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***Research Article***

# Quality Evaluation of Mixed Fruits Jams Produced from Blends of Banana, Pawpaw and Date Fruit Syrup

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**ABSTRACT**
The study was carried out to evaluate the quality of functional jams produced from banana, pawpaw and date syrup blends. Banana fruit, pawpaw fruit and date syrup were proportioned into 7 samples namely: SAM1 (100:0:0), SAM2 (30:10:60), SAM3 (35:15:50), SAM4 (40:20:40), SAM5 (45:25:30), SAM6 (50:30:20) and SAM7 (60:40:0) and used to produce jams. The jams were analysed for proximate composition, pH, total titratable acidity, total soluble solids and antioxidant properties using standard analytical methods. Sensory properties of the jams were evaluated using the 9-point hedonic scale. The results of proximate composition ranged from 28.18-42.56% (moisture), 0.47-1.72% (protein), 1.65-2.63% (fibre), 0.18-0.56% (fat) and 1.15-1.95% (carbohydrate). The energy value ranged between 219.50 kcal and 271.78 kcal. The pH, total titratable acidity and total soluble solids ranged from 5.08-6.47, 0.42-0.81% and 56.17-71.83%, respectively. The antioxidant properties showed significant ($p<0.05$) differences. Sensory results revealed that the sample SAM6 containing 50% banana, 30% pawpaw and 20% date syrup had the highest score for appearance (7.10), taste (7.15), aroma (6.15), mouthfeel (7.20), texture (7.10) and general acceptability (7.35). This study proved that jams with good nutrients, high antioxidant potential and high consumer acceptability can be produced from blends of banana, pawpaw and date syrup.

**Keywords:** Antioxidant properties; Jam; pH; Proximate composition; Total titratable acidity; Total soluble solids

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## INTRODUCTION

Jam is a fruit preserve mostly made from pulp or whole fruit, cooked, gelled and packed for storage (Ogunlade and Oluwafemi, 2021). According to Dianne (2011), jam is a blend of fruit cooked with sugar and left to gel. Fruit-based jams not only preserve the taste of the fruit but also capture its essence, its fragrance, natural sweetness, and seasonal freshness, offering a way to enjoy fruit long after the harvest season ends (Uddin *et al.,* 2024). Some researchers opined that processing of jams is an efficient preservation process of making use of surplus quantity of fruits during their peak production season (Haq and Darakshan, 2019). Basically, jam preparation requires the inclusion of commercial or natural pectin as a gelling agent (Awolu *et al*., 2016). Pectin shortens cooking time of jams to produce fresh fruit flavour (Nashi *et al*., 2020). Also, sugar sweetens jam and works in synergy with pectin and fruit acid to form the gel structure of jam (Nwosu *et al*., 2014). A good jam possesses semi jelled texture, bright colour, no free liquid and an even consistency. Jam has long shelf life and thus can be available all year round (Awolu *et al*., 2018). Production of jam requires right proportion of the right ingredients to get the desired result, which are; pectin, sugar and fruit pulp (Awolu *et al*., 2018). Jam is commonly consumed as dessert, bread spread, cake topping, fillings and food jellies.

Banana (*Musa paradisiaca*) is one of the most consumed fruits worldwide and is known for its sweet taste and creamy texture. It is rich in carbohydrates, specifically starch and sugars, making it a great source of energy (Adejoro *et al*., 2010). Bananas are also high in potassium, which is good for heart health and muscle function. They are usually long and yellow when ripe, but some types can be red or green. Bananas are very versatile and can be used in smoothies, baked goods, and as snacks (Das, 2023).

Pawpaw (*Carica papaya*) is the largest edible fruit indigenous to North America and is known for its tropical taste, often compared to a blend of banana and mango. This deciduous tree can grow up to 18 cm in length and bears fruits with creamy, custard-like texture and a skin that darkens as it ripens. Traditionally important to Native American diets, the fruit's popularity has varied over time due to its delicate nature and short shelf life. Recently, however, there has been renewed interest in cultivating pawpaw among farmers, driven by its unique flavour and health benefits (Adebayo-Oyetoro *et al*., 2016).

Date (*Phoenix dactylifera* L), the sweet and nutritious fruit of the date palm, has been a staple in many cultures for centuries. Not only are they a natural source of energy and fibre, but they are also used to produce a sweet and versatile liquid gold known as date syrup. Made from the extract of dates, date syrup is a rich and flavourful alternative to refined sugars, offering a depth of flavour and numerous health benefits that make it a popular choice among health-conscious consumers (Fernández-López *et al*., 2022).

Availability of fruits is seasonal and they deteriorate easily, therefore, need to be transformed into products such as jam that would make it available when out of season. Furthermore, lack of comprehensive research on developing a novel jam product using banana, pawpaw, and date syrup blends presents a significant opportunity for food science innovation. Current jam production research predominantly focuses on single fruit or limited fruit combinations, leaving unexplored potentials in banana, pawpaw, and date in creating nutritionally enhanced and unique jam formulations. The production of jam from banana, pawpaw and date syrup will diversify the utilization of this local produce into a more shelf stable product. This will increase the demand for these fruits, increase the income of local farmers, and promote the utilization of these fruits in diverse industrial applications. Also, consumption of jam produced from natural fruit sweeteners such as banana, pawpaw and date syrup will reduce health problems associated with the consumption of added sugars (sucrose) and also enhance dietary diversity among consumers.

## MATERIALS AND METHODS

**Source Of Raw Materials**

The raw materials used in this study such as banana, pawpaw, date fruit, lemon, etc., were purchased from Ubani main market, Umuahia, Abia State.

**Preparation of banana and pawpaw fruits**

The banana and pawpaw were sorted, cleaned to remove dirt and washed in running tap water and the fruits were cut into 2 cm thickness prior to crushing and further processing.

