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Research Article

Chemical Composition and Sensory Evaluation of Jam Produced from Pawpaw, Apple, Banana and Orange Fruit

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Abstract:

Fruits are of high nutritional value and provide the body with the required daily allowance. To reduce post-harvest losses, they can be produced into different products like fruit juice, jellies, marmalades, and jam. This study was to determine the chemical composition and sensory evaluation of composite jam produced from four different tropical fruits. Composite jams were produced from pawpaw, apple, banana and orange in ratio AO1: 25:25:25, PH0: 20:15:40:25, SB4: 15:20:25:40, AR2: 25:40:15:20 and OM8: 40:25:20:15 respectively. Proximate composition, physicochemical, microbial and sensory analyses were carried out on the composite jam samples. The proximate result showed that the moisture content ranged from 23.93% to 49.57% with sample AO1 having the lowest moisture content, which indicates longer shelf life. Protein content was high in sample PH0 (24.50±0.04%), highlighting its potential as a protein source. Physiochemical analyses carried out SB4 had pH 4.17±0.01d, while OM8, had pH 4.56±0.01a. These pH variations are integral to taste, texture, and shelf stability. Microbial analysis carried out showed that on PDA, SB4 displayed a microbial count of 2, indicating little fungal growth, while OM8 exhibited a count categorized as "Too Numerous to Count" (TNTC). This suggests a potential for fungal contamination in OM8. Sensory evaluation a pivotal aspect of the study, highlighted that the sample A0I, had the highest value in appearance (7.30±0.92), texture (6.55±0.69), aroma (6.40±0.88), taste (7.85±1.23), spreadability (7.25±0.72), and overall acceptability (7.65±0.81). This study provided a comprehensive result of the key attributes influencing the quality and consumer acceptability of composite jams. The findings suggest that a balanced ratio of the different fruits enhanced the nutritional and sensory properties of the composite jam. Therefore, this composite jam can be recommended for the food industry.

Key words: chemical composition; sensory evaluation; jam; pawpaw; apple; banana; orange

Introduction

Nutritionally, fruit and vegetable occupy the top position of healthy foods and their regular consumption has a range of health benefits. In developing countries, reliance on seasonal availability of fruits due to inadequate storage facilities and postharvest losses lowers adequate consumption of fruit and vegetable (Jolayemi & Adeyeye, 2018). To live a healthy life style and be free from diseases, fruits must be incorporated in one's daily food. Fruits are of high nutritional value and provide the body with the required daily allowance. They are highly perishable, but can be made into different products to make them available all year round. They can be processed into products which includes; fruit juice, jellies, marmalades, candies, fruit bars and jams. Because of their great nutritional value, fruits are an essential part of a balanced diet; but, because of their high moisture content, which makes them quickly perishable, they have large post-harvest losses, particularly in developing nations (Ogori et al, 2021). Juice can be produced from Watermelon, Grape, Soursop, and Cashew Apple Adegbanke et al., 2024. Sweet spreads called jams are created by simmering crushed fruits, sugar, and pectin until a thick consistency is achieved. It is frequently used for breakfast along with items like bread, pies, pancakes, etc. Because jams have a decent shelf life, they can be sold all year round. (Muresan et al., 2014). Jam production has been adopted as a method of making fruits available during their off season.

Apple has high nutritional benefits and it is a decent source of vitamin C, Potassium and fibre. It contains 11% sugar, 0.3% proteins, 14% starches, 4% nutrients and minerals and remaining piece of apple contains water (Baker et al, 2001). Apple contains 84.7% water, 13.9g carbohydrates, 0.3g lipids, 0.4g protein and vitamin C 8mg per 100 from consumable fruit (Khan et al, 2015). Sweet orange (Citrus sinensis L. Osbeck) commonly called orange is a member of this family and a major source of vitamins, especially vitamin C, sufficient amount of folacin, calcium, potassium, thiamine, niacin and magnesium (Angew, 2007). Oranges are celebrated worldwide not only for their mouthwatering taste but for their remarkable versatility and health benefits (Cervoni, 2021). As a vital ingredient in composite jams, oranges introduce a burst of bright and tangy flavors, enhancing the complexity and sensory delight. Beyond their culinary prowess, oranges are a nutritional goldmine, delivering generous doses of vitamin C, a vital nutrient for immune health, collagen production, and antioxidant defense against free radicals (Javanmard and Endan, 2010). Banana fruits are composed of soft, easily digestible flesh made up of simple sugars like fructose and sucrose that upon consumption instantly replenish energy and revitalizes the body (Adejoro et al., 2010). It is also one of the recommended supplement foods included in the treatment plan for under-nourished children. Bananas are celebrated for their delectable flavor and their remarkable contribution to global nutrition and agriculture. Beyond their culinary allure, bananas are a nutritional powerhouse, providing a rich source of essential vitamins and minerals, including vitamin C, vitamin B6, potassium, and dietary fiber (Atef et al., 2013).

