

Nutrient Composition and Sensory Attributes of Composite Fruit Jam Produced from Pineapple, Avocado, Pawpaw and Green Apple Blends

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ABSTRACT

Background: Pineapple, avocado, pawpaw, and green apple are tropical fruits valued for their rich nutrient profiles and health benefits. Composite fruit jams made from blends of these fruits can offer a nutrient-dense alternative to single-fruit jams.

Objective: This study aimed to produce composite fruit jams from blends of pineapple, avocado, pawpaw, and green apple in varying ratios, and evaluate their nutrient composition and sensory qualities.

Methods: Fully ripe fruits were processed with lemon juice and ginger. The fruit pulps were blended in four ratio combinations: 60:20:10:10, 20:60:10:10, 10:10:60:20, and 10:10:20:60, and coded as VP, OS, P, and S, respectively. Nutritional components including proximate contents, vitamins (A, B3, B6, B9, C, E), minerals (magnesium, potassium, sodium, iron), flavonoids, and phenols were analyzed using standard methods. Sensory attributes were assessed by 20 semi-trained panelists using a nine-point hedonic scale. Data were analyzed using ANOVA and Duncan's test ($P < 0.05$).

Results: Carbohydrates were the most abundant nutrient (80.08-88.65%). Sample P had the highest protein content (7.12%). Vitamin B9 (61.6-72.3 mg/100 g) and potassium (1.81-7.68 mg/100 g) were prominent. Phenolic content (2.46-8.29 mg/100 g) was higher than flavonoid content (0.19-0.28 mg/100 g). Sensory evaluation showed sample S was the most preferred.

Conclusion: Composite jams from these fruit blends are nutrient-rich and well accepted by consumers. They offer a potential method for fruit preservation and nutritional enhancement, though further studies on shelf-life are recommended.

Keywords: Depression, reserpine, probiotics, cassava, maize, fermentation.

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INTRODUCTION

According to the World Health Organization (1), more than two billion people globally suffer from micronutrients deficiencies resulting in high morbidity and mortality rates, and these occur predominantly amongst the vulnerable groups in low-income countries.

Fruits are one of the richest sources of micronutrients (2). In a study conducted by Awolu et al., (3) populations that consume generous

amount of fruits have significantly shown low incidence of diet-related diseases and cancers. However, fruits do not have the potential to last for a long period of time because their perishable and seasonal nature. In developing countries, huge fruit losses are recorded due to poor storage methods (5).

Fruit preservation is the process of treating and

handling fruits to stop and delay its spoilage, loss of quality, edibility or nutritional value, and prolong its shelf-life (4). There are ways fruits can be preserved to ensure their consumption when out of season (6). Jams, jellies and marmalades are good examples of sweet fruit preserves, and are often eaten or served with bread, cake, other pastries or dessert (7). Jam is a popular food product that has low cost, high organoleptic properties and long-term storage (8). Fruit jam is a semi-solid food product prepared by boiling the pulp of fruits with sugar, gelatin, citric acid and other ingredients to achieve a gel-like consistency (9). These ingredients should be used in correct proportions to achieve a good gel (7). Matured, ripe and undeteriorated fruits are best for jam production as they have high pectin levels and good flavors. Pectin is a thickening agent that changes the texture and flow of a product. Citric acid creates a network between sugar and pectin to enable jam formation (8). Sugar aids in gel formation, improves the flavor of the jam, and ultimately serves as a preserving agent by inhibiting microbial growth. A good fruit jam should have soft and even consistency, bright colored, good flavor and semi-jelled texture that is easy to spread with no free liquid (10,11). Fruit jams are of two types; single fruit jam made from a fruit and composite/mixed fruit jam made from two or more fruits (7). Composite fruit jams have better nutritional value and excellent sensory profile (8). Available literature has shown production, nutritional composition and sensory evaluation of composite fruit jams made from blends of several and similar fruits but there is no information on composite fruit jam formulated from pineapple, avocado, pawpaw and green apple blends. Therefore, this study seeks to produce composite fruit jams from blends of pineapple, avocado, pawpaw and green apple, evaluate their general acceptability, proximate, vitamins (Beta-carotene, B3, B6 and B9, C and E), mineral (magnesium, potassium, calcium and iron) and phytochemical (phenol and flavonoids) contents.

