and vegetables in enhancing food security can hardly be overestimated.

This research featured the effect of blend variations on the functional and sensory properties of cucumber, pineapple, and *Jatropha* leaf composite jam. The functional analysis involved chemical and proximate aspects, whereas sensory evaluation involved such attributes as appearance, aroma, taste, spreadability, and overall liking. The research objective was to produce a jam wherein blended fruits and vegetables complement each other to actualize a composite product of higher nutritional quality and appealing sensory properties.

STUDY OBJECTS AND METHODS

Chemicals and reagents. The chemicals and reagents were obtained from reputable sources and were of analytical grade standard.

Collection of samples. Healthy and mature cucumbers and pineapples were purchased from the North Bank market situated in Makurdi, Benue State, Nigeria. The fruits and vegetables can be considered consumer safe because the North Bank market, which serves the local community, is supervised by the local government and adheres to good hygiene (GHP) and good storage (GSP) practices. The fruit samples were selected according to shape, size, uniformity, color, and integrity. Fruits with signs of damage and diseases were discarded. Fresh *Jatropha* leaves were harvested from the vicinity of University of Agriculture in Makurdi, where other people of the community usually pluck them.

Making of jam. The technology of jam making involved three steps, namely: a) preparations and processing of the selected raw materials; b) formulation of cucumber, pineapple, and *Jatropha* leaf jam samples; and c) mixing of the pulp and sugar to make the jam.

The preparations and processing involved sorting and washing to remove soil and dirt from the fruit skin. The selected fruits were peeled, cut into small pieces,

Table 1 Concentrations of cucumber fruit, pineapple, and *Jatropha* leaf in jam, %

Samples	Pineapple	Cucumber	*Jatropha*	Total
Control sample	100	0	0	100
Experimental sample A	85	10	5	100
Experimental sample B	80	10	10	100
Experimental sample C	75	10	15	100
Experimental sample D	70	10	20	100

and then crushed/blended to obtain pulp. The *Jatropha* leaf was identified by the representatives of College of Agronomy, Federal University of Agriculture, Makurdi, Nigeria. The preparation of *Jatropha* leaf followed the method used by local artisans and underwent blending to obtain pulp.

Table 1 shows amounts of cucumber, pineapple, and *Jatropha* leaf in the jam. The ingredients were combined to formulate a blend for the jam based on the following percentage ratios:

a) control sample = 100% pineapple (P:C:J = 100:0:0);
b) experimental sample A = 85% pineapple; 10% cucumber; 5% *Jatropha* (P:C:J = 85:10:5);
c) experimental sample B = 80% pineapple; 10% cucumber; 10% *Jatropha* (P:C:J = 80:10:10);
d) experimental sample C = 75% pineapple; 10% cucumber; 15% *Jatropha* (P:C:J= 75:10:15); and
e) experimental sample D = 70% pineapple; 10% cucumber; 20% *Jatropha* (P:C:J = 70:10:20).

The pineapple jam with neither cucumber nor *Jatropha* leaf served as the control sample. In the subsequent blends, the amounts of *Jatropha* leaf increased, but the amount of cucumber remained constant.

The mixing of the pulp and sugar to make the jam followed standard procedures. The pulp and sugar were mixed and heated. The soluble solid formations were monitored during the process, until 55°C was attained [26]. The pectin served as a solution base. Pectin was added to hot water and heated until homogenous. It is at this stage that the fruit pulp, sugar, and citric acid were added into the pectin solution. Next, the jam was boiled until the layer of bubbles appeared, particularly at the sides of the vessel. After that, the hot jam was poured into clean dry wide-mouthed bottles and cooled to 35°C in a water bath until gelation started. At this point, the composite jam was ready for chemical, proximate, and sensory analyses.

Functional and sensory analyses of the jam. The functional analysis involved chemical and proximate aspects. The chemical measurements determined the contents of vitamins A (*β*-carotene) and C (ascorbic acid), mineral elements (calcium, zinc, magnesium, potassium, sodium, and iron), pH total titratable acidity (TTA), total sugar content (°Brix), and total soluble solids (TSS). The proximate measurements determined the moisture, protein, ash, fat, fiber, and carbohydrate contents. The sensory evaluation involved appearance, aroma, taste, spreadability, and overall liking.