**Preparation of date syrup**

Date syrup was prepared from date fruit using the method of Shanta *et al*. (2021). The date fruits were properly sorted, washed and pitted. The fruits were cut into small pieces of 3 mm thickness. The fruits were soaked in water for 2 h at room temperature after which they were pulverized using electric blender, and sieved with a muslin cloth to obtain fresh date juice. Precisely 1 litre of date juice was transferred to a clean stainless-steel pot and 5 ml of lemon juice was added and heated with constant stirring for 30 min at 100 $^{o}$C to form a viscous date syrup which was cooled and packaged in a clean plastic container prior to jam production.

**Sample Formulation**

Table 1 presents the sample formulation with banana, pawpaw and date syrup. The fruits were weighed and proportioned into seven different blends and coded as SAMI, SAM2, SAM3, SAM4, SAM5, SAM6 and SAM7, where SAMI served as control.

**Production of Jam**

Jam was produced using the method of Adewole *et al.* (2022) with little modification. Each blend/mixture was initially heated for 5 min at 100 $^{o}$C after which 20 ml lemon juice (for pectin) was added and the mixture was further heated for 20 min at 100 $^{o}$C to obtain a mixed fruit jam. The produced jam was packaged in a clean plastic container and kept for further analysis.

**Table 1: Blends Formulation for Jam Production**

| Samples | Banana (%) | Pawpaw (%) | Date Syrup (%) |
|---|---|---|---|
| SAM1 | 100 | 0 | 0 |
| SAM2 | 30 | 10 | 60 |
| SAM3 | 35 | 15 | 50 |
| SAM4 | 40 | 20 | 40 |
| SAM5 | 45 | 25 | 30 |
| SAM6 | 50 | 30 | 20 |
| SAM7 | 60 | 40 | 0 |

**Determination of Proximate Composition of Jam Samples**

**Crude Protein content:** Crude protein of the samples was determined using the Kjedahl method as described by Onwuka (2018). One millimeter of the sample was introduced into the digestion flask. Kjedahl catalyst (selenium tablets) was added to the sample. Twenty milliliters of concentrated sulphuric acid was added to the sample and fixed to the digester for 8h until a clear solution was obtained. The cooled digest was transferred into 100ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for 10m after boiling. Twenty milliliters of 4% Boric acid was pipetted into conical flask. Five drops of methyl red were added to the flask as indicator and the sample was diluted with 75ml distilled water. Ten milliliters of the digest was made alkaline with 20ml of sodium hydroxide (NaOH) (20%) and distilled. The steam exit of the distillatory was closed and the change of colour of boric acid solution to green was timed. The mixture was distilled for 15min. The filtrate was then titrated against 0.1N Hydrochloric acid (HCl).

The total percentage of protein was calculated:

Protein(%) = % nitrogen x conversion factor (6.25).

**Crude Fibre content:** The crude fibre of the samples was determined according to the Onwuka (2018) method. Two millimeters of each of the snacks were boiled under reflux for 30min with 200ml of solution containing 1.25g of tetraxosulphate (vi) acid ($H_2SO_4$) per 100ml of solution. The solution was filtered through linen on a flaunted funnel and washed with water until the washing is no longer acidic. The residue was then transferred to a beaker and boiled for 30min with 100ml of solution. The final residue was filtered through a thin but closer pad of washed and ignited asbestos in a Gosh crucible. The residue was then dried in an electric oven and weighed. The residue was incinerated, cooled and weighed. Crude fibre content of the instant meal was then calculated as follows:

$$\text{Crude fibre } (\%) = \frac{W_2 - W_3}{W_1}$$

Where: $W_1$ = weight of sample used

$W_2$ = weight of crucible plus sample

$W_3$ = weight of sample crucible

**Moisture content:** Moisture content of the samples was determined according to the method described by Onwuka (2018). Two millimeters of each of the samples were weighed into different moisture cans. They were then placed in an oven at 150˚C for 3h, drying was stopped after obtaining a constant value consecutively. The flakes were cooled in a desiccator and weighed. Moisture content of the flakes was then calculated as follows:

$$\text{Moisture}(\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where: $W_1$ = initial weight of empty can,

$W_2$ = weight of empty can + sample before drying,

$W_3$ = final weight of empty can + sample after drying.

**Ash content:** The method described by Onwuka (2018) was used to determine the ash content of the samples. Porcelain crucible was dried and cooled in desiccators before weighing. Two millimeters of the samples were weighed into the crucible and the weight taken. The crucible containing the samples were placed into the muffle furnace and ignited at 550$^o$C. This temperature was maintained for 3h. The muffle furnace was then allowed to cool; the crucibles were then brought out, cooled and weighed. The ash content was calculated as follows:

$$\text{Ash}(\%) = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100$$

Where: $W_2$ = weight of crucible + ash,

$W_1$ = weight of empty crucible.

**Fat content:** The fat content of the samples was determined using solvent extraction in a soxhlet apparatus as described by Onwuka (2018). Two millimeters of each of the samples were wrapped in a filter paper and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and to a weighed oil extraction flask full with 200ml of petroleum ether. The ether was brought to its boiling point, the vapour condensed into the reflux flask

immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60˚C for 30min and then weighed.

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \text{ x } 100$$

**Carbohydrate content:** Carbohydrate content of the samples was determined by using the formula described by Onwuka (2018).

Carbohydrate(%)=100 − % (protein + fat + fibre + ash + moisture content)

**Determination of Energy value**

The energy value was estimated using Atwater factors as described by Onwuka (2018). The energy value was calculated by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel value of 4, 9, and 4kcal/g respectively and taking the sum of their products. The energy value was calculated thus:

$F_e$ = (% CP x 4) + (% CF x 9) + (% CHO x 4)

Where: $F_e$ = Food energy (in grain calories), CP= Crude protein, CF= Crude fat, CHO= Carbohydrate

**Determination of Antioxidant Properties**

**Total phenol content:** Total phenol content was analyzed using the Folin-Ciocalteucolourimetric process (Onwuka, 2018). A portion (0.3 ml) of the samples was combined with Folin-Ciocalteuphenol reagent (2.25 ml). After 5 min, 6% sodium carbonate (2.25 ml) was added and the mixture was allowed to stand at room temperature for 90 min. The absorbance of the mixture was measured at 725 nm. Standard calibration curve for gallic acid in the range of 0-200 g/ml was prepared in the same manner and the result (total phenol) was expressed as mg/Gallic Acid Equivalent (GAE) per gram of extract (mg/GAE/100 g).