METHODS

Study design and material

This experimental study investigated the nutritional composition of composite fruit jams made from four tropical fruit blend: pineapple, avocado, pawpaw and green apple using standard methods. Fully mature and freshly ripe fruits with varying pectin level (pineapple, avocado, pawpaw and green apple), lemon (citric acid) and ginger (natural preservative) were purchased from International

Market, Abakaliki, Ebonyi State. Equipment used in the production of composite fruit jams was obtained from the Medical Food Administration Unit, Alex-Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State. All chemicals used for determination of nutrient content were of good analytical grade.

Sample preparation

The four fruits and ginger were washed with chlorinated water and rinsed clean with distilled water. Their outer skin was peeled off manually using a stainless knife, and pulps were pulverized into smooth texture and flowing consistency using an electric blender. The pulverized pulps were separated, and 500 g of each fruit pulp and 40g of ginger were weighed out into sterilized bowls. Furthermore, 45 ml of lemon juice was extracted from each 33g of lemon fruit. Four lemon fruits were cut in halves and a manual fruit juice extractor was used to carefully sieve out the pulp and seeds. Then, 45 ml of lemon juice was poured into each sterilized bowl containing 40 g of ginger and 500 g of formulated fruit pulps.

Sample formulation

The composite fruit jams were prepared by following the procedures demonstrated by Codex Alimentarius (12). Five hundred grams of each fruit pulp were subdivided into four proportions of 300, 100, 50 and 50 which were transcribed into the percentages of 60, 20, 10 and 10. Each sample was formulated based on this ratio, and coded as VP, OS, P and S. Figure 1 below shows the jam making process.

Proximate analysis

Moisture, protein, fat, ash and crude fiber contents were determined by the method described by A.O.A.C. (13). The content of carbohydrate in the formulated products were obtained by difference, subtracting the sum of moisture, protein, fat, ash and crude fiber from 100%.

Vitamins analysis

Vitamin A was determined by the colorimeter method described by A.O.A.C. (14). The High-Performance Liquid Chromatography method developed by Jale and Mustafa (15) was used in determination of vitamin B3. Vitamin B6 content was determined using the UHPLC-DAD method developed by Zhang et al. (16). Vitamins B9 and E contents were determined as described by A.O.A.C. (12). The 2,6 dichloroindophenol titrimetric method described by A.O.A.C. (14) was

used to determine vitamin C content.

Mineral analysis

Iron content of the samples was determined using the atomic absorption spectrophotometer method described by Goswami and Agarwal (17). Magnesium content was determined using the atomic spectrophotometer method described by A.O.A.C. (12). Sodium and potassium were determined using the flame photometry method as described by A.O.A.C. (12).

Phytochemicals analysis

The total phenol content was determined by slightly modifying the spectrophotometric method described by Kim et al. (18). Flavonoids content was determined according to the method described by El-Olemy (19).

Sensory evaluation

Composite fruit jam samples were served to 20 semi-trained panelists from Nutrition and Dietetics department, Alex-Ekwueme Federal Teaching Hospital, Abakaliki, Ebonyi, Nigeria. Multiple comparison test was adopted in the form of nine-point hedonic scale ('9' – like extremely and '1' – dislike extremely) to analyze the following parameters: color, taste, texture, spread ability and overall acceptability.

Data analysis

The Statistical Product and Service Solution (SPSS) 2021 package was used to analyze the nutrient composition and sensory evaluation results, and they were presented as mean \pm standard deviation. Analysis of variance (ANOVA) and Duncan's new multiple range test were used to separate and compare, respectively. Significance was accepted at $P < 0.05$. this includes colony morphology,