Chemical measurements. Determination of vitamins A (*β*-carotene) and C (ascorbic acid). Vitamins A (*β*-carotene) and C (ascorbic acid) were determined using the AOAC method with slight modifications [27]. Approximately 10 g of each sample was weighed into a 250 mL flask, followed by 50 mL of acetone. The mix was left for 2 h with occasional shaking and then filtered. The filtrate was measured, and an equal volume of saturated NaCl was added to wash the filtrate (carotene extract). The resulting mixture was shaken and transferred into a separating funnel to remove the layer of the extracted carotene. The supernatant was washed again with an equal volume of 100% potassium trioxocarbonate (IV) (K_2CO_3), which was separated and washed with 10–20 mL of distilled water. After separating water carotene and extracting carotenoid, the absorbance was defined by a spectrophotometer at 326 nm wavelength using 50:50 acetones and low boiling petroleum ether solution as the blank.

Determination of minerals. The list of mineral elements included calcium (Ca), zinc (Zn), magnesium (Mg), potassium (K), sodium (Na), and iron (Fe). Their content was determined using the AOAC method with slight modifications [28]. Approximately 1 g of each sample was weighed into a 100 mL round bottom flask, and 5 mL of perchloric acid was added and heated over an electric heater in a fume chamber until the solution became colorless. The solutions were diluted with distilled water to 10 mL mark, and the diluted samples were set aside for further studies. The Ca, Zn, Mg, K, Na, and Fe contents were analyzed using an atomic absorption spectrophotometer (AAS).

Determination of pH. The pH was determined using the AOAC method with slight modifications [27]. It required the use of a pH meter, calibrated using standard buffer solutions. The electrode was rinsed with distilled water and then dipped into 5 g of the sample, which was dissolved in 50 mL of water.

Determination of total titratable acidity. The total titratable acid was determined using the AOAC method with slight modifications [27]. This involved ~ 10 g of the sample dissolved in 100 mL of distilled water. Thereafter, 10 mL of the supernatant was titrated with 0.1N NaOH and phenolphthalein as an indicator. The total titratable acidity (%) was defined based on citric acid according to the equation below:

$$\textit{citric acid} = \text{volume of NaOH used} \times 0.1\text{N} \times \\ \times \text{mL equivalent of citric acid} \times 100 \qquad (1)$$

Determination of total sugar content (°Brix). The AOAC method helped to determine the total sugar content [28]. The experiment involved a hand-held sugar refractometer. The prism of the refractometer was cleaned, and a drop of the sample was placed on the prism and closed. Total sugar content (°Brix) was read off the scale of the refractometer.

Determination of total soluble solids. The AOAC method with slight modifications made it possible to determine the total soluble solids in the sample [28]. Dry empty dishes were weighed, and 5 g of the samples was put onto them. The dishes were then placed on a boiling water bath and left there until the water evaporated from the samples. The samples were then placed in an oven at 102°C for ~ 2 h. Readings were taken after cooling. The equation below was used to calculate total solids (%):

$$total\ solid = \frac{Weight\ of\ residue \times 100}{Weight\ of\ the\ sample} \quad (2)$$

Proximate measurements. Determination of moisture. The moisture of the sample was determined using the AOAC method with slight modifications [28]. Approximately 2 g of the samples were weighed in Petri dishes, then transferred into an oven, uncovered, and heated at 130–150°C for 3 h. After heating, the samples were removed and placed in a desiccator, where they were allowed to cool for 15 min before weighing. The procedure was repeated until constant mass. The loss in weight was reported as the percentage moisture content, using the equation below:

$$Moisture\ Content = \frac{Weight\ loss \times 100\%}{Weight\ of\ sample} \quad (3)$$

Determination of crude protein. The crude protein in the samples was determined using the AOAC method with slight modifications [28]. Approximately 0.8 g of each sample was digested in the Kjeldahl digestion system under a fume chamber. The digestion was allowed to cool and then distilled into boric acid containing bromocresor green indicators after it had been appropriately diluted first with water and then with solutions of sodium thiosulphate and sodium hydroxide. After that, the samples were titrated with 0.1N hydrochloric acid (HCl) solutions. Blank titrations were similarly carried out and the percentage protein content was calculated using the equation below:

$$Crude\ protein = \text{Nitrogen} \times 6.25$$
$$(1\text{ mL of }0.1\text{N HCl} = 0.0014\text{gN}) \quad (4)$$

Determination of ash. The ash of the sample was determined using the AOAC method with slight modifications [28]. Approximately 5 g of the sample was weighed into previously weighed ash dishes, placed in muffle furnace, and ignited at 550 ± 10°C for 5 h. After cooling, it was weighed to constant mass. The resulting ash (%) was calculated as below:

$$Ash\ content = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (5)$$

were W_1 is the weight of empty crucible; W_2 is the weight of crucible + weight of sample before ashing; and W_3 is the weight of crucible + weight of sample after ashing.