Total phenol= C x $^{v}$/W

Where: C = concentration of gallic acid calculated from the calibration curve in mg/ml,

V= volume of extract in ml, W= weight of plant ethanolic extract in g

**Total flavonoid content:** Total flavonoid content was determined colourimetrically using aluminum chloride ($AlCl_3 6H_2O$) solution and quercetin as described by Onwuka (2018). One (1) ml of sample extract was placed in a 10ml volumetric flask containing 5ml of distilled water and 0.3 ml of 5% sodium nitrite was added and mixed. After 5mins, 0.3ml of 10% aluminum chloride solution ($AlCl_3 6H_2O$) was added and the mixture was allowed to stand for another 6 min, after which 2 ml of 1 M sodium hydroxide was added and properly mixed. Absorbance of the mixture was read at 510 nm after 15-30 min, with a spectrophotometer. Quercetin (10-750 µg/ml) was used to plot a standard curve. Total flavonoid content was expressed as milligram quercetin equivalent per gram of sample mg QE/100 ml.

$$\% \text{ flavonoid} = \frac{W_3 - W_2}{W_1} \text{ x } \frac{100}{1}$$

Where: $W_1$= Weight of sample, $W_2$= Weight of empty flask, $W_3$= Weight of flask and residue

**Antioxidant capacity by FRAP assay**

The antioxidant activity by FRAP assay was determined using the modified method of Ruslan *et al.* (2018). FRAP solution was prepared in acetate buffer (pH 3.6). The sample extract (2 ml) was added to 2 mL of FRAP solution. After incubation at 50℃ for 30 min, the absorbance was read using spectrophotometer (Bosch Mode 752N UV/vis, Germany) at 593 nm. Ascorbic acid was used as the standard, FRAP (50 µg/mL) as the control, and acetate buffer as the blank. The antioxidant capacity was presented as $EC_{50}$ of FRAP capacity by determining the 50% exhibitory concentration using the calibration curve.

**Antioxidant activity by DPPH assay**

The antioxidant activity by DPPH assay was determined using the modified method of Ruslan *et al.* (2018). The sample extract (2 ml) was added to 2 mL of DPPH solution (50 µg/mL) to initiate the reaction for obtaining a calibration curve. The absorbance at 515 nm was measured after incubation at 50℃ for 30 min by using an ultraviolet (UV)–Vis spectrophotometer (Beckman Coulter DU 720, China). DPPH (50 µg/mL) was used as the control, ascorbic acid as the standard, and methanol as the blank. Analysis was conducted in duplicate for the standard and the samples. The antioxidant activity was revealed as $IC_{50}$ of DPPH scavenging activity by observing the 50% inhibitory concentration for the sample using the calibration curve.

**Determination of ABTS**

ABTS radical scavenging activity analysis of 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging activity of the yoghurt was conducted using Borrelli *et al*. (2023) method. ABTS+ radical solution was prepared by incubating the mixture of 3 mL of 7 mM ABTS stock solution (Sigma-Aldrich, USA) and 3 mL of 2.45 mM potassium persulfate (EMSURE, Germany) at room temperature for 16 hrs in darkness. The mixture was diluted with

80% ethanol (HmbG Chemical, Malaysia) to obtain absorbance of 0.70±0.005 at 734 nm using UV Vis spectrophotometer (Interscience, Malaysia). A total of 0.3 mL of a series of lotus rhizome extract solution (0.5 to 3.0 mg/mL) was mixed with 2.7 mL of ABTS+ radical solution and incubated for 30 min. The absorbance was measured at 734 nm using UV-Vis spectrophotometer with methanol as blank. The scavenging ability (%) and IC50 values were determined as previously described for DPPH.

**Determination of Chemical Properties of Jam Samples**

**Determination of pH**

The pH of each sample was determined using the method described by Onwuka (2018). The practical Hanna digital pH meter was used. Exactly 3 ml of the sample was measured into a beaker and 30 ml of distilled water was added and then stirred for 2 min. The pH meter was switched on and allowed to equilibrate then it was calibrated using buffer solution 10.01 and then a pH meter electrode was immersed into the sample in the beaker, the pH value was taken directly from the screen.

**Total Titratable Acidity (TTA)**

The total Titratable Acidity level of the jam samples was determined using the alkaline titrimetric method as described by Onwuka (2018). Boiled and cooled water (200ml) was placed into a 500ml Elenmeyer flask and 1ml of phenolphthalene was added as indicator. The water was titrated with 0.1/ NaOH to a definite pink end point. 109ml of each syrup sample was added to the flask. The sample was titrated against dilute alkaline solution (0.1N NaOH) with phenolphthalein as indicator. A pink colour was observed as the end point and the titratable acidity was calculated with the formula below

$$TTA = \frac{100}{W} \times N \times \text{titre}$$

Where: N = normality of titrant, W = Volume of sample used

**Determining of Total Soluble Solids (TSS)**

The total soluble solids of the jam samples were determined using a digital refractometric method described by Onwuka (2018). The refractometer prism was first cleaned and standardized with distilled water at 20 °C to ensure a 0.0 °Brix reading. Each syrup sample was homogenized by gentle inversion, and two to three drops were placed on the prism surface, ensuring complete coverage without bubbles. The lid was closed and the reading was allowed to stabilize, after which the °Brix value was recorded. The prism was cleaned and dried between samples, and three independent readings were obtained for each sample. For samples that were highly viscous, a 1:1 dilution with distilled water was carried out, and the final °Brix was calculated by multiplying the observed reading by the dilution factor. Results were expressed as mean °Brix ± standard deviation.

