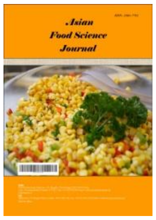

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Comparative Study on the Proximate, Physicochemical and Sensory Properties of Jams from Selected Tropical Fruits Spiced with Ginger, Garlic and Turmeric

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Fruit jams were produced from watermelon, pineapple and apple spiced with ginger, garlic and turmeric using standard method. The sample treatments were WA (watermelon 100%), WAGI (watermelon 95% + ginger 5%), WAGA (watermelon 95% + garlic 5%), WATU (watermelon 95% + turmeric 5%), WAGGT (watermelon 95% + ginger 5% + garlic 5% + turmeric 5%), PI (pineapple 95%), PIGI (pineapple 95% + ginger 5%), PIGA (pineapple 95% + garlic 5%), PITU (pineapple 95% + turmeric 5%), PIGGT (pineapple 95% + ginger 5% + garlic 5% + turmeric 5%), AP (apple 95%), APGI (apple 95% + ginger 5%), APGA (apple 95% + garlic 5%), APTU (apple 95% + turmeric 5%) and APGGT (apple 95% + ginger 5% + garlic 5% + turmeric 5%). The proximate,

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physicochemical (pH, total soluble solid, titratable acidity), antioxidant and sensory characteristics of the jams were determined using standard analytical procedures. The protein content of the sample ranged from 0.50 to 7.16% for reference sample (CNTP) and watermelon-garlic jam (WAGA). The fat and ash contents of the samples ranged from 0.21 to 2.55% and 1.03 to 4.38% for pineapple jam (PA) and reference sample (CNTP) respectively. The fibre content was 0.11% for reference sample (CNTP) and 1.90% for and watermelon-garlic jam (WAGA). The pH of the jams ranged from 3.10 to 3.50 for reference sample (CNTP) and apple-ginger-garlic-tumeric jam (APGGT) while total soluble solid and titratable acidity ranged from 50.00 and 69.80 °brix for pineapple-ginger-garlic-tumeric (PIGGT) and reference sample (CNTP) and 1.13 and 1.40 g/ml for CNTP and PIGA respectively. The TSS/TTA was 37.92 to 61.22 for PIGA and CNTP. The antioxidant activity of the sample was 25.45% for CNTP and 50.67% for PIGI while the total phenolic contents was 0.10 mmGAE/100 g and 0.28 mmGAE/100 g for CNTP and PIGI. The sensory values for the color ranged from 4.30 and 7.85 for WAGGT and PIGI while the taste ranged from 6.10 and 7.80 for APTU and PIGI. The overall acceptability ranged from 5.89 and 7.88 for CNTP and PIGI. Fruit jams spiced with ginger, garlic and turmeric was highly nutritious, however the pineapple-ginger jam showed a very high nutrient and bioactive components which make it to be a functional, healthy and immune booster foods for both children and adult alike.

Keywords: Treatments; reference sample; total soluble solid; titratable acidity; color.

1. INTRODUCTION

Among the perishable commodities, fruits are the essential ingredients in the human diets. They are high in nutritive value and make important nutritional contribution to human wellbeing and they are cheaper and better sources of healthy foods. They are naturally low in fat, sodium, calories and have absolutely no cholesterol. Fruits are significant source of several fundamental nutrients, including dietary fiber, Vitamin C, folate (folic acid), potassium, phyto-nutrients and many anti-oxidants like phenols, flavonoids and anthocyanins. These compounds protect the body from oxidative stress and degenerative diseases by developing the capacity to fight against ailments [1]. In different regions during certain parts of the year the perishable fruits are available as seasonal surplus and they create a glut in the market but in off-seasons they become scarce. The most common preserved fruit product to overcome the postharvest losses is fruit-jams. Jams are solid gel prepared from ripe fruits and are one of the most important breakfast ingredients. Jams are of two kinds: one is prepared from a single fruit and another is prepared from a combination of two or more fruits [2].