Determination of crude fat. The crude fat of the samples was determined using the AOAC method with slight modifications [28]. The procedure involved ~ 2 g of the prepared sample weighed into Soxhlet thimbles and fixed into the extraction flask of a given weight. Extraction with diethyl ether lasted for 5 h. At the completion, the diethyl ether was removed by evaporation on an electrical bath. The remaining fat in the flask dried in the oven at 60°C for 30 min, then it was cooled for 15 min and weighed. The fat content (%) was calculated as below:

$$Fat\ content = \frac{Weight\ of\ fat}{Weight\ of sample} \times 100 \quad (6)$$

Determination of crude fiber. The crude fiber of the samples was determined using the AOAC method with slight modifications [28]. The procedure involved weighing ~ 1 g of the sample and adding 100 mL of trichloroacetic acid as digesting reagent. The solution was brought to boil and reflux for approximately 40 min at 50–60°C. The flask was removed from the heater and cooled a little, followed by filtering the solution through Whatman filter paper. The residue was washed in hot water and methylated spirit. The filtrate was transferred to the muffle furnace, ignited at 550°C for 30 min, cooled, and weighed. The percentage of crude fiber content was calculated as follows:

$$Crude\ fiber = \text{the loss in weight after incineration} \times 100 \quad (7)$$

Determination of carbohydrate. The carbohydrate percent of the samples was determined according to the AOAC method and calculated using the equation below [27]:

$$Carbohydrate = 100 - (\%\text{ Moisture} + \%\text{ Fat} + \%\text{ Protein} + \%\text{ Crude fiber} + \%\text{ Ash}) \quad (8)$$

Sensory evaluation. The sensory evaluation was based on a 9-point hedonic scale according to the method described by Iwe, with slight modifications [29]. Ten panelists (N = 10) compared the sensorial variations between the different jams based on particular attributes. All the panelists reported zero allergy to the jam ingredients and participated in all sensory tests. Participation was voluntary, with verbal consent obtained prior to the evaluation. Participants were served with ~ 10 g of each jam on white disposable plates with a slice of bread from the same loaf. The plates were coded with three-digit random numbers and distributed randomly among the panelists. The appearance, aroma, taste, and spreadability of the samples were evaluated according to a nine-point hedonic scale, where 1 represented “dislike extremely” and 9 represented “like extremely”. The overall liking

Table 2 Vitamin and mineral content of jam from cucumber, pineapple, and *Jatropha* leaf in different proportions

Samples P:C:J	Vitamin C, mg/kg	β-carotene, mg/kg	Ca, mg/100g	Zn, mg/100g	Mg, mg/100g	K, mg/100g	Na, mg/100g	Fe, mg/100g
100:0:0 (control)	691.35^{a} ± 0.49	1.44^{a} ± 0.02	0.12^{e} ± 0.00	1.87^{e} ± 0.03	0.03^{d} ± 0.00	0.11^{e} ± 0.00	1.78^{b} ± 0.00	0.10^{e} ± 0.01
85:10:05	680.65^{b} ± 0.21	1.25^{b} ± 0.04	0.34^{d} ± 0.00	2.00^{d} ± 0.00	0.06^{c} ± 0.00	0.34^{d} ± 0.00	1.79^{b} ± 0.00	0.20^{d} ± 0.00
80:10:10	569.35^{c} ± 0.49	1.12^{c} ± 0.02	0.40^{c} ± 0.00	2.20^{c} ± 0.00	0.07^{b} ± 0.00	0.45^{c} ± 0.00	1.81^{b} ± 0.02	0.33^{c} ± 0.01
75:10:15	477.45^{d} ± 0.21	0.81^{d} ± 0.01	0.55^{b} ± 0.00	2.71^{b} ± 0.02	0.09^{a} ± 0.00	0.65^{b} ± 0.00	1.87^{b} ± 0.02	0.45^{b} ± 0.01
70:10:20	436.95^{e} ± 0.07	0.73^{e} ± 0.01	0.61^{a} ± 0.02	2.87^{a} ± 0.00	0.10^{a} ± 0.00	0.71^{a} ± 0.01	2.59^{a} ± 0.14	0.67^{a} ± 0.03
LSD	0.887	0.056	0.019	0.037	0.00	0.010	0.163	0.041

Values are mean ± standard deviations (SD) of two determinations

Values with same superscript within a column are not significantly different ($P > 0.05$)

P:C:J = pineapple:cucumber:*Jatropha* leaf

LSD = least significant difference

was considered as the mean of other attributes. The panelists had clean potable water to rinse/clean their mouths between each taste session to ensure the integrity of the experiment. The participants completed the score sheets after tasting.