**Sensory Evaluation**

The method described by Iwe (2014) was used to assess the sensory properties of the jams. The samples were assessed by 20 pre-trained panelists selected from Michael Okpara University of Agriculture, Umudike. The pre-trained panelists were instructed prior to the exercise. All samples were put on different plates and served to the panelists with portable water to rinse their mouths after each testing so as not to interfere with the taste of the preceding samples. Quality attributes such as appearance, taste, texture, mouthfeel and general acceptability of the products were scored on a 9-point hedonic scale. The degree of likeness was expressed as; 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely. Like extremely to like slightly constitute good while dislike slightly to dislike extremely constitutes poor. Neither like nor dislike indicates that the product was neither good nor bad.

**Experimental Design**

The experimental design used for this study was the Complete Randomized Design (CRD).

**Statistical Analysis**

Experimental data were analyzed by one-way analyses of variance (ANOVA) using SPSS version 22 and means were separated using Duncan Multiple Range (DMRT) and Least Significant Difference (LSD) Test at a significant level $p<0.05$. Results were expressed as the means ± standard deviation of two separate determinations.

## RESULTS AND DISCUSSION

**Proximate composition of jam samples from banana, pawpaw and Date syrup blends**

The results of the proximate composition of the jam samples are presented in Table 2. Significant differences ($p<0.05$) were observed among the samples for all parameters assessed. The moisture content of the samples ranged from 28.18 to 42.56%. The highest moisture value (42.56%) was recorded in SAM7 (60% banana: 40% pawpaw: 0% date), while the lowest value (28.18%) was observed in the 100% banana jam sample (SAM1). A progressive increase in moisture was observed as the proportion of pawpaw

increased and date syrup decreased in the blends. This increase may be due to higher free water content of pawpaw compared to the concentrated solids of banana and date syrup. Moisture values in this study were found to be lower than 35 to 55% reported by Adeola and Aworh (2020) for pineapple-pawpaw jams, but similar to 27 to 34% observed by El-Sohaimy *et al*. (2015) in date-based jams. The relatively lower moisture contents, especially in samples such as SAM1 to SAM3, suggest better microbial stability, firmer texture, and longer shelf life, which are desirable for consumer safety and product storability. The protein content of the jam samples ranged from 0.47 to 1.72%. The highest protein value (1.72%) was found in SAM1 (100% banana jam), while the lowest value (0.47%) was obtained in SAM7 (60% banana: 40% pawpaw: 0% date). The decline in protein with increasing pawpaw proportion may be attributable to dilution by higher moisture content of pawpaw fruit. This also suggests that pawpaw may be a poor source of protein when compared to banana and date syrup. Similar low protein ranges (0.26 to 0.69%) were reported by Ayedun *et al*. (2021) for apple-banana jam blends, while higher values (1.5 to 1.9%) have been observed in date-enriched jams due to the nutritive richness of date pulp. Although protein levels are generally low in jams, the higher protein values in banana-rich samples like SAM1 may provide a modest nutritional advantage.

**Table 2: Proximate Composition of the Jam samples produced from banana, pawpaw and Date syrup blends**

| Sample | Moisture (%) | Protein (%) | Fibre (%) | Fat (%) | Ash (%) | CHO (%) | EV (kcal) |
|---|---|---|---|---|---|---|---|
| SAM1 | $28.18^{g}$±0.04 | $1.72^{a}$±0.02 | $2.63^{a}$±0.03 | $0.56^{a}$±0.03 | $1.95^{a}$±0.01 | $64.97^{a}$±0.00 | $271.78^{a}$±0.34 |
| SAM2 | $29.04^{f}$±0.04 | $1.59^{b}$±0.01 | $2.54^{b}$±0.01 | $0.53^{a}$±0.02 | $1.85^{b}$±0.02 | $64.47^{b}$±0.01 | $268.93^{b}$±0.25 |
| SAM3 | $29.46^{e}$±0.05 | $1.42^{c}$±0.02 | $2.51^{b}$±0.01 | $0.46^{b}$±0.01 | $1.77^{c}$±0.02 | $64.40^{c}$±0.02 | $267.38^{c}$±0.13 |
| SAM4 | $31.64^{d}$±0.02 | $1.24^{d}$±0.02 | $2.25^{c}$±0.01 | $0.41^{c}$±0.02 | $1.63^{d}$±0.01 | $62.85^{d}$±0.01 | $259.99^{d}$±0.22 |
| SAM5 | $33.27^{c}$±0.02 | $0.95^{e}$±0.01 | $1.89^{d}$±0.01 | $0.33^{d}$±0.02 | $1.56^{e}$±0.01 | $62.02^{e}$±0.04 | $254.79^{e}$±0.11 |
| SAM6 | $39.23^{b}$±0.03 | $0.78^{f}$±0.01 | $2.04^{e}$±0.02 | $0.25^{e}$±0.01 | $1.48^{f}$±0.02 | $56.24^{f}$±0.01 | $230.27^{f}$±0.02 |
| SAM7 | $42.56^{a}$±0.04 | $0.47^{g}$±0.01 | $1.65^{f}$±0.02 | $0.18^{f}$±0.01 | $1.15^{g}$±0.02 | $54.02^{g}$±0.01 | $219.50^{g}$±0.06 |

Means with different superscripts within the same column are significantly different ($p<0.05$).

**Key:** CHO= Carbohydrate, EV= Energy value, SAM1 = 100% Banana Jam, SAM2 = 30% Banana: 10% Pawpaw: 60% Date Jam blend, SAM3 = 35% Banana: 15% Pawpaw: 50% Date Jam blend, SAM4 = 40% Banana: 20% Pawpaw: 40% Date Jam blend, SAM5 = 45% Banana: 25% Pawpaw: 30% Date Jam blend, SAM6 = 50% Banana: 30% Pawpaw: 20% Date Jam blend, SAM7 = 60% Banana: 40% Pawpaw: 0% Date Jam blend.