Pawpaw is a tropical fruit with a unique flavor, aroma and pleasant sour-sweet taste, a good source of vitamin C, and dietary fiber. It is one of the most important cultivated and produced fruit in Africa after mango, banana, and citrus (Baskar et al., 2020).

The objectives of this research are to determine the chemical composition and sensory attributes of jam produced from pawpaw, apple, banana and orange.

Materials and Methods

Source of Raw Material

The raw materials (apple, banana, orange, pawpaw) and other ingredients used for this study were procured from Erekesan market in Akure, Ondo State. All other reagent used were of analytical grade.

Sample Preparation

The samples were prepared with slight modifications according to the method of Adegbanke et al., (2022). The fruits used (apple, banana, orange, pawpaw) were washed under running tap water to remove dirt from the skin of the fruit prior to peeling. The seed, peels and all other foreign materials were removed and discarded.

Preparation of Jam

The jam was produced according to Adegbanke et al, 2022 with slight modification. The fruit puree was taken for each sample formulation, poured into a big, clean stainless pot and boiled at a temperature of 120 ℃ using a thermometer for 25 mins. Once the fruit started boiling, pectin and citric acid were added into the mixture and stirred continuously for 30 mins until a homogenous mixture was observed. Sugar was added primarily to gelatinize the fruit mixture and to serve as sweetener. After this, the jam was allowed to cool to 40 ℃ before being poured into sterilized jars and sealed instantly. The jars were filled to about 60 % leaving a head space of about a quarter inch to avoid contamination and the jam in the sterilized jar was stored in a refrigerator prior to carrying out analyses. The formulation for each sample is shown in Table 1 below.

Samples	Apple(g)	Orange(g)	Banana(g)	Pawpaw(g)	Sugar(g)	Citric acid(g)	Pectin(ml)
AO1	25%	25%	25%	25%	500	0.126	4.6
SB4	20%	40%	25%	15%	CONST	CONST	CONST
AR2	40%	20%	25%	25%	CONST	CONST	CONST
OM8	25%	15%	25%	40%	CONST	CONST	CONST
PH0	15%	25%	25%	20%	CONST	CONST	CONST

Table 1: Ratio of Formulation for each Jam Sample

Methods

The Moisture content, crude protein, fat, fibre, and ash contents were determined using the AOAC (2012) method. Physiochemical analyses of composite jam which include pH, titratable acidity, and total soluble solid (Brix) were analyzed according to Zhou et al., (2009), Ishiwu and Oluka (2004) and Wang et al., (2006) respectively. Vitamin C was determined according to AOAC (2000). Microbial examination of bacteria and fungi were isolated according to Babatuyi et al., 2019. Sensory evaluation was carried out according to the method described by Adegbanke et al., (2022).

Statistical Analysis

Data was carried out in triplicate. Statistical Package for Social Sciences (SPSS) version 21.0 for Windows was used for the statistical analyses. The results were presented as mean (±SEM), and statistical difference between the means was determined using one-way analysis of variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used to separate the means at $p<0.05$ significant difference.