Statistical analysis. The obtained data underwent a one-way analysis of variance (ANOVA). The results were expressed as the mean values ± standard deviation (SD) of duplicate measurements. The Fisher's least significant difference (LSD) test helped to resolve the differences between mean values. The level of statistical significance was set at $P < 0.05$ (95% confidence interval). IBM SPSS version 20.0 software (version 2011) was used to run the data analysis.

RESULT AND DISCUSSION

Variations in chemical components. Tables 2 and 3 show the vitamin and mineral composition of pineapple jams with cucumber and *Jatropha* leaf, as well as their total titratable acidity, pH, Brix, and total soluble solids. Among the experimental samples, significant differences ($P < 0.05$) were found in the chemical component composition compared to the control. The pH and TTA of the sample containing pineapple, cucumber, and *Jatropha* leaf in the ratio of 85:10:5 were similar ($P > 0.05$) to those of the sample 80:10:10. Compared to the experimental samples, however, the control sample (100:0:0) obtained noticeably higher values of vitamin C, β-carotene, TTA, and Brix, but lower values of Ca, Zn, Mg, K, Na, Fe, pH, and TSS.

Considering the pH among the experimental samples, the marginal decreases in acidity probably happened due to the addition of blended *Jatropha* leaf pulp, in spite of the fact that the cucumber amount was constant in samples 85:10:05 and 70:10:20. Such pH variations might agree with the data reported by Rahman about comparative studies of pineapple, papaya, and ash gourd jam preserves and candies [30]. Despite being significantly lower ($P < 0.05$) than in the control, the Brix of the blends of the current study might compete well with those of carrot-cucumber jam sweetened with honey [3].

Adding to the above-mentioned significant differences, some trends in the parameters under study were observed among the experimental samples herein. For instance, as amounts of *Jatropha* leaf increased and those of pineapple decreased, significant increases ($P < 0.05$) were found in Ca, Zn, Mg, K, Na, Fe, pH, and TSS.

On the other hand, vitamin C, β-carotene, TTA, and Brix demonstrated significant ($P < 0.05$) decreases. Vitamin C contents in the experimental samples could compete favorably with those in the grape and apricot jams reported by Mohd-Naeem *et al.* [31]. Indeed,

Table 3 TTA, pH, Brix, and TSS of jam from cucumber, pineapple and, *Jatropha* leaf in different proportions

Samples P:C:J	TTA, %	pH	Brix, °brix	TSS, %
100:0:0 (control)	0.17^{a} ± 0.98	3.16^{c} ± 0.09	79.05^{a} ± 0.07	84.38^{c} ± 0.02
85:10:05	0.13^{b} ± 0.28	3.18^{c} ± 0.01	73.15^{b} ± 0.07	84.79^{c} ± 0.02
80:10:10	0.12^{b} ± 0.35	3.23^{c} ± 0.03	69.00^{c} ± 0.00	87.31^{bc} ± 3.59
75:10:15	0.09^{c} ± 0.35	3.41^{b} ± 0.01	66.20^{d} ± 0.14	89.11^{b} ± 0.02
70:10:20	0.09^{c} ± 0.21	3.85^{a} ± 0.07	64.10^{e} ± 0.14	96.17^{a} ± 0.04
LSD	0.013	0.14	0.26	4.12

Values are mean ± standard deviations (SD) of two determinations

Values with same superscript within a column are not significantly different ($P > 0.05$)

TTA = total titratable acidity; TSS = total soluble solids

P:C:J = pineapple:cucumber:*Jatropha* leaf

LSD = least significant difference

Table 4 Proximate components in pineapple jam with cucumber and *Jatropha* leaf in different proportions

