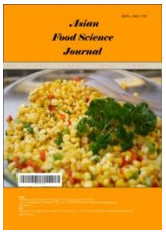

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Physicochemical, Anti-Oxidant and Sensory Characteristics of Spiced Jam from Blends of Selected Tropical Fruits

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Authors' contributions

This work was carried out in collaboration among all authors. Author OAA conceptualization, supervision, methodology, data collation, writing the original draft and editing. Author AOA conceptualization, supervision, writing the review and editing. Author OOE sensory analysis and editing All authors read and approved the final manuscript.

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ABSTRACT

Jams are preserved fruits and sugars which are packaged in cans or bottles for long-term preservation. The processing involves the disruption of the fruit tissue followed by heating with water and sugar to activate the pectin prior being put into containers. Jams were processed from two selected tropical fruits namely, pineapple and watermelon. The jam produced was spiced with ginger and turmeric at 5% level using a standard methods. The treatments are WA (watermelon 100%), WAG (watermelon 95% + ginger 5%), WAT (Watermelon 95% + turmeric 5%), WAGT (watermelon 95% + ginger 5% + turmeric 5%), PI (pineapple 100%), PIG (pineapple 95 % + ginger 5%), PIT (pineapple 95% + turmeric 5%) and PIGT (pineapple 95% + ginger 5% + 5% turmeric). The proximate, physiochemical, antioxidant, total phenolic, color and sensory characteristics of the spiced jams were determined using standard analytical procedures. The proximate result showed that the moisture content of the samples ranged from 3.61-20.55% for Watermelon jam (WA) and reference sample (CNTP); protein 0.50-5.16% for (CNTP) and watermelon-ginger jam (WAG); fat

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and ash contents were 0.21-2.55% and 0.38-1.53% for (CNTP) and pineapple jam (PI) respectively. The pH of the spiced jam ranged from 3.10-3.40 for (CNTP) and (WAG) while the sugar brix ranged from 69.80-79.50° brix. The titratable acidity of the samples ranged from 1.03-1.06 g/ml for pineapple-turmeric jam (PIT) and (CNTP).The TSS/TTA ratio was 52.88 and 5.39 for (CNTP) and (WA) respectively. The antioxidant properties of the sample ranged between 31.39-50.67% for (WA) and (PIG). Total phenolic content was 0.14-0.25 MM GAE/ 100 ml for watermelon jam (WA) and (PIT). The L*, a* and b* values for the samples ranged from 23.23-33.16, 1.05-6.69 and 3.35-13.55. The result for sensory scores of the spiced jams ranged from 5.66-7.98 and 6.20-7.88 for color and taste respectively while the mouth feel was 5.05-7.46. The overall acceptability scores ranged from 6.40-7.90. Conclusively, pineapple and watermelon jams spiced with ginger and turmeric were nutritious and acceptable, however, pineapple-ginger jam was most nutritious and acceptable, hence, pineapple-ginger jam can be utilized as a functional food and can also contribute to the improvement of Nigeria food composition database.

Keywords: Jams; spiced; physicochemical; antioxidant; total phenolic.

1. INTRODUCTION

Many consumed fruits in Nigeria are usually surplus in their various seasons as more than fifty percent are lost as a result of the perishable nature of fruits which are occasioned by high moisture content, poor post-harvest processing and marketing policies [1]. Transformation of fruits into juices, jams and chutneys have reduced post-harvest spoilage of fruits and this has formed the basis for lucrative added value chains for fruits in countries like the Caribbean and the Africa [2]. Many tropical fruits have been processed to develop various products which have gained global relevance over a period of time due to their characteristic exotic aroma and color [3]. Many of these fruits which are readily available for utilization and processing include orange, grape, pineapple, banana, guava and watermelon. The utilization of these fruits depends on the intended finished product which may be juice, drink and jam. Fruits exhibit high antioxidant capability as they often serve as scavengers of free radicals in the body system, thereby preventing oxidative damage in the body (Hussein et al., 2016). The attention of many scientists has been focused on the roles of oxidative stress in the development of many diseases. Free radicals generation is considered to be the main cause of oxidative stress, which subsequently leads to damage of lipids, proteins and nucleic acids and this has been reported to have resulted in the development of many degenerative diseases, such as cardiovascular and nervous system disorders and immune system malfunction, hence antioxidants, which can inhibit or delay substance oxidation in the body system could be important for prevention of these degenerated diseases [4,5,6,7]. Watermelon (*Citrullus lanatus*) is a popular staple summer fruit in the world which is consumed frequently as a dessert, fruit salad and used in garnishing drinks as it is a natural and good source of antioxidants [8]. Watermelon is a good source of carotenoid lycopene and a good source of phenolic antioxidants and it contains cucurbitacin E, a triterpene anti-inflammatory phytonutrient and good amounts of the amino acid citrulline [9]. Water melon has been reported by researchers to be an excellent source of immune-supportive vitamin C and vitamin A, potassium and magnesium, carbohydrates, sugar, soluble and insoluble fiber, sodium, vitamins, minerals, fatty acids, amino acids [10,11] (Dimitrovski et al., 2010).