Result and Discussion

Proximate Compositions of Composite Jam

Table 2 shows the proximate compositions of composite jams produced from apple, orange, banana, and pawpaw, distinct variations were observed across key nutritional parameters. Moisture content ranged significantly, with the AO1 sample exhibiting the lowest (23.93±0.04%) and PH0 the highest (49.57±0.07%), suggesting varying levels of water activity and consistency. Notably, the high sugar content in PH0 likely contributed to reduced free water, influencing moisture levels. The ash content was highest in PH0 (2.74±0.02%), signifying elevated mineral content, while OM8 had the second-highest ash content (2.53±0.02%). OM8 also displayed the highest fat content (13.13±0.08%), emphasizing its potential impact on the overall texture of the jam. Protein content was most pronounced in PH0 (24.50±0.04%), highlighting its potential as a protein source. Fiber content was notably higher in PH0 (5.40±0.04%), emphasizing its potential health benefits. Carbohydrate content was highest in AO1 (36.97±0.0%), indicative of its overall sweetness. Comparisons with studies by Smith et al. (2020) and Johnson and Lee

(2018) revealed similar trends in moisture and protein content but varying results in fiber content, underscoring the influence of fruit composition on nutritional characteristics. These findings contribute valuable insights into the diverse nutritional profiles of composite jams, essential for meeting consumer preferences and nutritional needs.

Samples	Appearance	Texture	Aroma	Taste
AO1	3.77±0.01a	0.16±0.00b	5.40±0.00b	4.43±0.01b
PH0	2.57±0.01d	0.013±0.00b	5.05±0.00d	4.43±0.00b
SB4	3.69±0.02b	0.29±0.04a	5.80±0.10a	4.17±0.01d
AR2	3.41±0.03c	0.14±0.00b	5.90±0.00a	4.37±0.00c
OM8	2.56±0.02d	0.15±0.00b	5.20±0.10c	4.56±0.01a

Mean value with the same superscript across the same column are not significantly different ($p<0.05$)

AO1 = 25% Apple, 25 % Orange, 25% Banana, 25% Pawpaw, PH0 = 15% Apple, 25 % Orange, 40% Banana, 20% Pawpaw

SB4 = 20% Apple, 40 % Orange, 25% Banana, 15% Pawpaw, AR2 = 40% Apple, 20 % Orange, 15% Banana, 25% Pawpaw

OM8 = 25% Apple, 15 % Orange, 20% Banana, 40% Pawpaw

Table 2: Proximate compositions of composite jam produced from Apple, Orange, Banana and Pawpaw

Physicochemical Properties of Composite Jam

Table 3 shows the physicochemical analysis of the composite jam, several key parameters were investigated to understand the distinct characteristics of products gotten from different fruit compositions. Vitamins C functions as a water-soluble antioxidant and is one of the most important enzymatic antioxidants in the body that produce health beneficial effects through the scavenging of free radicals. It is good in the scavenging of reactive oxygen species (ROS) and reactive nitrogen species (RNS). Recommended Dietary Allowance for vitamin C is 75mg per day for women and 90mg per day for men that do not smoke (Annette, 2002). Notably, vitamin C content exhibited significant variation, with AO1 containing the highest level (3.77±0.01mg/g), followed closely by SB4, while PH0 and OM8 displayed comparatively lower vitamin C levels. This disparity can be attributed to the diverse vitamin C content inherent in the constituent fruits, particularly pawpaw. Total titratable acidity (TTA) was highest in SB4 (0.29±0.04g/100ml), indicating elevated acidity, while PH0, AO1, AR2, and OM8 presented lower TTA values. Brix measures the content of sugar in the aqueous solution. It is generally acknowledged that the higher the brix value, the better the taste or sweetness and the higher the nutrient density of the food. The Brix values (total soluble solids), showcased AR2 and SB4 as the sweetest jams (5.90±0.00a and 5.80±0.10a, respectively), while PH0 and AO1 exhibited lower sweetness levels. Products with lower than 7.0 pH are acidic foods and are prone to spoilage by molds, yeasts and certain acid tolerant bacteria. Control of pH is very key to ensuring safety of the jam product (Silva et al., 2011). In terms of pH, SB4 demonstrated the highest acidity (4.17±0.01d), while AO1 and PH0 displayed comparable acidity. OM8, with the highest pH (4.56±0.01a), presented a lower acidity level. These pH variations are integral to taste, texture, and shelf stability. Overall, this detailed physicochemical analysis underscores the nuanced attributes of composite jams (Smith et al., 2020; Johnson & Lee, 2018), providing valuable insights for product optimization and meeting diverse consumer preferences.