Watermelon (*Citrullus lanatus*) is a fruit which belongs to the family of cucurbitaceae and contain about 95% water. The fruit is round with reddish mesocarp having a lot of seeds. There are various species with different colored endocarp, for example, red flesh, yellow flesh, and orange flesh. It contains vitamins B1 and B6, potassium, calcium, iron, zinc and magnesium in addition to vitamin A and C which are generally common to all fruits and vegetables [3]. Watermelon (*Cochliobolus lunatus)* is rich in carotenoids some of which include lycopene, phytofluene, phytoene, beta-carotene, lutein and neurospnene [4]. Lycopene makes up the majority of the carotenoids in the watermelon.

Pineapple pulp coloration is related to the carotenoid content, β-carotene being responsible for about 35% of total pigments [5]. β-carotene, α-carotene and cryptoxanthin stand out for their provitamin A activity, being converted into vitamin A or retinol after ingestion. Furthermore, carotenoids have antioxidant action, protecting cells and tissues from damage caused by free radicals, strengthening the immune system and inhibiting the development of certain types of cancers [6]. Pineapple fruits also exhibit high levels of other antioxidants such as phenolic compounds and vitamin C [7-8]. Phenolic compounds responsible for bitterness, astringency, flavor, color and oxidative stability of fruits and vegetables have shown an effect in health protection, with not only antioxidant activity by scavenging free radicals, but also inhibition of hydrolytic and oxidative enzymes and anti-inflammatory functions in human cells [9]. Apple is the most popular temperate fruit in the world because of its crispy texture and sweet taste.

Apples form an important part of human diet as they are a rich source of sugars, minerals, dietary fibre and functional compounds such as ascorbic acid and phenolics [10-11]. The quality and consumer acceptability of apples is associated with their overall sensory appeal and chemical composition [12-13]. Sugars, organic acids and phenolic compounds, the major compounds in apple, impart taste characteristics, such as flavor, bitterness and astringency to the fruits [14].

Ginger (*Zingiber officinale* Roscoe) is one of the most commonly consumed dietary condiments in the world. The main active phytochemicals present in ginger are gingerols, shogoals and paradols, and they have strong antioxidant and chemopreventive properties [15]. Ginger extracts have been extensively studied for a broad range of biological activities including antibacterial, anticonvulsant, analgesic, antiulcer, gastric antisecretory, antitumor, antifungal, antispasmodic, antithrombotic, hypocholesterolemic, antiallergic, antiserotogenic , anticholinergic and other beneficial activities. Many studies have proved that ginger is endowed with strong antioxidant [16-17] antigenotoxic, antimutagenic and anticarcinogenic properties both in *in vitro* and *in vivo* studies.

Garlic (*Allium moly*), is a species in the onion genus, *Allium. Allium moly*, also known as golden garlic and lily leek. The most important chemical constituents reported from *Alliums* are the sulfur compounds. It has been estimated that cysteine sulfoxides (e.g. alliin) and the non-volatile γ-glutamylcysteine peptides make up more than 82% of the total sulfur content of garlic [18]. The important components of garlic are allicin and sulphur containing compounds like diallyl sulphide (DAS) and diallyldisulphide (DADS) possessing antitumor and antioxidant properties [19-20]. Garlic has been claimed to aid in preventing cardiovascular diseases, high cholesterol level, high blood pressure and cancers of stomach and colon. Garlic is also well recognized for treating tuberculosis, malaria, asthma, diabetes and for improving immune system. Ginger has been determined to be effective against nausea caused by seasickness, morning sickness and chemotherapy, inflammation, rheumatism, fever, common cold, diabetes, asthma, nervous system disorders and digestive disorders.

Turmeric (*Curcuma longa*) is a dietary spice belonging to the family *zingiberaceae*. It is a colouring and flavouring agent in foods, and has been reported to possess antioxidant properties both in *in vitro* and animal studies. Aqueous extracts of turmeric showed antioxidant and antimicrobial activity due to the presence of curcumin (5%), a polyphenolic compound. It is known that the phenolic character of curcumin is responsible for its anti-oxidant properties [21].