The fibre content of the samples ranged from 1.65 to 2.63%. The highest value (2.63%) was recorded in the 100% banana jam, while the lowest value (1.65%) was recorded in SAM7 (60% Banana: 40% Pawpaw: 0% Date Jam blend). Fibre values decreased with increasing pawpaw substitution, which reflects the higher fibre density of banana and concentrated date syrup compared to pawpaw. The fibre content obtained were higher than the <1% reported for clarified strawberry jams (Onwuka *et al*., 2019), but comparable to the 2.0 to 3.5% crude fibre observed in date-banana-based composite jams (El-Sohaimy *et al*., 2015). The relatively higher fibre in samples such as SAM1 to SAM3 suggest that the consumption the jams from these samples may improve digestion and satiety, and may enhance consumer appeal for health-conscious markets.

The fat content of the jam samples ranged from 0.18 to 0.56%, with the highest fat value (0.56%) recorded in the 100% banana jam, although it was not significantly different ($p>0.05$) 0.53% fat content recorded for sample SAM1 (30% Banana: 10% Pawpaw: 60% Date Jam blend), while the lowest fat value (0.18%) was obtained in sample SAM7 (60% Banana: 40% Pawpaw: 0% Date Jam blend). There was a progressive decline in fat content with increasing pawpaw fruit inclusion which suggest that pawpaw may be a poor source of fat when compared to banana and date syrup. The fat values were within the typical range (<1%) reported for most fruit jams (Adeola and Aworh, 2020; Ayedun *et al*., 2021), since fruits are naturally low in fat. This indicates that the jam blends may be considered virtually fat-free, which is advantageous for consumers seeking low-fat products and ensures that the jams retain their fruit-forward sensory qualities without oily aftertaste.

The ash content of the jam samples ranged from 1.15 to 1.95%. The highest ash content was found in the 100% banana jam, while the lowest was observed in SAM7. A decreasing trend in ash was observed as pawpaw proportion increased, reflecting reduced mineral concentration due to higher water content.

According to Arukwe *et al*. (2026), ash content indicates total mineral content of the original food and the low values observed in the blends depict low mineral content in pawpaw fruits compared to banana. The ash values obtained in the present study were found to be lower than 4.30% reported in locust bean pulp jam (Akubor, 2023), but comparable to the 1.2 to 1.9% reported in banana-date jam formulations (El-Sohaimy *et al*., 2015). The relatively high mineral content of the control sample may improve nutritional quality and contribute to essential dietary minerals for consumers.

Similarly, carbohydrate content was observed to progressively decrease with increase in pawpaw fruit inclusion. The carbohydrate content of the jam samples ranged from 54.02 to 64.97%, with the highest value observed in the control sample (SAM1) and the lowest in SAM7 (60% Banana: 40% Pawpaw: 0% Date Jam blend). The observed carbohydrate content decrease with increasing pawpaw substitution may be due to the dilution effect of high moisture content of pawpaw fruit. The carbohydrate range obtained in this study was found to be comparable to 55.24 to 70.62% reported for various commercial jams (Adeola and Aworh, 2020; Ayedun *et al*., 2021). High carbohydrate content is expected in jams, as sugar is the major preservative and energy contributor. The higher carbohydrate level in the control sample may be advantageous for better gelling, and consumer preference for sweetness, while the lower values in blended samples make them suitable as reduced-sugar alternatives for calorie-conscious consumers.

The energy values of the jam samples ranged from 219.50 to 271.78 kcal. The highest energy value was obtained in SAM1, while the lowest was recorded in SAM7. The energy values correspond closely with the carbohydrate levels, since carbohydrates are the main energy source in jams. According to Zain *et al*. (2022), energy levels are a cumulative function of macronutrients primarily carbohydrates, fats, and proteins. This suggests that SAM1 to SAM3 would be energy-dense, appealing to consumers seeking quick energy sources, while SAM6 to SAM7 may be targeted toward consumers requiring lower-calorie options. The energy values were found to be lower than 328.78 kcal reported for locust bean pulp jams (Akubor, 2023), and higher than the 150 to 200 kcal recorded for reduced-calorie jams with sugar replacers (Onwuka *et al*., 2019).

**Chemical properties of Jam produced from banana, pawpaw and Date syrup blends**

The results of the physicochemical properties of the jam samples are presented in Table 3. Significant differences ($p<0.05$) were observed among the samples in terms of pH, titratable acidity (TTA), and total soluble solids (TSS). The pH of the jam samples ranged from 5.08 to 6.47. The highest pH value was recorded in SAM1 (100% banana jam), while the lowest was observed in SAM7 (60% banana: 40% pawpaw: 0% date). A gradual decrease in pH was noted with increasing pawpaw substitution and decreasing date syrup inclusion, reflecting the naturally higher acidity of pawpaw compared to banana and date syrup. The pH values in this study are higher than 3.3 reported for locust bean pulp jam (Akubor, 2023), but comparable to 5.0 to 6.2 observed in tropical fruit jams such as mango, pawpaw, and banana blends (Adeola and Aworh, 2020). The relatively high pH values suggest reduced tartness, a sweeter flavour profile, and a need for careful preservation, since lower acidity typically reduces microbial stability.

The titratable acidity (TTA) of the samples ranged from 0.42 to 0.84%. The highest TTA value was obtained in SAM6 (50% banana: 30% pawpaw: 20% date), while the lowest TTA was recorded in SAM1 (100% banana jam). An increasing trend in acidity was observed as pawpaw substitution increased, which agrees with the naturally acidic nature of pawpaw fruit. The acidity values in this study were found to be lower than 0.8 to 1.2% reported for strawberry and grape jams (El-Sohaimy *et al*., 2015), but similar to 0.45 to 0.90% observed in pawpaw-pineapple jams (Adeola and Aworh, 2020). Higher acidity values in blends such as SAM6 may be desirable for microbial safety and gel formation, while lower acidity in banana-rich jams such as SAM1 and SAM2 may reduce shelf stability unless adequately preserved.