Sample	Proximate components, %					
P:C:J	Moisture	Protein	Ash	Fat	Fiber	Carbohydrate
100:0:0	3.82^{e} ± 0.03	0.061^{e} ± 0.001	0.0140^{c} ± 0.0010	0.023^{d} ± 0.004	0.123^{e} ± 0.001	96.14^{a} ± 0.00
85:10:05	10.17^{d} ± 0.02	0.134^{d} ± 0.016	0.0390^{b} ± 0.0001	0.145^{a} ± 0.004	0.217^{d} ± 0.009	89.29^{b} ± 0.01
80:10:10	15.20^{b} ± 0.02	0.405^{c} ± 0.008	0.0410^{b} ± 0.0001	0.136^{ab} ± 0.001	0.305^{c} ± 0.008	83.90^{d} ± 0.01
75:10:15	15.61^{a} ± 0.02	0.506^{b} ± 0.008	0.0800^{ab} ± 0.0020	0.134^{bc} ± 0.001	0.417^{b} ± 0.007	83.25^{e} ± 0.01
70:10:20	10.88^{c} ± 0.02	0.707^{a} ± 0.007	0.1100^{a} ± 0.0010	0.124^{c} ± 0.006	0.592^{a} ± 0.007	87.58^{c} ± 0.00
LSD	0.08	0.02	0.00	0.01	0.02	0.26

Values are mean ± standard deviations (SD) of two determinations

Values with same superscript within a column are not significantly different ($P > 0.05$)

P:C:J = pineappl:cucumber:*Jatropha* leaf

LSD = least significant difference

the presence of blended cucumber and *Jatropha* leaf pulp brought about fluctuations among the parameters under study. Pineapple, cucumber, and *Jatropha* leaf certainly helped to fortify the composite jam of this study with minerals and vitamins, which makes it a useful source of health-promoting compounds. When Zn becomes deficient, certain individuals may demonstrate carbohydrate intolerance [32]. Increase in Ca intake could help to manage and reduce the diabetic and osteoporosis situations in senior citizens [33].

Variations in proximate components. Table 4 shows the proximate components in cucumber, pineapple, and *Jatropha* leaf composite jam. The experiment demonstrated significant differences ($P < 0.05$) in moisture, protein, ash, fat, fiber, and carbohydrate among the experimental samples, compared to the control. Specifically, the proximate components of moisture, protein, ash, fat, and fiber in the control (P:C:J = 100:0:0) were significantly lower ($P < 0.05$) than in the experimental samples. Probably, it happened due to the absence of cucumber and *Jatropha* leaf in the control. Only the amount of carbohydrates in the control sample was significantly higher ($P < 0.05$) than in the experimental samples.

However, the sample P:C:J = 85:10:5 demonstrated drastic increases and decreases in proximate components, which clearly shows the impact of cucumber pulp and *Jatropha* leaf. In particular, with increasing *Jatropha* leaf and decreasing pineapple amounts, some substances increased significantly ($P < 0.05$) among the experimental jams. Thus, protein, fat, and fiber increased from 0.134 to 0.707%, from 0.039 to 0.110%, and from 0.217 to 0.592%, respectively. However, this increase did not happen in the experimental sample P:C:J = 70:10:20, where moisture and fat contents decreased significantly ($P < 0.05$).

Given its carbon and nitrogen provision for the gluconeogenesis and energy synthesis, protein remains among the key macro-nutrients gaining increasing attention, particularly in terms of ecology and economy [34]. Additionally, ash content considers the total minerals in food: it is the inorganic material left after organic matter has been oxidized [35]. In the current study, the addition of cucumber and *Jatropha* leaf increased the content of crude protein, thus elevating the curcumin in the experimental samples. Curcumin is a protein moiety with anti-inflammatory and antioxidant properties [36, 37]. The chemical constituent of curcumin could improve the episodic memory in cadmium induced (memory) impairment via acetycholiesterase and adenosine deaminase activities [38, 39].

Table 5 Sensory attributes of pineapple jam with cucumber and *Jatropha* leaf in different proportions

Sample	Sensory properties				
P:C:J	Appearance	Taste	Aroma	Spreadability	Overall liking
100:0:0	8.20^{a}	7.93^{a}	7.67^{a}	3.87^{b}	7.27^{a}
85:10:05	7.07^{b}	7.93^{a}	7.67^{a}	7.27^{a}	7.73^{a}
80:10:10	6.47^{bc}	7.93^{a}	7.27^{a}	7.67^{a}	7.60^{a}
75:10:15	5.73^{cd}	7.33^{a}	6.93^{ab}	7.80^{a}	7.53^{a}
70:10:20	5.07^{d}	7.07^{a}	6.47^{b}	7.60^{a}	6.87^{a}
LSD	1.05	n.s.	0.70	1.05	n.s.