Fruit jams are important in the diet of every age group as they provide quick boosts of energy. Good jam has a soft even consistency without distinct pieces of fruit, a bright color, a good fruit flavor and easy to spread semi-jel like texture without free liquid. Inclusion of the spices to jam will the nutritionally content of the jam but also will improves the health functionality of the jam due to the presence of some bioactive components present in the selected spices, hence this study was aimed at exploring the nutritional and the antioxidant importance of jam spiced with ginger, garlic and turmeric to improve its nutritional and health functionality.

2. MATERIALS AND METHODS

2.1 Collection of Materials

The raw materials such as pineapple (*Ananas comoscus*), watermelon (*Citrullus lanatus*) and apple (*Malus domestica borkh*) were purchased at Sango market Ibadan, Nigeria. The garlic bulbs, ginger and tumeric rhizomes were purchased from different sales point in Ibadan, Oyo State, Nigeria and transported to the Food Processing and Analytical Laboratory of the Department of Food Science and Technology, The Oke-Ogun Polytechnic Saki, Nigeria for processing.

2.2 Preparation of Fresh Ginger and Turmeric Rhizome and Garlic Bulb Juice

Freshly harvested ginger and turmeric rhizomes were washed and cleaned by removing all the dirt and impurities. After peeling the ginger, garlic and turmeric rhizomes, they were cut into small pieces for the extraction of juice using juice extractor. The obtained juice was then filtered through muslin cloth to obtain clear juice and kept in the refrigerator until further use.

2.3 Jam Preparation

A modified method described by [22] was adopted for this purpose. The fruits were washed with potable water to remove surface contamination, cut and peeled manually. They are immediately packaged and frozen (-18 ℃)

until further processing into jam. The thoroughly washed, peeled fruits were separately blended in a blender (Sumeet Food Processor, Model A). Jams were prepared in laboratory conditions under ambient temperature. The jam formulation was fruits (1000 g), sucrose (470 g), methoxyl pectin (Danisco Ingredients, Denmark) (10 g) and citric acid (4 g). Citric acid was used for adjusting pH values for proper pectin gelatinisation (pH necessary for gelatinisation was 2.8-3.3). Fruit blended with larger part of sucrose, citric acid, ginger and turmeric juice at 5% level were mixed and thermally processed at 80°C for 20 min. Pectin was mixed with part of sucrose and added at the final stage of the jam processing. Fruit jams were cooked until the final product contained 65 °brix. 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 room temperature and stored in the dark at 20 ℃ until analysis. The blending ratio of the fruits and the spices is shown in Table 1.

The quantity of sugar to be added to the jam in order to attain the desired ^{o}brix of 68 was calculated as:

Weight of sugar =

$$\frac{°Brix\ of\ product-\ °Brix\ of\ fruit}{100} \times weight\ of\ pulp$$

2.4 Proximate Composition

Moisture content One gram of sample in pre-weighed crucible was placed in an oven at 105 °C for 24 h, cooled, and reweighed. The percentage moisture was calculated as follows:

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

W1 is the weight of the crucible, W2 is the weight of the crucible after drying at 105 °C and sample, and W3 is the weight of the crucible and the sample after cooling in airtight desiccators.

2.5 Crude Protein

Crude protein content was determined using the micro- Kjeldahl. A volume of 10 ml H_2SO_4 added to 3 g of sample was digested with a Kjeldahl digestor (Model Bauchi 430) for 1h. A volume of 40 ml water was added and distilled using a Kjeldahl distillation Unit (Model unit B – 316) containing 40% concentrated sodium hydroxide and Millipore water. Liberated ammonia was collected in 20 ml boric acid with bromocresol green and methyl red indicators and titrated against 0.04 N H_2SO_4. A blank (without sample) was likewise prepared. Percent protein was calculated as:

Crude protein (%) =

$$\frac{Sample\ titre-\ blanck\ titre \times 14 \times 6.25}{Sample\ weight} \times 100$$