Pineapple (*Ananas comosus* L.) is a fruit that belongs to the Bromeliaceae family and the fruit is cultivated in many tropical and subtropical countries [12]. Pineapple has widely been processed to various nutritious food products such as jam, jelly, juice. It is a rich source of vitamin A, B, and C as well as calcium, phosphorous, and iron. The bioactivity nature of this fruit is due to the occurrence of compounds such as polyphenols and ascorbic acid, flavonoids, phenolic compounds such as quercetin, flavones-3-ol, flavones, *p*-coumaric acid and ferulic acid which has been found to significantly contribute to the antioxidant activity of the fruit [13,14,13,15]. Jam is a semi-solid food product that is obtained when fruits or vegetables pulp were coked with sugar, citric acid and pectin. It can also be defined as an intermediate moisture food made by boiling sugar with fruit pulp, pectin, acid and other ingredients to a reasonable consistency. The low cost, all year round availability and sensorial properties has made jams to be a popular and demanding food product by all ages (Gakowska et al., 2013).

Traditionally, jam was produced as an effort to preserve fruits during the off-season for consumption and it must consist a total soluble content of 45 °Brix and at least 40% fruit content.

To our knowledge, the nutritional and antioxidant contents of fruit jam spiced with ginger and turmeric pulp consumed in Nigeria are not yet researched hence, the aim of this work was to produce jam from watermelon and pineapple spiced with ginger and turmeric and determine its proximate, physicochemical, antioxidant and sensory characteristics.

2. MATERIALS AND METHODS

2.1 Source and Collection of Samples

Healthy and ripened watermelon and pineapple fruits with uniform and regular size, shape, and maturity used in this experiment were purchased from a local market in Saki Oyo State, Nigeria. The ginger and turmeric used were obtained from a local dealer in the same market. Sugars, flavor, pectin and citric acid were gotten from a local supermarket in Ibadan. All these materials were transported to the Department of Food Science and Technology Laboratory, The Oke-Ogun Polytechnic Saki, Nigeria for further processing.

2.2 Ginger and Turmeric Rhizome Juice Preparation

Freshly harvested ginger and turmeric rhizomes were washed and cleaned by removing all the dirt and impurities using potable water. After peeling, the ginger, turmeric and rhizomes were cut into small pieces for the extraction of juice with the aid of juice extractor. The obtained juice was then filtered through muslin cloth to obtain clear juice of ginger and tumeric.

2.3 Preparation of Jam

A slightly modified method described by Adepoju et al. [16] was adopted for this determination. The fruits were rinsed with potable water to eliminate any form of contaminant. It was then cut and manually peeled. They are immediately packaged and frozen (-1 ℃) until further processing into jam. The thoroughly washed, peeled fruits were separately blended in a blender (SUMEET FOOD PROCESSOR, MODEL A). Jams were prepared conditions under ambient temperature in laboratory. The jam formulation was 1000 g fruits, 400 g sucrose, 13 g methoxyl pectin (Danisco Ingredients, Denmark) and 3 g citric acid. Citric acid was used for adjusting pH values for proper pectin gelatinisation (pH necessary for gelatinization was 2.8-3.3). Fruit blended with larger part of sucrose, citric acid, ginger and turmeric juice at 5% level were thoroughly mixed and thermally heated at 75°C for 15 min. Pectin was mixed with part of sucrose and added at the final stage of the jam processing. Fruit jams were cooked until 68° brix of the final product was achieved. When the processed mass reached 68° Brix, the jams were filled into hot glass jars, capped and pasteurized at 80°C for 10 min. They were allowed to cool at ambient temperature and stored in the dark at 20 ℃ until analysis. The blending ratio of the fruits and the spices is shown in Table 1.

Table 1. Watermelon-pineapple-ginger-tumeric jam blends formulation

Samples	Watermelon	Pineapple	Ginger	Tumeric
WA	100	-	-	-
WAG	95	-	5	-
WAT	95	-	-	5
WAGT	95	-	5	5
PI	-	100	-	-
PIG	-	95	5	-
PIT	-	95	-	5
PIGT	-	95	5	5

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
AGT- Watermelon-ginger-tumeric jam;
PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam

The amount of sugar to be added to the jam to attain the desired ^{o}Brix of 68 was calculated as:

$$\text{Weight of sugar} = \frac{\text{Brix of product} - \text{Brix of fruit}}{100} \times \text{weight of pulp}$$

2.4 Chemical Analysis

2.4.1 Proximate composition

2.4.1.1 Dry matter and moisture content

About 2 ml of each sample was measured into a previously weighed crucible, dried over water for 5 min. The crucible plus sample taken was transferred into the oven set at 1000℃ to dry to a content weight for 24 h. After this, the crucible plus sample was removed from the oven and transfer to the desiccator, cooled for ten minutes and weighed [17]. The weight of empty crucible is W_0; the crucible plus sample was W_1while the weight of crucible plus oven dried sample was W_3.

$$\% \text{ dry matter (DM)} = \frac{W3 - WO}{W1 - WO} \times 100$$

$$\% \text{ Moisture} = \frac{W1 - W3}{W1 - W0} \times 100$$

% Moisture content = 100 - % DM

2.5 Fat Content

AOAC method [17] was used for the analysis of fat content. Clean and dried thimble was weighed (W_1) and 5 g oven dried sample was added and re-weighed (W_2). Round bottom flask was filled with petroleum up to three-quarter of the flask. Soxhlet extractor was connected with a flux condenser to adjust the heat sources so that the solvent boils gently. The samples were put inside the thimble and inserted into the soxhlet apparatus and extraction under a reflux was carried out with petroleum ether for 9 h. After the barrel of the extractor is empty, the condenser was removed as well as the thimble. They were then taken into the pre-heated oven at 100 ℃ for 1 h and afterwards allow to cool in the desiccator and weighed again (W_3).