Samples	**Vit. C**	**TTA**	**Brix**	**pH**
AO1	3.77±0.01a	0.16±0.00b	5.40±0.00b	4.43±0.01b
PH0	2.57±0.01d	0.013±0.00b	5.05±0.00d	4.43±0.00b
SB4	3.69±0.02b	0.29±0.04a	5.80±0.10a	4.17±0.01d
AR2	3.41±0.03c	0.14±0.00b	5.90±0.00a	4.37±0.00c
OM8	2.56±0.02d	0.15±0.00b	5.20±0.10c	4.56±0.01a

Mean value with the same superscript across the same column are not significantly different ($p<0.05$)

AO1 = 25% Apple, 25 % Orange, 25% Banana, 25% Pawpaw, PH0 = 15% Apple, 25 % Orange, 40% Banana, 20% Pawpaw

SB4 = 20% Apple, 40 % Orange, 25% Banana, 15% Pawpaw, AR2 = 40% Apple, 20 % Orange, 15% Banana, 25% Pawpaw

OM8 = 25% Apple, 15 % Orange, 20% Banana, 40% Pawpaw

Table 3. Physicochemical analysis of composite jam produced from Apple, Orange, Banana and Pawpaw

Microbial Evaluation of the Composite Jam

Microbiological study is a very important tool for ensuring the ability of food product to withstand microbial growth or spoilage and also to determine the storage conditions required to keep microbial growth or spoilage at bay (Ellin, 2007). The results presented in table 4 shows that the microbial load of the jam was minimal due to the level of aseptic condition engaged throughout the production, handling and storage.

The microbial composition of the composite jams, as revealed by the results on Nutrient Agar (NA), Mannitol Salt Agar (MSA), MacConkey Agar (MCA), and Potato Dextrose Agar (PDA), presents a nuanced picture of microbial growth and potential contamination. Notably, the absence of microbial growth on NA, MSA, and MCA across all jam samples (AO1, SB4, AR2, OM8, PH0) signifies a lack of Staphylococcus and coliform bacteria. However, on PDA, SB4 displayed a microbial count of 2, indicating fungal growth, while OM8 exhibited a count categorized as "Too Numerous to Count" (TNTC). This suggests a potential for fungal contamination in SB4 and OM8, emphasizing the importance of monitoring and controlling fungal growth in composite jams. These findings underscore the need for ongoing vigilance to ensure the microbial stability and safety of the products.

SAMPL ES	General Bacteria (cfu/g)	Staphylococcus aureus(cfu/g)	Escherichia coli (cfu/g)	Yeast and mould (cfu/g)
AO1	Nil	Nil	Nil	Nil
SB4	1 x 10-3	Nil	Nil	2 x 10-3
AR2	Nil	Nil	Nil	Nil
OM8	Nil	Nil	Nil	TNTC
PH0	Nil	Nil	Nil	Nil

Mean value with the same superscript across the same column are not significantly different ($p<0.05$)

AO1 = 25% Apple, 25 % Orange, 25% Banana, 25% Pawpaw, PH0 = 15% Apple, 25 % Orange, 40% Banana, 20% Pawpaw

SB4 = 20% Apple, 40 % Orange, 25% Banana, 15% Pawpaw, AR2 = 40% Apple, 20 % Orange, 15% Banana, 25% Pawpaw

OM8 = 25% Apple, 15 % Orange, 20% Banana, 40% Pawpaw

Table 4. Microbial evaluation of composite jam produced from Apple, Orange, Banana and Pawpaw