2.6 Crude Fiber

A weighed crucible containing 1 g of sample was attached to the extraction unit (in Kjeldahl, D-40599; Behr Labor-Technik GmbH, Dusseldorf, Germany) and into this 150 ml of hot 1.25% H_2SO_4 was added and digested for 30 min, the acid was drained and sample washed with hot distilled water for 1 h. The crucible was removed and oven dried overnight at 105°C, cooled, weighed, and incinerated at 550°C in a muffle furnace (MF-1-02; PCSIR Labs, Lahore, Pakistan) overnight and reweighed after cooling. Percentage extracted fiber was
calculated as:

Crude fiber (%) =

$$\frac{Weight\ of\ digested\ sample-Weight\ of\ ashed\ sample}{Weight\ of\ sample} \times 100$$

2.7 Lipid

Lipid content was estimated using TecatorSoxtec (Model 2043[20430001]; Hilleroed, Denmark). A quantity of 1.5 g sample mixed with 2.3 g anhydrous sulfate was weighed into a thimble and covered with absorbent cotton, while 40 ml of petroleum ether (40–60°C Bpt) was added to a pre-weighed cup. Both thimble and cup were attached to the extraction unit. The sample was extracted using ethanol for 30 min and rinsed for 1 h. Thereafter, the solvent was evaporated from the cup to the condensing column. Extracted fat in the cup was then placed in an oven at 105 °C for 1 h and cooled and weighed. Percent fat was calculated as:

$$\text{Lipid (\%)} = \frac{Initial\ cup\ weight-Final\ cup\ weight}{Weight\ of\ sample} \times 100$$

2.8 Ash

Ash and mineral contents were determined according to AOAC (Association of Analytical Chemists) numbers 923.03 and 984.27 (AOAC 2005). Two grams of sample was added into a pre-weighed crucible was incinerated in muffle furnace at 600 °C.

$$\text{Ash (\%)} = \frac{W2-W3}{W2-W1} \times 100$$

where W_1 is the weight of cleaned, dried, ignited, and cooled crucible, W_2 the weight of the crucible and sample after incinerating at 600 °C, and W_3 the weight of the crucible and sample after cooling in an airtight homogenized vessel.

2.9 Carbohydrate

The carbohydrate content was determined by difference, that is, addition of all the percentages of moisture, fat, crude protein, ash, and crude fiber was subtracted from 100%. This gave the amount of nitrogen-free extract otherwise known as carbohydrate.

% Carbohydrate =

100 – (% Moisture + % Fat + % Ash + % Crude fiber + % Crude protein

2.10 Physicochemical Properties

2.10.1 pH

The pH was determined using a glass electrode pH meter (TS 625, UK). The pH meter was calibrated with buffers at pH 4.0 followed by pH 7.0. 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 according to AOAC [23]. Ten gram of fresh watermelon jam sample was taken in a 500 ml beaker and homogenized with distilled water in a blender (MX-798S, National, Malaysia). The blender materials were then filtered and transferred to a 500 ml volumetric flask and the volume was made up to the mark with distilled water. Five milliliters of the pulp solution was taken in a conical flask. Two to three drops of phenolphthalein indicator solution was added and then the conical flask was 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 at the percent titratable acidity was calculated using the following formula:

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

2.12 Brix

The brix content in the jams were determined using the hand held refractometer (Bellingham and Stanly, Model A85171). 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 (soluble sugar) of each sample was read in triplicates from the scale of the refractometer at 20 ℃ when held close to the eye.

2.13 Radical DPPH Scavenging Activity

Free radical scavenging capacity of extracts were determined using the stable DPPH according to Hwang and Do-Thi [24]. The final concentration was 200 µM for DPPH and the final reaction volume was 3.0 ml. The absorbance was measured at 517 nm against a blank of pure methanol after 60 min of incubation in a dark condition. Inhibition percentage of the DPPH free radical was calculated by the following equation:

Inhibition (%) = 100 × [(Acontrol - Asample)/Acontrol]

Acontrol- absorbance of the control reaction (containing all reagents except the test compound).