$$\% \text{ Fat} = \frac{Weight\ loss\ of\ sample\ (extracted\ fat)}{original\ weight\ of\ sample} \times 100$$

$$= \frac{W2 - W3}{W2 - W1} \times 100$$

2.6 Crude Fibre

AOAC method [17] was used for the analysis of crude fibre. The sample was measured into a 500 ml long beaker and 100 ml of hot 1.25% H_2S04 was added to it. The beaker was placed on the digested apparatus that had been pre-heated. The content was boiled and refluxed for 25 min. The content was then filtered through Whatman GF/A paper by gravity. The beaker was rinsed with distilled water and the residue was transferred from the paper back into the beaker with the aid of 1.25% hot sodium hydroxide (NaOH) and the volume of the NaOH was adjusted to 200 ml. The beaker was returned onto the digestion apparatus, boiled and refluxed for 30 min. It was then filtered and rinsed and the paper was then transferred with residue into a crucible and dried at 1000 ℃ overnight. It was then cooled in a dessicator and weighed. The sample was placed in a furnace at 6000 ℃ for 6 h, cooled in a desiccator under the room temperature and reweighed (weight B). The loss in weight during incineration indicates the weight of crude fibre in the sample.

$$\% \text{ Crude fibre} = \frac{\text{Weight A} - \text{Weight B}}{\text{Sample weight}} \times 100$$

2.7 Crude Protein

About 3 g of the samples was weighed into micro Kjeldahl digestion flask and one tablet of Selenium catalyst was added. The mixture was digested on an electro thermal heater until clear solution was obtained. The flask was allowed to cool after which the solution was diluted with distilled water to 50 ml. About 5 ml of this was transferred into the distillation apparatus. 5 ml of 2% boric acid was pippeted into a 100 ml conical flask (the receiver flask) and four drops of screened methyl red indicator were added. About 50% NaOH was continually added to the digested sample until the solution turned cloudy which showed that the solution had become alkaline. Then distillation was carried out into the boric acid solution in the receiver flask with the delivery tube below the acid level. As the distillation continues, the pink color solution of the receiver flask turned blue indicating the presence of ammonia. Distillation was continued until the content of the flask was about 50 ml after which the delivery of the condenser was rinsed with distilled water. The resulting solution in the conical flask was then titrated with 0.1M HCl.

2.8 Ash Content

Ash was analysed by incineration of known weights of the samples at temperature of 550ºC in a muffle furnace (Gallenkamp, size 3).

About 2g of samples was weighed into a clean pre-weighed crucible (W_1). The weight of the crucible and the samples before ashing began were weighed and recorded as (W_2). Crucible containing the samples were placed in a muffle furnace allowing the temperature to rise to about 550ºC for 3 h until ashing is completed. This continued till samples became grey in color. After the ashing process, the crucibles with the ash was allowed to cool in desiccators and then weighed as (W_3).

$$\%\ \text{Total ash content} = \frac{(\text{weight of crucible+ash})}{\text{weight of sample before ashing}} - \text{weight of crucible} \times 100$$

$$= \frac{W3-W1}{W2-W1}$$

w_1 is the weight of empty crucible w_2 is the weight of sample and crucible before ashing
w_3 is weight of crucible and the ashed sample

2.9 Carbohydrate Content

Carbohydrate content of the sample was expressed as a percentage of the difference of the difference between the addition of other chemical composition and 100

% Carbohydrate = 100 - (Moisture + Protein + Fat + Ash + Fibre)

2.10 Physicochemical Properties of the Jam

2.10.1 pH

The pH was determined using a glass electrode pH meter (TS 625, UK). The buffer solutions was calibrated at pH 4.0 in the first instance, then followed by pH 7.0 respectively. The glass electrode was placed into the filtrate to measure the pH and stabilized reading was recorded. For accuracy of the reading, the glass electrode was washed after each reading with distilled water and wiped to dry with soft tissue paper.

2.11 Titratable Acidity

The titratable acidity of jam was determined as described by AOAC [17]. 12 g of fresh watermelon jam sample was taken in a 600 ml beaker and homogenized with distilled water in a blender (MX-798S, National, Malaysia). The blended materials were then filtered and transferred to a 600 ml volumetric flask and the volume was made up to the mark with distilled water. Two to three drops of phenolphthalein indicator solution was added to five milliliters of the pulp solution in the conical flask and then shaken vigorously. It was then titrated immediately with 0.01N NaOH solution from a burette till the permanent pink color appeared. The volume of NaOH solution required for the titration was noted from burette reading and the percent titratable acidity was calculated using the following formula.

$$\text{Citric acid (\%)} = \frac{\text{Titre (ml)}\times\text{NaOH normality (0.1 M)}\times\text{Vol made up (50 ml)}\times\text{citric acid eq weight (64 g)}\times 100}{\text{Volume of sample for titre (5 ml)}\times\text{weight of sample taken (10 g)}\times 1000}$$

2.12 Sugar Content (brix)

Hand held refractometer (Bellingham and Stanly, Model A85171) was used to determine the brix content of the developed jams. The prism of the refractometer was cleaned and a drop of each of the samples were placed on the prism and closed. The sugar content (total soluble solid) of each sample was read in triplicates from the scale of the refractometer at 20 ℃ when held close to the eye.

2.13 Viscosity

Modified method of Awolu et al., [18] was used to analyse the viscosity of the sample. Viscosity was analyzed using Rion-viscotester, model VA-04F. The heated jam samples were poured into the viscometer cup. The rotor was suspended into the sample to initiate rotational movement and the values were obtained in decipascal-second unit at three selected temperatures of 30℃, 40℃ and 50℃ respectively.