JAM-MAKING FLOW CHART

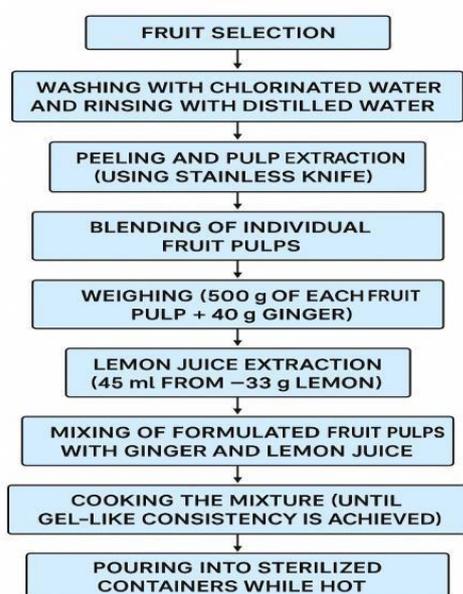


Figure 1. Jam making flow chart

RESULTS

Proximate composition of the jam samples

Table 2 shows the proximate composition of the formulated composite fruit jams. The moisture content of the samples had a significant difference of $P < 0.05$. The results of the fat content showed a significant difference ($P < 0.05$). The ash content of the samples was comparable but there was no significance ($P > 0.05$). Regarding the fiber content, the samples were significantly different from each other. A similar case was recorded for carbohydrates, and it is the most abundant nutrient in the formulated samples. Protein content of P and S were significantly different, but that was not the case of sample OS and VP ($P > 0.05$).

Table 1: Sample formulation

Sample	Pineapple pulp (500 g)	Avocado pulp (500 g)	Pawpaw pulp (500 g)	Green apple pulp (500 g)	Lemon juice	Ginger
VP	300 g (60%)	100 g (20%)	50 g (10%)	50 g (10%)	45 ml	40 g
OS	100 g (20%)	300 g (60%)	50 g (10%)	50 g (10%)	45 ml	40 g
P	50 g (10%)	50 g (10%)	300 g (60%)	100 g (20%)	45 ml	40 g
S	50 g (10%)	50 g (10%)	100 g (20%)	300 g (60%)	45 ml	40 g

Table 2: Proximate composition of the jam samples per 100 g

Samples	Moisture (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
P	11.21 ^a ±.014	1.00 ^c ±.000	0.51 ^a ±.014	0.10 ^b ±.000	7.12 ^a ±.007	80.08 ^d ±.036
S	9.02 ^c ±.021	1.02 ^{ab} ±.007	0.52 ^a ±.007	0.30 ^a ±.000	2.61 ^b ±.014	86.55 ^c ±.021
O	9.60 ^b ±.000	1.02 ^a ±.000	0.50 ^a ±.000	0.06 ^b ±.007	1.82 ^c ±.014	87.01 ^b ±.008
VP	7.79 ^d ±.014	1.01 ^{bc} ±.007	0.51 ^a ±.007	0.25 ^a ±.071	1.81 ^c ±.007	88.65 ^a ±.049

¹Values mean ± standard deviation of two replications.

²Values followed by different letters are significantly (P < 0.05) different from each other.

³Sample P: Contains 60% pawpaw, 20% green apple, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁴Sample S: Contains 60% green apple, 20% pawpaw, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁵Sample OS: Contains 60% avocado, 20% pineapple, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

⁶Sample VP: Contains 60% pineapple, 20% avocado, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

Table 3: Vitamin composition of the jam samples per 100 g

Samples	Vitamin A (mg/100 g)	Vitamin B ₃ (mg/100 g)	Vitamin B ₆ (mg/100 g)	Vitamin B ₉ (mg/100 g)	Vitamin C (mg/100 g)	Vitamin E (mg/100 g)
P	0.03 ^b ±0.00	0.19 ^c ±0.01	17.10 ^b ±0.14	66.59 ^b ±0.01	15.95 ^c ±0.07	3.35 ^a ±0.38
S	0.05 ^a ±0.01	0.30 ^b ±0.01	14.75 ^d ±0.07	63.51 ^c ±0.01	14.75 ^d ±0.07	3.90 ^a ±0.42
OS	0.01 ^c ±0.00	0.46 ^a ±0.00	17.55 ^a ±0.21	61.59 ^d ±0.02	20.10 ^a ±0.28	1.95 ^b ±0.07
VP	0.03 ^b ±0.01	0.44 ^a ±0.01	16.15 ^c ±0.07	72.30 ^a ±0.00	19.15 ^b ±0.07	4.00 ^a ±0.28

¹Values mean ± standard deviation of two replications.