Asample- absorbance with the test compound. The standard curve was prepared using Trolox.

2.14 Total Phenolic Content

The total phenolic content was determined according to the Folin-Ciocalteu procedure [25] Briefly, the extract (100 mg) was transferred into a test tube and the volume adjusted to 3.5 ml with distilled water and oxidized with the addition of 250 mg of Folin-Ciocalteau reagent. After 5 min, the mixture was neutralized with 1.25 ml of 20% aqueous sodium carbonate (Na_2CO3) solution. After 40 min, the absorbance was measured at 725 nm against the solvent blank. The total phenolic content was determined by means of a calibration curve prepared with gallic acid, and expressed as mg of gallic acid equivalent (mg GAE) per 100 g of sample.

2.15 Sensory Properties of the Samples

The sensory evaluation of the jam were carried out using a panel of 50 comprising of students and staff of the Department of Food Science and Technology, The Oke-Ogun Polytechnic, Saki Oyo State, Nigeria. The samples were assessed on a 9-point hedonic scale with 1 representing dislike extremely and 9 like extremely. The samples were presented in a random pattern and the parameters evaluated included; texture, flavor, taste, appearance, spreadability and general acceptability. A glass of water was presented to each panelist for rinsing of mouth in between each evaluation in accordance with Iwe [26].

2.16 Statistical Analysis

Statistical analysis was conducted in triplicate and mean values reported using Analysis of Variance (ANOVA) through the use of SPSS version 23.0 and separation of the mean values were carried out using the Least Significant difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

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

The proximate composition of the jams shows that the moisture content of the reference sample (CNTP) was 20.55% which was significantly ($p<0.05$) higher than other samples as shown in Table 2. The moisture content of apple and apple-ginger jams was the lowest with a value of 10%. The value of moisture in the present study was lowered when compared with value of 28.66-34.42% for pumpkin-orange jam reported by [27]. Moisture has a great impact on the storage ability of food products. High sugar content in jam products makes the moisture unavailable for the growth of microorganisms, thereby improving the storage ability of jam [28]. Premise on this, the moisture content reported in the study was low, hence may be stored for long on the shelf.

The protein content of the jams were 7.16%, 7.00% and 6.33% for watermelon-ginger jam (WAGI), watermelon-garlic (WAGA) jam and pineapple-ginger jam (PIGI) respectively. The reference sample (CNTP) showed the lowest value of protein content of 0.50%. The protein content reported in the study was significantly higher than 3.01-3.49% for pumpkin-orange jam [27]. The protein content was also higher than the value of 0.27% which is the recommended amount of protein in jam [29]. The low protein in some jam samples in the study is not surprising as fruits and their products are known to be low in protein [30].

The fat content of the spiced jams shows a decreasing trend when compared with the unspiced jams. For instance, watermelon jam (WA) has a fat content of 2.38% while watermelon-ginger jam (WAGI), watermelon-garlic jam (WAGA) and watermelon-turmeric jam (WATU) has fat contents of 0.55%, 0.55% and 0.45% respectively. Likewise, the pineapple jam (PI) has fat content of 2.55% while pineapple-ginger jam (PIGI), pineapple-garlic jam (PIGA) and pineapple-tumeric jam (PITU) were 2.43%, 2.33% and 2.20%. The decrease trend in the fat content of the spiced jam may be as a result of the different spices incorporated into the jam as this may have a beneficial importance in human diet especially those under weight control programs.