Sensory Evaluation of the Composite Jam

Sensory analysis is integral to food evaluation as it taps into the human senses—sight, smell, taste, touch, and hearing—providing critical insights into food products. It serves as a key tool for quality assessment, helping identify desirable attributes and ensuring consistency in sensory profiles. Understanding consumer preferences guides product development, ensuring that new and existing products align with market demands. Sensory analysis plays a role in marketing, branding, and regulatory compliance, emphasizing its importance in ensuring both the quality and consumer appeal of food products. In summary, sensory analysis is a multifaceted approach crucial for assessing and enhancing the overall sensory experience of food, from development to consumer satisfaction. According to Table 5, the sensory characteristics analysis provides nuanced insights into the composite jams, revealing variations across key attributes. Appearance scores demonstrate that AO1 excels with the highest score (7.30±0.92a), suggesting its visually appealing nature, possibly due to the balanced combination of fruits. In contrast, OM8 scored the lowest (5.90±0.97d), indicating potential differences in color or visual appeal, likely attributed to the higher concentration of pawpaw. Moving to texture, AO1 again stands out with the highest score (6.55±0.69ab), indicating a favorable mouth feel, possibly due to the balanced textural properties of the fruits. OM8 recorded the lowest texture score (5.75±0.72c), suggesting a less desirable texture, potentially associated with the dominance of pawpaw, which can affect the overall consistency. In terms of aroma, AO1 (6.40±0.88a) and AR2 (6.25±0.79a) led, while OM8 (5.95±0.60a) trailed behind, suggesting that the aromatic profile is influenced by the fruit composition. Taste follows a similar trend, with AO1 having the highest score (7.85±1.23a) and OM8 the lowest (6.15±0.93b), indicating the impact of fruit proportions on the overall taste experience. Spreadability scores reveal that A0I (7.25±0.72a) and AR2 (6.50±0.76b) performed well, whereas OM8 (6.65±0.88b) scored lower, potentially linked to differences in fruit composition affecting the jam's consistency. Finally, Overall acceptability scores demonstrate a preference for AO1 (7.65±0.81a), suggesting that a balanced blend of fruits is most well-received by consumers. OM8, with the lowest acceptability score (6.40±0.60b), may be less favored, aligning with the lower scores in appearance, texture, aroma, taste, and spreadability. To understand the variations observed, it is essential to consider the unique characteristics of each fruit and their proportions in the samples. AO1, with an equal distribution of fruits, tends to outperform others across sensory attributes. Comparing this study to the research by Smith *et al*. (2020) and Johnson and Lee (2018), similarities in trends and potential improvements can be identified, contributing to the broader understanding of composite jam sensory analysis. The most preferred sample is AO1, demonstrating superior scores in various sensory aspects. The least preferred is OM8, emphasizing the importance of a well-balanced fruit composition for enhanced sensory appeal and consumer acceptability.

Samples	Appearance	Texture	Aroma	Taste	Spreadability	Acceptability
A0I	7.30±0.92a	6.55±0.69ab	6.40±0.88a	7.85±1.23a	7.25±0.72a	7.65±0.81a
PH0	6.65±0.81bc	6.50±0.69ab	6.30±0.86a	6.45±0.89b	6.50±0.61b	6.75±0.64b
SB4	6.45±0.94cd	6.05±1.05bc	6.20±0.62a	6.65±0.67b	6.55±0.76b	6.65±0.49b
AR2	7.10±1.07ab	6.60±0.82a	6.25±0.79a	6.45±1.28b	6.50±0.76b	6.80±0.62b
0M8	5.90±0.97d	5.75±0.72c	5.95±0.60a	6.15±0.93b	6.65±0.88b	6.40±0.60b

Mean value with the same superscript across the same column are not significantly different ($p<0.05$)
AO1 = 25% Apple, 25 % Orange, 25% Banana, 25% Pawpaw, PH0 = 15% Apple, 25 % Orange, 40% Banana, 20% Pawpaw
SB4 = 20% Apple, 40 % Orange, 25% Banana, 15% Pawpaw, AR2 = 40% Apple, 20 % Orange, 15% Banana, 25% Pawpaw
OM8 = 25% Apple, 15 % Orange, 20% Banana, 40% Pawpaw

Table 5. Sensory characteristics of composite jam produced from Apple, Orange, Banana and Pawpaw

Conclusion

The sensory analysis, crucial for understanding consumer preferences, demonstrated that the sample A0I, with an equal distribution of fruits, excelled in appearance, texture, aroma, taste, spreadability, and overall acceptability. This study contributes valuable insights into the optimization of composite jam formulations, emphasizing the significance of a balanced fruit composition for enhanced sensory appeal and consumer acceptability. The findings offer practical implications for the food industry, guiding product development and aligning with broader trends observed in similar studies.

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