2.14 Color Parameters

Konica MINOLTA CM-3500d equipment (Konica Minolta Inc., Tokyo, Japan) with reference to illuminant D65 and a visual angle of 10° was used to measure the upper surface color of the sample. The results were expressed using the CIE system (CIE, 2004). The established color parameters were as follows: (lightness)—0 is black, and 100 is white; redness (+) greenness (−); yellowness (+) blueness (−); and —the color saturation value (chroma) as well as *h* —the hue angle. There were three replicates for each sample. Color differences ΔE between samples were calculated according to the CIE formula.

$$\Delta E * = [(\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2)]1/2$$

2.152, 2-diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Assay

The DPPH scavenging activity assay was carried out according to a modified method of Wojdyło et al., [19] with slight modification. This assay measures the ability of the jams to reduce DPPH free radicals. DPPH solution (80 µM) was freshly prepared by dissolving the reagent in 50% acetone. Sediment-free sample solutions were diluted to 10 mg/ml using 50% acetone and then collect from the supernatant after centrifuged at 7500 rpm for 15 min. A volume of 150 µl of this solution was allowed to react with 100 µl sample in a 96-well microplate, and the absorbance was measured at 550 nm every 3 min for 1 h using the bio assay reader (HTC 7000 Bio Assay Reader (Perkin Elmer, Norwalk, CT). While all samples were run in duplicates, the antioxidant activity was calculated as follows.

% DPPH scavenging activity = [(Acontrol – Asample)/Acontrol] x 100%

2.16 Total Phenolic Content

The total phenolics content of the jam were determined using the folin-ciacalteu colorimetric method as described by Maranz and Wiesman [20] with some modifications. 0.4 ml of diluted sample was added to 2 ml of Folin–Ciocalteau reagent (prediluted 10-fold with distilled water) and shaken well. The mixture was allowed to stand at room temperature for 6 min. 0.5 ml of sodium carbonate (7.5%) was added to the mixture, shaken and left at ambient temperature for 30 min. Absorbance was measured at 750 nm in a spectrophotometer (Ultrospec 4300 Pro UV/Vis, Amersham Biosciences, NJ, USA). The thin layer chromatography was assessed by plotting the gallic acid calibration curve and expressed as milligrams of gallic acid equivalents per ml of sample (mmGAE/100 ml).

2.17 Sensory Properties of the Sample

Jam products were subjected to sensory method described by Iwe [21] using 50 panelists. The panelists were asked to assess each sample for color, taste, mouthfeel, flavor, spreadability and overall acceptability using a questionnaire designed by the Department of Food Science and Technology. A sensory acceptance test on 9-point Hedonic Scale Test was conducted where scale range from 1-dislike extremely to 9-extremely like.

2.18 Data Analysis

Results were subjected to statistical analysis using SPSS statistical package (Version 23.0). Analysis of variance (ANOVA). Duncan's multiple range tests and mean ± standard deviation was chosen to determine any significant difference among the samples.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Spiced Jam from Blends of Selected Tropical Fruits

The moisture content of the spiced jams ranged between 3.61-20.55% for watermelon jam (WA) and the reference sample (CNTP) as shown in Table 2. The moisture content observed in the study was lower when compared with the value for roselle jam which was reported to contain 33.00-35.00% [22]. The values was also found to be lowered than the moisture content of 30.60-34.70% from watermelon and pawpaw jams [23]. Generally, the moisture content of any food is an index of its water activity and it is used as a measure of stability and susceptibility to microbial attack [22]. Therefore, the low moisture recorded in the study indicate that the jam may have a long shelf life. The protein content of the formulated jams ranged between 0.50-5.16% for the reference sample and watermelon-ginger jam (WAG) respectively. The protein content observed was higher than the protein content of jam made from jackfruit (0.46%) as reported by Eke-Ejiofor and Owuno, [24]. The high protein content of watermelon-ginger jam (WAG) agreed with the work of Akomolafe and Ajayi [25] who also reported high protein value of 6.50-7.10% for sour-sop jams. The crude fat content of the jams ranged from 0.21-2.55% with pineapple jam (PI) having the highest and reference sample (CNTP) the lowest. This value was lower to the value of 3.45% for sour-sop jams as reported by [26]. The low fat content of the sample is an indication that the formulated jams will stored for long time without spoilage by oxidative rancidity at right temperature and moisture. The value for the crude fibre of the formulated jams ranged between 0.11-1.34% for control sample (CNTP) and pineapple-tumeric jams respectively. The results showed that the formulated jams is rich in fibre compared with the reference sample. Dietary fibre has been found to help in improving feacal output, lower feacal pH and more importantly increases significantly the daily excretion of butyrate of the consumer which are

putative markers of colonic health in human [27]. All the jam samples have similar carbohydrate content ranging from 78.36-88.49%). The value of the carbohydrate for the jams in this study was higher than value of 14.00-48.00% for jack fruit jam as reported by Eke-Ejiofor and Owuno, [24].