The total soluble solids (TSS) content of the jam samples ranged from 56.17 to 71.83%. The highest TSS value was recorded in the 100% banana jam, while the lowest was observed in SAM7 (40% Banana: 20% Pawpaw: 40% Date Jam blend). A progressive decline in TSS was noted with increasing pawpaw substitution, which is consistent with the lower soluble sugar content of pawpaw compared to the concentrated sugars in date syrup. The TSS values obtained are in line with the 60 to 72°Brix standard recommended for jams and jellies (Codex Alimentarius, 2019). They are also comparable to the 58 to 70% range reported in pineapple to banana jams (Adeola and Aworh, 2020) and higher than the 50 to 60% observed in reduced-sugar formulations (Onwuka *et al*., 2019). High TSS value in the control

sample (100% banana) indicates enhanced sweetness, improved gelling capacity, and better preservation due to reduced water activity, whereas lower TSS values in the pawpaw rich blends (SAM6 to SAM7) may appeal to consumers seeking less-sweet and lower-calorie products.

**Antioxidant properties of jam produced from banana, pawpaw and Date syrup blends**

The results of the antioxidant properties of the jam samples are presented in Table 4. The DPPH radical scavenging activity values ranged from 33.07 to 74.38%. The highest DPPH value was recorded in SAM1 (100% banana jam), while the lowest value was found in SAM7 (60% banana: 40% pawpaw blend). The progressive decline in DPPH activity as banana proportion decreased and pawpaw proportion increased suggests that banana pulp may be a richer source of antioxidant compounds such as dopamine, catecholamines, and phenolic acids compared to pawpaw (Wall, 2020). These results are consistent with those of Adeola and Aworh (2020), who reported DPPH ranges of 35 to 70% in mixed tropical fruit jams, indicating that banana-based jams compare favourably with other fruit spreads in terms of antioxidant capacity. The high scavenging activity of SAM1 and SAM2 highlights the potential of banana and date syrup blends to reduce oxidative stress when consumed regularly.

FRAP values ranged from 2.72 to 6.16 mmol $Fe^{2+}$/g. The highest reducing power was observed in SAM1, while the lowest was in SAM7. The trend shows that date syrup supplementation (SAM2 and SAM3) sustained higher reducing power compared to pawpaw-enriched formulations. This can be attributed to the high concentration of polyphenols and flavonoids present in date syrup, which contribute significantly to ferric ion reduction (Al-Farsi *et al*., 2021). Similar FRAP values (3.0 to 6.8 mmol $Fe^{2+}$/g) were reported in jams formulated with mango and dates (Olawoye *et al*., 2021), indicating that date syrup fortification is an effective way of boosting the reducing potential of jams.

**Table 3: Chemical Properties of Jam Produced from Banana-pawpaw-Date syrup**

| Sample | pH | TTA (%) | TSS (%) |
|---|---|---|---|
| SAM1 | $6.47^{a}$±0.02 | $0.42^{g}$±0.01 | $71.83^{a}$±0.02 |
| SAM2 | $6.25^{b}$±0.02 | $0.52^{f}$±0.02 | $69.32^{b}$±0.01 |
| SAM3 | $6.06^{c}$±0.02 | $0.57^{e}$±0.01 | $67.41^{c}$±0.03 |
| SAM4 | $5.74^{d}$±0.03 | $0.65^{d}$±0.00 | $62.45^{d}$±0.02 |
| SAM5 | $5.34^{e}$±0.04 | $0.76^{c}$±0.01 | $58.06^{e}$±0.02 |
| SAM6 | $5.17^{f}$±0.04 | $0.84^{a}$±0.01 | $57.33^{f}$±0.02 |
| SAM7 | $5.08^{g}$±0.01 | $0.81^{b}$±0.01 | $56.17^{g}$±0.01 |

Means with different superscripts within the same column are significantly different ($p<0.05$).

**Key:** TTA= Total titratable acidity, TSS= Total soluble solids, SAM1 = 100% Banana Jam, SAM2 = 30% Banana: 10% Pawpaw: 60% Date Jam blend, SAM3 = 35% Banana: 15% Pawpaw: 50% Date Jam blend, SAM4 = 40% Banana: 20% Pawpaw: 40% Date Jam blend, SAM5 = 45% Banana: 25% Pawpaw: 30% Date Jam blend, SAM6 = 50% Banana: 30% Pawpaw: 20% Date Jam blend, SAM7 = 60% Banana: 40% Pawpaw: 0% Date Jam blend.

**Table 4: Antioxidant properties of Jam produced from banana-pawpaw-Date syrup**

| Sample | DPPH (%) | FRAP (mmol$Fe^{2+}$/g) | ABTS (mmolTE/g) | TPC (mgGAE/g) | TFC (mgQE/g) |
|---|---|---|---|---|---|
| SAM1 | $74.38^{a}$±0.02 | $6.16^{a}$±0.03 | $9.62^{a}$±0.01 | $2.69^{a}$±0.01 | $1.43^{a}$±0.02 |
| SAM2 | $70.46^{b}$±0.03 | $5.82^{b}$±0.01 | $9.02^{b}$±0.01 | $2.24^{b}$±0.01 | $1.18^{b}$±0.01 |
| SAM3 | $65.62^{c}$±0.01 | $5.46^{c}$±0.02 | $7.47^{c}$±0.01 | $1.93^{c}$±0.02 | $0.65^{c}$±0.02 |
| SAM4 | $53.68^{d}$±0.01 | $4.77^{d}$±0.02 | $6.33^{d}$±0.02 | $1.73^{d}$±0.01 | $0.61^{c}$±0.01 |
| SAM5 | $46.45^{e}$±0.04 | $3.68^{e}$±0.01 | $5.91^{e}$±0.01 | $1.58^{e}$±0.01 | $0.53^{d}$±0.02 |
| SAM6 | $39.13^{f}$±0.02 | $3.12^{f}$±0.01 | $4.23^{f}$±0.03 | $1.22^{f}$±0.00 | $0.45^{e}$±0.03 |
| SAM7 | $33.07^{g}$±0.01 | $2.72^{g}$±0.02 | $3.86^{g}$±0.03 | $0.83^{g}$±0.01 | $0.27^{f}$±0.04 |

Means with different superscripts within the same column are significantly different ($p<0.05$).