The ash content of watermelon-ginger jam (WAGI), watermelon-garlic jam (WAGA) and watermelon turmeric jam (WATU) were 1.67%, 1.70% and 1.77% while watermelon jam (WA) value was 1.67%. The pineapple-ginger jam (PIGI), pineapple-garlic jam (PIGA) and pineapple-tumeric jam (PITU) has ash content of 1.83%, 1.73% and 1.76% respectively and they were significantly ($p< 0.05$) differed from 1.03% for pineapple jam (PI). The ash content in the study was higher than 0.27% for jackfruit jam [31] and 0.18 and 0.12% for grape and blueberry jams respectively reported by [32]. Ash content has been regarded as an indicator for mineral compositions in food products [33]. The high ash content observed in the spiced jams may be due to the organic compounds present in in the different spices used which invariably the mineral bioavailability of the jams. Increasing trend was observed in the fibre content of spiced jam when compared with the unspiced and reference samples. The fibre values of watermelon-ginger jam (WAGI), watermelon-garlic jam (WAGI) and watermelon-tumeric jam (WATU) were 1.72, 1.90 and 1.67% while the watermelon jam (WA) and reference jam (CNTP) were 1.61 and 0.11% respectively.

The crude fibre value observed in the study was higher than pawpaw and sour-sop jams which was 0.05 and 0.04% as reported by [34]. It could be observed that the inclusion of spices into the jams improved the fibre content of the jam samples. Study have shown that fibre help in digestion, bowel movement and body maintenance [35]. However, excess consumption of in any diet may bind trace element thereby leading to deficiency of Iron and Zinc in the body [36]. The carbohydrate contents ranged from 76.49 to 78.84% for pineapple-ginger jam (PIGI) and apple-ginger jam (APGI).

The carbohydrate in the study was significantly higher than 63.16 and 55.38% for pawpaw and sour-sop jams [34]. Carbohydrate is a readily available source of energy for the body, thereby acting as protein-sparing action in the body [37].

3.2 Physicochemical Composition of the Spiced Jams

The pH of the samples ranged from 3.10 and 3.55 for reference sample (CNTP) and apple-ginger-garlic-tumeric jam (APGGI) as shown in Table 3. The pH range of the samples in this study is lower to the pH of melon jam 4.10 reported by [38]. The low pH of the spiced jams is assumed to facilitate the inversion of 35-55% of the added sugar during cooking and thereby limit the crystallization of sugar. It should be emphasis also that jam pH must not be too low as too low pH could induce deterioration of sensory quality, sugar crystallization and excessive acidic flavor [39].

The total soluble solid of the spiced jams showed a decrease trend when compared to the unspiced jams. Watermelon jam (WA) has total soluble solid of 57.50 °brix whereas the watermelon-ginger jam (WAGI), watermelon-garlic jam (WAGA) and watermelon-tumeric jam (WATU) has total soluble solid of 55.25, 53.50 and 52.50 °brix respectively. A similar trend was observed for pineapple jam (PI) with total soluble solid of 59.27 °brix while pineapple-ginger jam (PIGI), pineapple-ginger jam (PIGA) and pineapple-tumeric jam (PITU) has total soluble solid of 55.27, 53.10 and 52.10 °brix. The total soluble solid of jams in the study is lower to 64.42 °brix for apple-pineapple-peach mixed jam [40]. The correct sugar content is a critical factor for proper gel formation and preservation action of jam. If the total soluble solid of a jam is less than 45 °brix, it will reduce the shelf life of the final product and the jam will also have a runny consistency. Contrastingly, if the total soluble solid is higher than 68 °brix, the jam will be stiffed and the sugar might begin to for crystals inside the jam which will eventually affect the texture of the final product [41]. It can therefore be deduced from the present study that the range of total soluble solid for the jams will not crystallize, have a firm consistency and prolonged shelf life.

The titratable acidity of the samples showed a significant ($p < 0.05$) difference. The watermelon jam (WA), watermelon-ginger jam (WAGI), pineapple-tuemric jam (PITU) and reference jam (CNTP) has titratable acidity of 1.15 g/ml while watermelon-garlic jam (WAGA) and pineapple-ginger-garlic-tumeric jam (PIGGT) has the highest titratable acidity of 1.40 g/ml. These values were higher than 0.31 g/ml for jackfruit jam as reported by [31]. The importance of high acidity in the spiced jams cannot be underestimated as it has showed that the samples can be stored for longer period.