3.2 Physicochemical Properties of Spiced Jam from Blends of Selected Tropical Fruits

The physicochemical properties of the jams is shown in Table 2. The pH value of the watermelon-ginger jam (3.40) was significantly higher that of the reference jam (3.10). This values was slightly lower than the value of (3.95) for pineapple jam as reported by Fasogbon et al., [28]. However, the values obtained in the study was within the range reported by Gonzalez et al., [29] for Kiwi and orange marmalade (3.04-3.68). The low pH obtained from the study is desirable as low pH has been reported to retard some specific bacteria growth (Othman et al., 2013). There was a significant ($p< 0.05$) difference among the jam samples. Watermelon-tumeric jam (WAT) has the highest sugar brix of 79.50° brix while the reference sample (CNTP) has the lowest value of 69.80° brix. The sugar brix for watermelon-ginger-tumeric jams (WAGT), pineapple-ginger jam (PIG) and pineapple-tumeric jam (PIT) were 70.25, 77.27 and 72.25° brix respectively. These values were within the range of 70.50° brix for mixed jam of pawpaw and pineapple as reported by [30] as well as mixed jams of pawpaw and orange 72.50° brix by Lago et al., [31]. A total soluble solid content lower than 60° brix make the gel weak whereas a total soluble solid content higher than 70° brix may cause crystallization of sugar which can result to undesirable changes in the texture of the jam [32]. The total titratable acidity of the jams showed no significant ($p> 0.05$) difference. The values for total titratable acidity ranged from 1.03 to 1.06 g/ml for watermelon-ginger-tumeric jam (WAGT) and pineapple jam (PI). The value of total titratable acid for all the jam samples in the study was within the range of 1.03 g/ml for pineapple jam as reported by Fasogbon et al., [28]. The variation in the value of titratable acidity of the sample may be as a result of the difference in the acid content of the fruits used in the development of the jams. The ratio of sugar brix to the titratable acidity for watermelon-tumeric jam (WAT) was 75.71 while the reference jam (CNTP) was 66.48. The ratio of total soluble solid to total titratable acidity is a quality index which is associated to the degree of sweetness of jam products [32]. The ratio values observed in the study indicates that the products present a more pronounced sweetness which invariably affect the consumer's acceptability. The viscosity of the jams showed a reducing trend as the temperature increases. For instance, the watermelon jam (WA) showed values of 107.75, 110.11 and 90.00 cp at 30, 40 and 50 ℃ respectively. The viscosity of jams in the present study has shown that it flowability of the jam occurred best at 50 ℃. Flow behavior and rheological properties are related to the quality of jams which is an important parameter highly considered in commercial manufacturing of jam products, therefore, it is important to maintain jam viscosity as a quality check during manufacturing [33].

3.3 Antioxidant Activity and Total Phenolic Content of Spiced Jam from Blends of Selected Tropical Fruits

The antioxidant activity of the spiced jam is shown in Fig. 1. The pineapple-ginger jam showed the highest value of antioxidant activity of 50.67% while the watermelon jam showed the least value 31.39%. The value of antioxidant activity on the study is higher than the value of 25.49-30.25% for tart cherry jam as reported by Javanmard and Endan [34]. The antioxidant capacity of many tropical and sub-tropical fruits is usually characterized with high levels of L-ascorbic acid, however, many works has reported that when it comes to antioxidant capacity, the main role belong to the synergism of many active compounds, this implies that aside from L-ascorbic acid, there are many other substances that can behave as antioxidants themselves as well as substances that have no antioxidant capacity but may intensify antioxidant capacity of L-ascorbic acid [35,36]. Nutritional quality of foods are mainly based on total phenolic profile, subsequently, considered to be the index of medicinal values of natural food products [38] The total phenolic content of the spiced jam showed a significant difference ($p< 0.05$) as shown in Fig. 2. The pineapple-tumeric jam (PIT) have the highest total phenolic content of 0.25 mmGAE/100 ml followed by pineapple jam (PI) with the value of 0.22 mmGAE/100 ml while the watermelon jam (WA) recorded the lowest value of 0.14 mmGAE/100 ml. The value of total phenolic observed in the study is lower to the value of 2.99-3.34 mmGAE/100 ml for cherry jams as reported by Scibisz and Mitek [38]. Phenolics are naturally occurring components adequately and evenly distributed in the plants

genre and they are beneficial components of human diet, hence they are important constituents of plants which have multiple functions as dietary phytochemicals for human where they showed a wide range of functional and biological activities [39].

3.4 Color Parameters of the Spiced Jam

The color parameters of the spiced jams is shown in Table 3. The L* values related to the appearance of the jam. The average L* values for pineapple-ginger jam (PIGI), pineapple-tumeric jam (PIT) which was 33.16 and 31.44 were significantly higher than watermelon jam (WA) and reference sample (CNTP) with values of 24.68 and 23.23 respectively. Also the b* values for pineapple-ginger-tumeric jam (PIGT) and pineapple-tumeric jam (PIT) which are 13.55 and 12.43 were higher than watermelon jam (WA) and reference sample (CNTP) which are 4.53 and 3.35. The L* and b* values obtained in this study is similar to the value of 30.56, 4.59 and 12.05 respectively for apricot jams as reported by Melgarejo et al., [40]. Many reactions could take place during thermal and concentration processing of foods that affect product color like pigment degradation, especially, carotenoids, anthocyanin and chlorophyll, browning reactions such as the Maillard reaction, enzymatic browning and oxidation of ascorbic acid [41].