**Key:** DPPH = diphenyl-picryl-hydryl, FRAP = ferric reducing power, ABTS = 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), TPC= Total phenolic content, TFC= Total flavonoid content, SAM1 = 100% Banana Jam, SAM2 = 30% Banana: 10% Pawpaw: 60% Date Jam blend, SAM3 = 35% Banana: 15% Pawpaw: 50% Date Jam blend, SAM4 = 40% Banana: 20% Pawpaw: 40% Date Jam blend, SAM5 = 45% Banana: 25% Pawpaw: 30% Date Jam blend, SAM6 = 50% Banana: 30% Pawpaw: 20% Date Jam blend, SAM7 = 60% Banana: 40% Pawpaw: 0% Date Jam blend.

The ABTS values ranged from 3.86 to 9.62 mmolTE/g. The highest ABTS value was found in SAM1, while the lowest value was observed in SAM7. The higher ABTS activity in banana-date-rich formulations could be linked to their abundance of hydrophilic antioxidants such as ascorbic acid and water-soluble polyphenols. Pawpaw inclusion reduced ABTS values, likely due to its lower ascorbic acid content compared to banana and dates. These results are in agreement with Chinedu *et al*. (2020), who observed ABTS values of 4.2 to 9.8 mmol TE/g in mixed tropical fruit jams. The result of this study implies that banana with date jams provide stronger radical scavenging activity, which may protect consumers from oxidative damage.

The total phenol content (TPC) values ranged from 0.83 to 2.69 mgGAE/g. The highest phenolic content was recorded in SAM1 (100% banana jam), while the lowest was found in SAM7 (60% Banana: 40% Pawpaw: 0% Date Jam blend). Banana pulp and date syrup are known for their phenolic compounds such as gallic acid, ferulic acid, and caffeic acid, which contribute to high TPC (Singh *et al*., 2016). The values recorded in this study were comparable to those reported by Onwuka *et al*. (2019), who observed TPC values of 1.0 to 2.8 mg GAE/g in fruit jams enriched with natural sweeteners, but were higher than 0.05 to 0.08 mg/100g reported by Okudu and Umahi (2022) for jam from soursop and pawpaw. Higher TPC levels are nutritionally desirable, as phenolics contribute to anti-inflammatory and anti-aging properties.

There was a progressive decline in total flavonoid content (TFC) of the jam samples with increase in pawpaw fruit inclusion. The TFC values ranged from 0.27 to 1.43 mgQE/g. The highest flavonoid content was observed in SAM1, while the lowest was in SAM7. Flavonoids such as quercetin and rutin in bananas and dates may have accounted for the higher values observed in their blends. The decline in TFC with increased pawpaw proportion suggests that pawpaw is less rich in flavonoids. Similar ranges (0.3 to 1.5 mg QE/g) were reported in papaya to pineapple jams by Adegunwa *et al*. (2019). From a health perspective, flavonoid-rich jams such as SAM1 and SAM2 may offer improved protection against cardiovascular diseases and oxidative stress.

**Sensory evaluation of jam produced from banana, pawpaw and Date syrup blends**

The results of the sensory properties of the jam samples are presented in Table 5. The appearance scores ranged from 4.65 to 7.10. The highest appearance score was recorded in SAM6 (50% banana: 30% pawpaw: 20% date blend), while the lowest score was obtained in SAM7 (60% banana: 40% pawpaw: 0% date blend), though it was not significantly different ($p>0.05$) from the rest of the samples. The relatively high appearance score of samples SAM6 (50% Banana: 30% Pawpaw: 20% Date Jam blend) may be attributed to its balanced fruit blend which gave a visually appealing colour and consistency. These values are consistent with the 4.50 to 7.20 range reported for tropical mixed fruit jams (Adeola and Aworh, 2020). Since appearance often influences consumer purchase intent, sample SAM6 (50% Banana: 30% Pawpaw: 20% Date Jam blend) demonstrates a strong competitive edge.

Taste scores ranged from 4.80 to 7.15. The highest taste score was observed in sample SAM6 (50% Banana: 30% Pawpaw: 20% Date Jam blend), though it was not significantly different ($p>0.05$) from samples SAM2, SAM4, SAM5, while the lowest taste score was observed in SAM7 (60% Banana: 40% Pawpaw: 0% Date Jam blend). The superior taste of SAM6 may be due to the complementary sweetness of banana and date syrup combined with the mild flavour contribution of pawpaw. Conversely, the low taste acceptability of SAM7 suggests that the absence of date syrup reduced palatability. Similar findings were reported by Onwuka *et al*. (2019), where jams containing date syrup or honey scored higher in sweetness and consumer preference than those without.

The aroma scores ranged from 4.65 to 6.15. The highest aroma score (6.15) was found in SAM6, though it was statistically similar ($p>0.5$) to samples SAM1 (5.50), SAM2 (5.20), SAM4 (5.05), and SAM5 (5.45), while the lowest (4.65) was obtained in SAM7. The higher aroma scores in date-supplemented samples reflect the characteristic pleasant flavour compounds in dates, as also highlighted by El-Sohaimy *et al*. (2015). The low aroma perception of SAM7 indicates that pawpaw substitution alone was insufficient to produce a strong aromatic profile.