The TSS/TTA ratio in the study ranged from 37.92 for pineapple-garlic jam (PIGA) and 61.22 for reference sample (CNTP). The TSS/TTA in the present study is lower than pawpaw (102.34) and sour-sop jam (90.73) as reported by [34]. Higher ratio values of TSS/TTA is a quality index related to the sweetness of the jam products [42]. Thus, the lower ratio observed in this study indicates that the products present a less pronounced sweetness.

3.3 Antioxidant Activity and Total Phenolic Content of the Spiced Jams

The inhibition percentage of the radical DPPH jam is presented in Fig. 1.The percentage inhibition of the jam samples significantly ($p<0.05$)

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

Sample	Watermelon	Pineapple	Apple	Ginger	Garlic	Tumeric
WA	100	-	-	-	-	-
WAGI	95	-	-	05	-	-
WAGA	95	-	-	-	05	-
WATU	95	-	-	-	-	05
WAGGT	95	-	-	05	05	05
PI	-	100	-	-	-	-
PIGI	-	95	-	05	-	-
PIGA	-	95	-	-	05	-
PITU	-	95	-	-	-	05
PIGGT	-	95	-	05	05	05
AP	-	-	100	-	-	-
APGI	-	-	95	05	-	-
APGA	-	-	95	-	05	-
APTU	-	-	95	-	-	05
APGGT	-	-	95	05	05	05

WA- Watermelon jam
WAGI- Watermelon-ginger jam
WAGA-Watermelon-garlic jam
WATU- Watermelon-tumeric jam
WAGGT-Watermelon-ginger-garlic-tumeric jam
AP-Apple jam
APGI-Apple-ginger jam
APGA-Apple-garlijam
PI- Pineapple jam
PIGI-Pineapple-ginger jam
PIGA-Pineapple-garlic jam
PITU-Pineapple-tumeric jam
PIGGT-Pineappple-ginger-garlic-tumeric jam
APTU-Apple-tumeric jam
APGGT-Apple-ginger-garlic-tumeric jam.

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

Samples	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
WA	10.61^{g}±0.02	4.33^{c}±0.01	2.38^{b}±0.02	1.67e±0.01	1.61^{f}±0.02	76.61^{f}±0.01
WAGI	11.43^{c}±0.02	7.16^{a}±0.01	0.55^{h}±0.01	1.70^{h}±0.01	1.72^{e}±0.02	77.54^{b}±0.01
WAGA	11.00^{e}±0.01	7.00^{b}±0.01	0.55^{d}±0.02	1.77^{i}±0.01	1.90^{a}±0.02	78.14^{a}±0.01
WATU	11.50^{b}±0.02	6.22^{c}±0.02	0.45^{g}±0.01	1.79^{g}±0.01	1.67^{f}±0.02	77.43^{d}±0.02
WAGGT	11.30^{b}±0.01	6.30^{c}±0.02	0.45^{g}±0.02	1.98^{d}±0.02	1.80^{c}±0.01	77.14^{e}±0.01
PI	10.83^{f}±0.02	4.00^{f}±0.01	2.55^{a}±0.01	1.03^{c}±0.01	1.73^{e}±0.01	77.36^{c}±0.02
PIGI	11.00^{e}±0.01	6.33^{d}±0.02	2.43^{b}±0.02	1.83^{f}±0.02	1.78^{d}±0.01	76.49^{g}±0.01
PIGA	11.01^{e}±0.02	6.05^{f}±0.02	2.33^{d}±0.02	1.73^{g}±0.02	1.80^{c}±0.01	77.14^{e}±0.02
PITU	11.11^{d}±0.02	4.91^{e}±0.01	2.20^{c}±0.01	1.76^{g}±0.01	1.84^{b}±0.01	77.60^{b}±0.01
PIGGT	10.40^{g}±0.02	4.05^{f}±0.01	2.00^{c}±0.02	1.17^{f}±0.02	1.75^{e}±0.02	77.60^{b}±0.02
AP	10.00^{j}±0.01	4.00^{f}±0.01	2.30^{d}±0.01	1.14^{j}±0.02	1.76^{e}±0.02	78.82a±0.01
APGI	10.01^{j}±0.01	4.01^{f}±0.02	2.20^{d}±0.02	1.63^{i}±0.02	1.77^{e}±0.01	78.84^{a}±0.02
APGA	10.22^{i}±0.01	4.20^{g}±0.02	2.10^{c}±0.01	1.64^{i}±0.01	1.73^{e}±0.02	77.61^{b}±0.01
APTU	11.11^{d}±0.02	4.45^{f}±0.01	2.00^{d}±0.02	1.11^{b}±0.01	1.80^{c}±0.02	78.03^{a}±0.02
APGGT	11.01^{e}±0.02	3.44^{h}±0.01	2.00^{d}±0.02	1.63^{i}±0.01	1.75^{e}±0.01	78.17^{a}±0.01
CNTP	20.55^{a}±0.02	0.50^{i}±0.01	0.21^{i}±0.02	4.38^{a}±0.01	0.11^{g}±0.02	78.36^{a}±0.01