Values are mean sensory scores obtained from ten panelists

Values with same superscript within a column are not significantly different ($P > 0.05$)

P:C:J = pineapple:cucumber:*Jatropha* leaf

LSD = least significant difference

n.s = not significant

Vegetables play essential role in human nutrition and can provide some carbohydrates, proteins, and energy [35]. The crude fiber of jam could help to secure the intestinal mucous, thereby excluding any malignant growth-causing elements [40]. In the current work, the moisture peaked in the experimental sample P:C:J = 75:10:15. The increase in ash also indicates that this sample is a promising source of minerals [13]. Carbohydrate content in the experimental samples decreased significantly ($P < 0.05$), specifically in the samples 85:10:5 (89.29%), 80:10:10 (83.90%), and 75:10:15 (83.25%). Such decreases in carbohydrate suggest the composite jam can be highly promising for diabetes management. However, the sample 70:10:20 demonstrated the increased carbohydrate content (87.58%).

Sensory attributes. Sensory evaluation includes such aspects as appearance, aroma, taste, etc., which cumulatively helps to reveal the overall liking. Typically, aroma plays a key role in the overall liking [25]. Table 5 shows the sensory attributes of cucumber, *Jatropha* leaf, and pineapple composite jam. The experimental samples appeared significantly different ($P < 0.05$) in appearance, aroma, and spreadability but not ($P > 0.05$) in taste and overall liking, compared to the control.

For appearance, the control sample (P:C:J = 100:0:0) scored much higher than the experimental samples. With decreasing pineapple and increasing *Jatropha* leaf proportions, the appearance obtained somewhat decreasing trend: 85:10:5 > 80:10:10 > 75:10:15 > 70:10:20. For aroma, the score of the control (100:0:0) sample did not differ significantly ($P > 0.05$) from that of 85:10:5, 80:10:10, and 75:10:15. For spreadability, the control scored significantly lower than the experimental samples 85:10:5, 80:10:10, and 75:10:15.

Compared to the control, the variations in appearance, aroma, and spreadability can be attributed to cucumber and *Jatropha* leaf blends. However, such variations could also arise from the (slight) differences in thermal treatment during the jam making process. Moreover, either decreasing the pineapple or increasing *Jatropha* leaf amounts did not significantly affect ($P > 0.05$) the spreadability. It is highly unlikely that the respective peaks and drops of *Jatropha* leaf and pineapple amounts had an impact on the taste of the experimental samples. Additionally, the overall liking did not show significant changes ($P > 0.05$) among the experimental samples. Potentially, the sample P:C:J = 85:10:5 appeared more preferable based on consumer acceptability, given the higher scores for appearance and taste, compared to the other samples.

CONCLUSION

This study featured the effect of different proportions of pineapple, cucumber, and *Jatropha* leaf on the functional and sensory properties of the composite jam.

The vitamin and mineral composition, as well as total titratable acidity (TTA), pH, Brix, and total soluble solids (TSS) showed significant differences ($P < 0.05$), with the minor exceptions of pH and TTA. The proximate components (ash, fat, fiber, moisture, and protein) of the control (P:C:J = 100:0:0) appeared significantly ($P < 0.05$) lower compared to the experimental samples. The appearance, aroma, and spreadability demonstrated significant differences ($P < 0.05$), but the taste and overall liking remained similar ($P > 0.05$). The composite jam proved functionally nutritious and demonstrated a good sensory appeal.

Jatropha leaf appears to be on the rise in scientific literature. Despite this, it still remains understudied. Further research should be aimed to promote it as a functional food ingredient and ensure the consumer safety of the finished product. In the future, pineapple jam with cucumber and *Jatropha* leaf should be tested for quality and shelf-life under various storage conditions.

CONTRIBUTION

A.F. Ogori, J. Amove, and P. Evi-Parker conceived, designed, and performed the analysis, collected the data, and wrote the manuscript. A.F. Ogori, J. Amove, G. Sardo, C.O.R. Okpala, G. Bono, and M. Korzeniowska contributed to the data analysis. G. Sardo, C.O.R. Okpala, G. Bono, and M. Korzeniowska proofread the manuscript.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the laboratory staff of the Department of Food Science and Technology, Federal University of Agriculture, Makurdi, Nigeria. G. Sardo and G. Bono appreciate funding support from IRBIM-CNR - Mazara del Vallo, Italy. C.O.R. Okpala and M. Korzeniowska express their gratitude to Wrocław University of Environmental and Life Science, Poland, for financial support.

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