Mouthfeel scores ranged from 5.85 to 7.20. The highest score was recorded in SAM6, while the lowest was found in SAM3. The smooth texture and balanced consistency of SAM6 likely contributed to its favourable mouthfeel. These values agree with Adegunwa *et al*. (2019), who reported that the inclusion of natural sweeteners like dates improved smoothness and overall creaminess in fruit spreads.

The texture scores ranged from 5.50 to 7.10. The highest texture score was obtained in sample SAM6 (50% Banana: 30% Pawpaw: 20% Date Jam blend), which was statistically similar to 6.40 texture score recorded for SAM5 (45% Banana: 25% Pawpaw: 30%

Date Jam blend), while the lowest (5.50) was recorded in SAM7. A firmer and more uniform texture was observed in SAM6, possibly due to the synergistic pectin content of banana and pawpaw combined with the viscosity-enhancing effect of date syrup. This aligns with Olawoye *et al*. (2021), who found that optimal blends of fruits and natural sweeteners enhanced spread-ability and consistency in jams.

General acceptability (GA) scores ranged from 5.35 to 7.35. The highest GA score was observed in SAM6, while the lowest was obtained in SAM7. Sample SAM6 was most preferred by panelists, reflecting its balance of taste, aroma, appearance, and texture. Conversely, the low GA score for SAM7 suggests that formulations lacking date syrup may be less appealing to consumers. These findings are similar to those of Adeola and Aworh (2020), who reported higher consumer preference for fruit jams enriched with natural sweeteners.

**Table 5: Sensory Evaluation of Jam produced from banana-pawpaw-Date syrup blends**

| Sample | Appearance | Taste | Aroma | Mouthfeel | Texture | GA |
|---|---|---|---|---|---|---|
| SAM1 | $4.85^{b}$±1.50 | $6.80^{a}$±1.36 | $5.50^{ab}$±1.57 | $6.25^{b}$±1.89 | $6.15^{b}$±1.14 | $6.45^{c}$±1.10 |
| SAM2 | $4.80^{b}$±1.32 | $6.40^{a}$±1.27 | $5.20^{ab}$±1.28 | $5.95^{b}$±1.67 | $5.65^{b}$±0.99 | $6.15^{d}$±1.60 |
| SAM3 | $5.50^{b}$±1.85 | $5.45^{b}$±1,54 | $4.90^{b}$±1.62 | $5.85^{b}$±1.18 | $6.10^{b}$±1.45 | $6.00^{d}$±0.79 |
| SAM4 | $5.10^{b}$±1.12 | $6.65^{a}$±1.31 | $5.05^{ab}$±2.16 | $6.40^{ab}$±1.05 | $5.95^{b}$±1.50 | $6.35^{c}$±1.23 |
| SAM5 | $5.50^{b}$±1.19 | $6.65^{a}$±1.35 | $5.45^{ab}$±0.76 | $6.60^{ab}$±1.27 | $6.40^{ab}$±1.23 | $6.70^{b}$±1.22 |
| SAM6 | $7.10^{a}$±1.07 | $7.15^{a}$±1.39 | $6.15^{a}$±1.90 | $7.20^{a}$±1.20 | $7.10^{a}$±1.94 | $7.35^{a}$±1.39 |
| SAM7 | $4.65^{b}$±1.95 | $4.80^{b}$±1.06 | $4.65^{b}$±1.53 | $6.00^{b}$±1.17 | $5.50^{b}$±1.50 | $5.35^{d}$±1.73 |

Means with different superscripts within the same column are significantly different ($p<0.05$).

Key: GA= General acceptability, SAM1 = 100% Banana Jam, SAM2 = 30% Banana: 10% Pawpaw: 60% Date Jam blend, SAM3 = 35% Banana: 15% Pawpaw: 50% Date Jam blend, SAM4 = 40% Banana: 20% Pawpaw: 40% Date Jam blend, SAM5 = 45% Banana: 25% Pawpaw: 30% Date Jam blend, SAM6 = 50% Banana: 30% Pawpaw: 20% Date Jam blend, SAM7 = 60% Banana: 40% Pawpaw: 0% Date Jam blend.

## CONCLUSION

The results revealed that the proximate composition of the samples was significantly influenced by the blending ratios. Banana- and date-based formulations showed higher moisture and carbohydrate content, while pawpaw inclusion increased crude fibre and ash content. These variations indicate that the nutrient density of jam can be tailored depending on the fruit proportions used, thereby meeting diverse consumer nutritional needs.

The physicochemical parameters demonstrated that increasing pawpaw content led to lower pH and total soluble solids but higher titratable acidity, while date syrup contributed to elevated soluble solids and moderated acidity. This highlights the critical role of fruit balance in achieving the ideal physicochemical stability and shelf quality of jams.

Antioxidant evaluation showed that 100% banana jam (SAM1) exhibited the highest DPPH, FRAP, ABTS, TPC, and TFC values, followed closely by banana to date blends (SAM2). Pawpaw-rich blends, especially without date syrup (SAM7), had the lowest antioxidant potential. These findings underscore the functional benefit of banana and date syrup as superior sources of bioactive compounds, positioning such blends as promising functional spreads capable of conferring health-promoting properties against oxidative stress.

The sensory assessment revealed that the most acceptable formulation was SAM6 (50% banana: 30% pawpaw: 20% date syrup), which achieved the highest ratings for appearance, taste, aroma, mouthfeel, texture, and general acceptability. Conversely, pawpaw-only formulations without date syrup (SAM7) scored lowest in most sensory attributes, indicating limited consumer appeal. The results emphasize the importance of date syrup not only as a natural sweetener but also as a flavour and texture enhancer in jam formulation.

The findings demonstrate that jams formulated with a balanced proportion of banana, pawpaw, and date syrup (particularly the 50% banana: 30% pawpaw: 20% date syrup formulation (SAM6)) provided a desirable combination of nutritional quality, antioxidant potential, and consumer acceptability and is therefore recommended.

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