²Values followed by different letters are significantly (P < 0.05) different from each other.

³Sample P: Contains 60% pawpaw, 20% green apple, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁴Sample S: Contains 60% green apple, 20% pawpaw, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁵Sample OS: Contains 60% avocado, 20% pineapple, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

⁶Sample VP: Contains 60% pineapple, 20% avocado, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

Vitamin composition of the jam samples

The results of vitamins (A, B₃, B₆ and B₉, C and E) analysis are presented in Table 3. The samples were not significantly different in terms of their vitamin A contents. The vitamin B₃ content of sample P is significantly different from other samples; however, sample VP and OS showed no significant difference

(P > 0.05). The vitamin B₆ content of the samples varied and had a significant difference. Sample VP had the highest folate content and was significantly different from others. For vitamin C, sample OS was significantly higher than other samples. The vitamin E content of Sample OS showed a significant difference (P < 0.05) from the rest.

Mineral composition of the jam samples

The mineral composition of the formulated products is shown in Table 4. The sodium content of the samples showed no significant difference ($P > 0.05$). This result contrasted with that of potassium, as significant difference was observed amongst the samples ($P < 0.05$). The iron composition of sample OS and P are not significantly different, but sample VP and S showed a significant difference. Regarding magnesium, sample S is significantly higher than other samples.

Phytochemicals composition of the jam samples

In Table 5, the phenol value of fruit jams showed a

significant difference while the flavonoid values of samples OS and VP were significantly different from samples P and S.

Sensory evaluation of the jam sample Table 6 shows the sensory qualities of each sample. The formulated products have similar texture, taste, flavour and spread ability attributes as there was no significant difference ($P > 0.05$) in their results. Sample S had the best colour and is significantly different from other samples. The color of samples VP and P showed no significant difference. In overall acceptability, sample S had the highest score, while sample VP and P were comparable.

Table 4: Mineral composition of the jam samples per 100 g

Samples	Sodium (mg/100 g)	Potassium (mg/100 g)	Iron (mg/100 g)	Magnesium (mg/100 g)
P	2.02 ^b ±2.80	7.68 ^a ±0.02	0.04 ^c ±0.01	0.34 ^b ±0.01
A	0.03 ^a ±0.01	5.55 ^b ±0.04	0.07 ^b ±0.00	0.52 ^a ±0.01
OS	0.02 ^a ±0.01	4.07 ^c ±0.00	0.03 ^c ±0.00	0.25 ^c ±0.04
VP	0.02 ^a ±0.00	1.81 ^d ±0.01	0.11 ^a ±0.01	0.33 ^b ±0.01

¹Values mean ± standard deviation of two replications.

²Values followed by different letters are significantly ($P < 0.05$) different from each other.

³Sample P: Contains 60% pawpaw, 20% green apple, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁴Sample S: Contains 60% green apple, 20% pawpaw, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁵Sample OS: Contains 60% avocado, 20% pineapple, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

⁶Sample VP: Contains 60% pineapple, 20% avocado, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

Table 5: Phytochemicals composition of the jam samples per 100 g

Samples	Flavonoid mg GAE/g dry wt	Phenol (QE)/g dry wt
P	0.19 ^b ±0.01	8.29 ^a ±0.01
S	0.19 ^b ±0.01	2.46 ^d ±0.01
OS	0.27 ^a ±0.00	4.11 ^c ±0.01
VP	0.28 ^a ±0.01	6.31 ^b ±0.03

¹Values mean ± standard deviation of two replications.

²Values followed by different letters are significantly ($P < 0.05$) different from each other.

³Sample P: Contains 60% pawpaw, 20% green apple, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁴Sample S: Contains 60% green apple, 20% pawpaw, 10% pineapple, 10% avocado, 45 ml of lemon juice and 10g of ginger.

⁵Sample OS: Contains 60% avocado, 20% pineapple, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

⁶Sample VP: Contains 60% pineapple, 20% avocado, 10% pawpaw, 10% green apple, 45 ml of lemon juice and 10g of ginger.