3.5 Sensory Properties of the Spiced Jam

The sensory properties of the spiced jam is shown in Fig. 1. Pineapple-ginger jam (PIG) has the highest preference for color with a mean score of (7.98) while the watermelon-ginger jam (WAG) with a mean score of (7.70) was the second highest. There was a marked difference between the color of other jams and the reference sample (CNTP) with a mean score of (5.60). With regards to color, the reference sample without the addition of ginger may be undesirable. Pineapple-ginger jam (PIG) and watermelon jam (WAG) has the highest preference for taste with a mean scores of (7.88) and (7.56) respectively. However, a significant ($p<0.05$) differences were observed amongst all other jam samples including the reference sample. With regards to the mouthfeel, there were significant differences observed amongst the jam samples. The mouthfeel is a textural sensory attribute that describe the smoothness or generally how the samples feels in the palate of the assessor. Pineapple-ginger jam (PIG) has the highest preference with a mean score of (7.46) while watermelon-ginger jam (WAG) followed as the second highest with a mean score of (7.05) and the reference jam sample has the least mean value of (5.05). In terms of the overall acceptability, the pineapple-ginger and watermelon-ginger jam samples have a mean score of (7.9) and (7.8) respectively as compared to reference sample with a mean score of (6.4), hence it can be concluded that pineapple-ginger jam was more acceptable and this has shown that the developed jams based on its general acceptability will be accepted by the consumers when introduced into the market.

Table 2. Proximate composition (%) of the spiced jam

Sample	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
WA	3.61^{g}±0.02	4.33^{d}±0.01	2.38^{a}±0.02	1.40^{c}±0.01	1.17^{g}±0.02	87.11^{b}±0.03
WAG	4.43^{d}±0.01	5.16^{a}±0.01	0.38^{g}±0.01	1.27^{g}±0.02	1.22^{f}±0.02	88.48^{a}±0.03
WAT	4.50^{c}±0.03	4.22^{f}±0.02	1.45^{f}±0.03	1.29^{f}±0.03	1.11^{h}±0.03	86.49^{c}±0.02
WAGT	4.40^{d}±0.02	4.79^{b}±0.03	1.57^{e}±0.02	1.48^{b}±0.01	1.30^{b}±0.01	86.46^{c}±0.02
PI	3.83^{h}±0.02	3.50^{g}±0.02	2.55^{b}±0.01	1.53^{a}±0.01	1.23^{e}±0.03	87.36^{b}±0.03
PIG	4.00^{f}±0.04	4.47^{c}±0.02	2.43^{c}±0.02	1.33^{e}±0.04	1.28^{c}±0.03	86.49^{c}±0.02
PIT	4.11^{e}±0.01	4.41^{e}±0.03	2.41^{d}±0.03	1.26^{g}±0.03	1.34^{a}±0.01	86.47^{c}±0.02
PIGT	4.73^{b}±0.02	3.40^{h}±0.02	2.40^{d}±0.02	1.39^{d}±0.01	1.26^{d}±0.01	86.82^{c}±0.03
CNTP	20.55^{a}±0.02	0.50^{i}±0.03	0.21^{h}±0.01	0.38^{h}±0.02	0.11^{i}±0.01	78.36^{d}±0.02

**Values are mean Standard deviation of three replications; Values followed by different letters along the same column are significantly (P ≤ 0.05) different from each other*

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
WAGT- Watermelon-ginger-tumeric jam;
CNTP-Reference sample
PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam;

Table 3. Physicochemical properties of the spiced jam

Samples	pH	Sugar (°Brix)	Titrable acidity (g/ml)	TSS/TTA	Viscosity		
					30℃	**40**℃	**50**℃
WA	3.30^{b}±0.02	75.50^{c}±0.03	1.04^{b}±0.02	72.59	170.75^{e}±0.01	110.11^{e}±0.02	90.00^{e}±0.03
WAG	3.40^{a}±0.02	75.25^{c}±0.02	1.05^{b}±0.01	71.67	149.75^{f}±0.02	120.01^{c}±0.02	93.23^{d}±0.03
WAT	3.20^{c}±0.01	79.50^{a}±0.03	1.05^{b}±0.02	75.71	316.75^{b}±0.03	115.12^{d}±0.03	98.02^{b}±0.02
WAGT	3.20^{c}±0.03	70.25^{f}±0.02	1.03^{c}±0.03	68.20	180.75^{d}±0.01	101.23^{f}±0.03	89.12^{f}±0.02
PI	3.20^{c}±0.02	77.27^{b}±0.01	1.06^{a}±0.01	72.89	129.70^{g}±0.04	100.10^{f}±0.02	88.23^{f}±0.03
PIG	3.15^{d}±0.02	72.25^{d}±0.02	1.04^{a}±0.01	69.47	254.72^{c}±0.02	125.12^{b}±0.01	95.00^{c}±0.03
PIT	3.15^{d}±0.01	72.10^{e}±0.03	1.05^{b}±001	68.66	356.23^{a}±0.03	150.11^{a}±0.03	99.93^{a}±0.02
PIGT	3.30^{b}±0.01	75.00^{c}±0.01	1.04^{b}±0.02	72.11	112.00^{h}±0.02	89.45^{g}±0.03	70.24^{g}±0.03
CNTP	3.10^{e}±0.02	69.80^{g}±0.02	1.05^{b}±0.01	66.48	105.11^{i}±0.01	80.02^{h}±0.03	65.56^{h}±0.02