Table 6: Sensory evaluation of the jam sample per 100g

Sample	Texture	Taste	Flavour	Spreadability	colour	General acceptability
P	7.25±1.03	7.40 ^a ±1.7	7.50 ^a ±1.57	7.15 ^a ±1.57	7.40 ^b ±0.88	7.34 ^{ab} ±0.97
S	8.00 ^a ±1.99	7.35 ^a ±1.2	7.40 ^a ±1.31	8.00 ^a ±1.41	8.70 ^a ±0.57	7.89 ^a ±0.78
OS	7.10 ^a ±1.99	7.30 ^a ±1.3	6.90 ^a ±1.44	7.70 ^a ±1.38	6.50 ^c ±1.73	7.10 ^b ±1.22
VP	7.70 ^a ±1.03	7.80 ^a ±1.5	7.40 ^a ±1.27	7.80 ^a ±0.95	7.60 ^a ±1.39	7.66 ^{ab} ±0.97

¹Values mean ± standard deviation of two replications.

²Values followed by different letters are significantly (P < 0.05) different from each other.

³Scale: 1=dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like or dislike, 6=like slightly, 7= like moderately, 8= like very much and 9= like extremely.

DISCUSSION

The findings from this study revealed that the formulated composite fruit jams are good sources of carbohydrates. This aligns with previous studies that reported its rich presence in their jam samples (3, 20). Carbohydrates are important for providing energy needed for daily activities and bodily functions, making these jams a significant energy source, particularly in regions where these tropical fruits are found abundantly. Current research also emphasizes the importance of carbohydrates for sustaining energy levels and supporting physical and mental performance by consuming these fruit jams (21).

The likelihood of food spoilage increases with high moisture levels; this implies that the jam products from this investigation may have a longer shelf life than jam made from blends of pineapple, tomato and pawpaw as the moisture content were found to be significantly lower (22). The fruit jams' low moisture contents are attributed to the fruits' high sugar content, which lowers the amount of available water (23). Additionally, the jams' minimal fat content lengthens its shelf-life. A product's high fat content accelerates rancidity leading to deterioration, affecting the taste and ultimately tampering with its nutritional quality (24). Recent studies in food science have ascertained that rancidity of foods products are only minimal when the fat content is lower (25).

The jam sample with 60% avocado, 20% pineapple and 20% of papaya and green apple had the highest vitamin content, the heat treatment caused

most of the vitamins present in the fruits to be lost. Yet, there was a significant amount of vitamin B9 in the samples. The fact that these fruits are excellent providers of this may account for this. Folate is vital for DNA synthesis and repair, and its presence in these jams can help prevent nutritional deficiencies, especially in populations with poor folate intake. Studies also highlight the role of folate in preventing neural tube defects during pregnancy and promoting heart health (26).

This study also suggests composite fruit jams made from these fruits should not be considered as sources of sodium, calcium, iron and magnesium. Although potassium was predominant in the samples that contain 60% and 30% pawpaw pulp, its presence in other samples was minute. Recent dietary guidelines suggest that a balanced intake of minerals can only be achieved through proper food diversification to ensure overall nutritional adequacy (27). Therefore, while these jams provide certain nutritional benefits, they should be consumed alongside other foods to have a balance in minerals.

Phenolic compounds are known for their health benefits, including reducing inflammation and lowering the risk of chronic diseases. The higher phenol content in these composite fruit jams compared to previous studies suggests they may offer better antioxidant properties. This might be because the fruits used in the investigation are high-quality phenol sources (24). Recent studies confirm the health benefits of phenolic compounds, emphasizing their role in combating oxidative stress

and reducing cardiovascular disease risk. However, it may experience a reduction in its nutritional quality during storage, indicating the need for proper storage conditions (28).

CONCLUSION

This study corroborates that the composite jams produced are good sources of essential nutrients which can be beneficial in promoting bodily activities, help manage malnutrition and other related health diseases in both children and adults. Additionally, future research on the shelf-life parameters of these composite fruit jams is recommended to determine if there are changes in the nutritional value and sensory properties of these products during storage

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