Table 4. Color parameters of the spiced jam

Samples	L*	a*	b*	H*	ΔC	ΔE	W (%)
WA	24.68^{h}±0.02	2.01±0.01	4.53^{h}±0.01	66.08^{f}±0.02	7.71^{d}±0.02	8.83^{b}±0.01	24.52^{h}±0.02
WAG	25.26^{f}±0.02	1.96^{g}±0.02	5.30^{f}±0.01	69.75^{d}±0.01	6.96^{f}±0.02	7.89^{f}±0.01	25.05^{f}±0.02
WAT	24.88^{g}±0.02	1.12^{h}±0.02	4.98^{g}±0.02	72.29^{c}±0.01	7.50^{e}±0.02	8.55^{d}±0.01	24.71^{g}±0.02
WAGT	26.61^{e}±0.02	6.69^{a}±0.02	6.69^{e}±0.02	74.22^{b}±0.01	5.64^{h}±0.02	6.13^{h}±0.01	26.28^{e}±0.02
PI	28.56^{d}±0.01	4.02^{d}±0.01	8.38^{d}±0.01	64.40^{g}±0.01	8.35^{c}±0.01	8.36^{e}±0.01	27.96^{d}±0.02
PIG	30.65^{c}±0.01	4.95^{c}±0.01	10.12^{c}±0.02	63.93^{h}±0.02	8.65^{b}±0.01	8.80^{c}±0.02	29.74^{c}±0.02
PIT	31.44^{b}±0.02	2.81^{e}±0.01	12.43^{b}±0.01	77.27^{a}±0.01	6.29^{g}±0.01	6.79^{h}±0.02	30.26^{b}±0.02
PIGT	33.16^{a}±0.01	5.76^{b}±0.01	13.55^{a}±0.01	66.99^{e}±0.02	9.33^{a}±0.01	10.08^{a}±0.02	31.55^{a}±0.02
CNTP	23.23^{i}±0.01	1.05^{i}±0.01	3.35^{i}±0.01	55.65^{i}±0.02	4.55^{i}±0.02	5.45^{i}±0.02	20.11^{i}±0.02

**Values are mean Standard deviation of three replications. Values followed by different letters along the same column are significantly (P ≤ 0.05) different from each other*

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
AGT- Watermelon-ginger-tumeric jam;
CNTP- Reference sample

PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam;

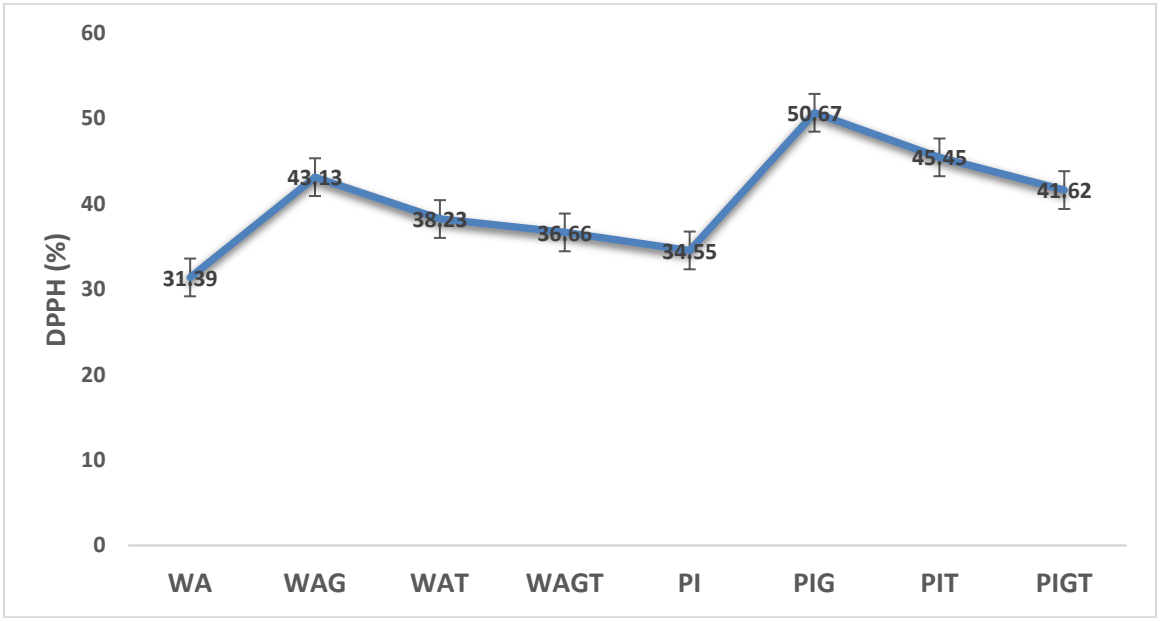

Fig. 1. Antioxidant activity of the spiced jam

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
WAGT- Watermelon-ginger-tumeric jam;
PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam

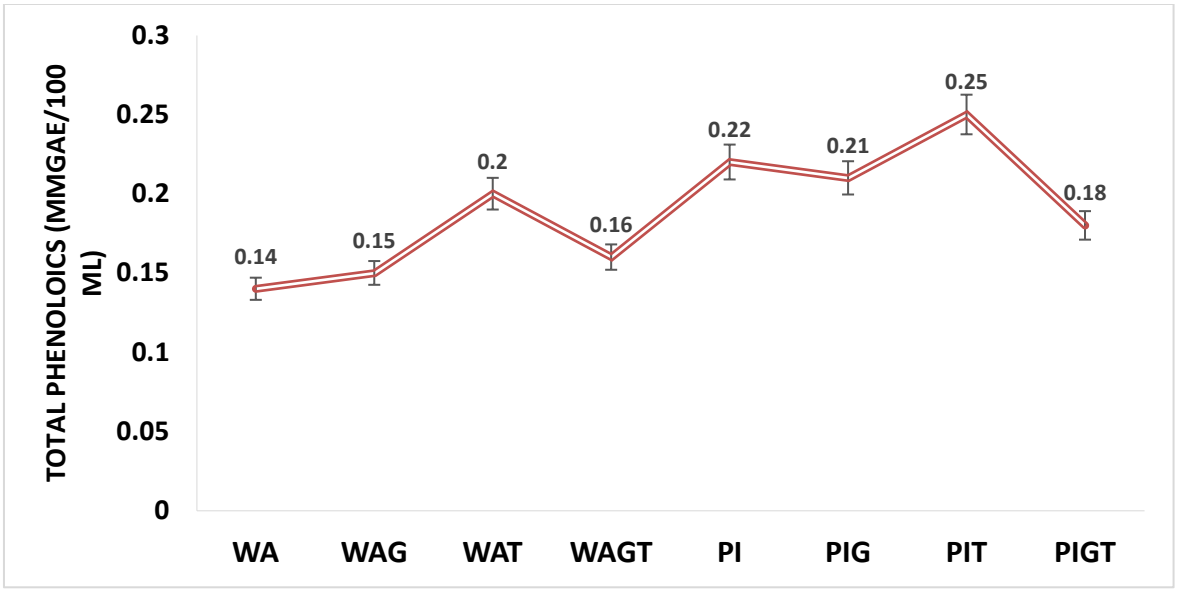

Fig. 2. Total phenolic content of the spiced jam

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
AGT- Watermelon-ginger-tumeric jam;
PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam

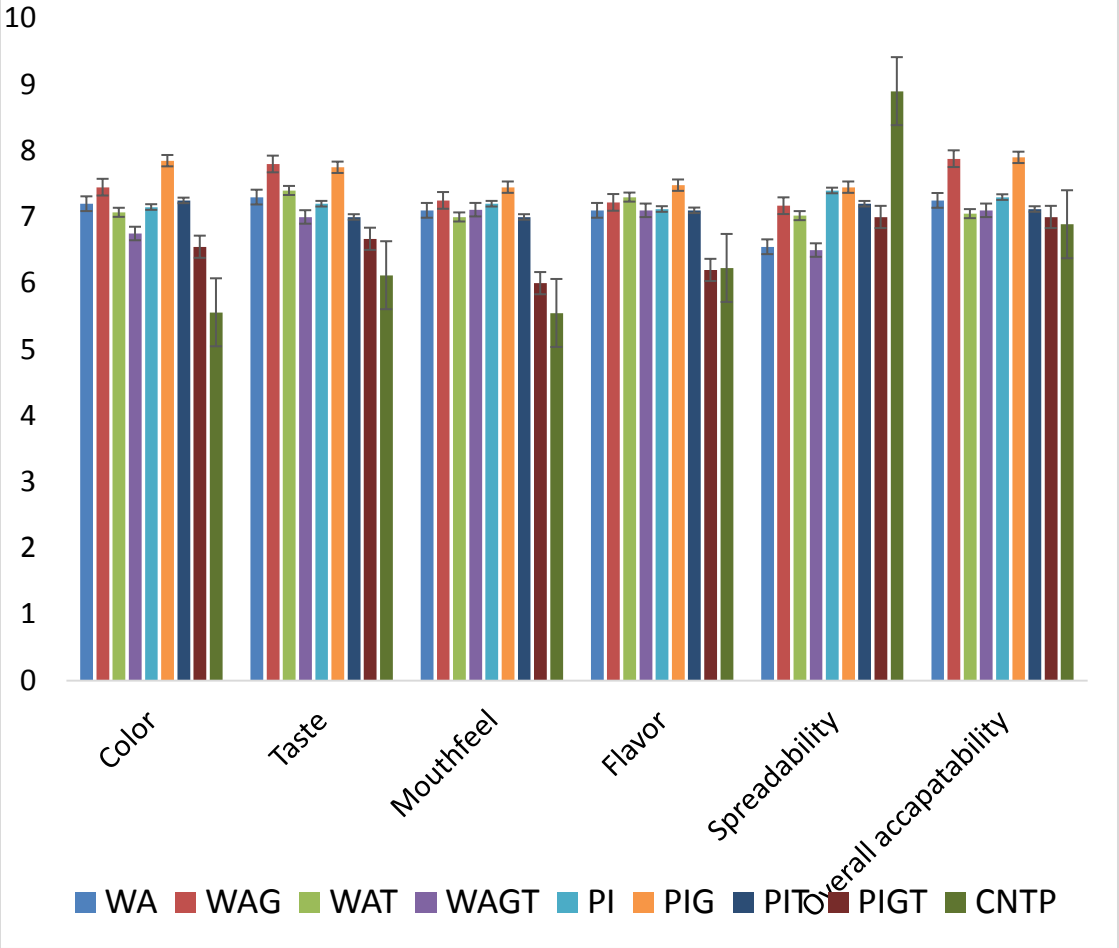

Fig. 3. sensory characteristic of the spiced jam

WA- Watermelon jam;
WAG- Watermelon-ginger jam;
WAT-Watermelon-tumeric jam;
WAGT- Watermelon-ginger-tumeric jam;
CNTP- Reference sampleConclusion
PI- Pineapple jam;
PIG-Pineapple-ginger jam;
PIT-Pineapple-turmeric jam;
PIGT-Pineapple-ginger-tumeric jam;

4. CONCLUSION

The study revealed that production of pineapple-ginger jam has more nutritional quality from the point view of the proximate, physicochemical and antioxidant composition results. It was equally generally accepted by the sensory assessors, hence, optimal utilization of pineapple and ginger for jam production would improve the health status of the consumers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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