**Values are mean Standard deviation of three replications.*
Values followed by different letters along the same column are significantly ($P \leq 0.05$) different from each other
WA- Watermelon jam
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differed with pineapple-ginger jam (PIGI) showed the highest value of 50.67% while the reference jam (CNTP) has the lowest value of 20.65%. The antioxidant activity observed in the study was higher than 1.19% for tomato jam as reported by [43]. They were also higher than 10.06%, 9.95% and 8.96% for cherry, apricot and fig jams respectively [40]. Natural antioxidants have been known to exhibit a wide range of biological effects including antibacterial, antiviral, anticancer, anti-inflammatory, anti-allergic, anti-thrombic and vasodilatory activities. Antioxidant activity gives rise to anti-carcinogenicity, antimmunogenicity and anti-aging activities [44-45].

The total phenolic contents of the jam samples showed an increasing trend as shown in Fig. 2. The watermelon jam (WI) has a value of 0.14 mmGAE/ 100 g) while watermelon-ginger jam (WAGI), watermelon-garlic jam (WAGA) and watermelon-tumeric jam (WATU) has values of 0.25, 0.20 and 0.15 mmGAE/100 g respectively. The pineapple-ginger jam (PIGI) also showed the highest content of 0.28 mmGAE/100 g while watermelon-ginger-garlic-tumeric jam (WAGGT), pineapple-ginger-garlic-tumeric jam (PIGGT) and reference sample (CNTP) has the lowest value of 0.1mmGAE/100 g. Phenolics are naturally occurring compounds widely distributed in the plants kingdom and beneficial components of human diet. They are important constituents of plants which have multiple functions as dietary phytochemicals for human where they display a broad range of functional and biological activities [46].

3.4 Sensory Parameters of the Spiced Jams

The mean score value for the color of the watermelon jam (WA), watermelon-ginger jam (WAGI) watermelon-garlic jam (WAGA) and watermelon-tumeric jam (WATU) were 7.20,7.45, 6.10 and 7.07 respectively respectively. The reference sample (CNTP) showed the least value for color which was 5.50 as shown in Table 4. There were significant ($p < 0.05$) difference in the color and taste of the spiced and unspiced pineapple jams. The mean score for color and taste of pineapple-ginger jam (PIGI) with the values of 7.85 and 7.75 were found to be significantly higher than the pineapple jam (PI) with the value of 7.15 and 7.20. The overall acceptability of the pineapple-ginger jam (PIGI) with value of 7.88 was significantly higher than other samples including the reference sample. It can therefore be concluded that the pineapple-ginger jam was more acceptable by the panelists.

Table 3. Physicochemical properties of the spiced jam

Samples	pH	TSS (°brix)	TTA (g/ml)	TSS/TTA
WA	3.30^{c}±0.02	57.50^{g}±0.01	1.14^{d}±0.02	57.50^{d}±0.01
WAGI	3.40^{b}±0.02	55.25^{e}±0.02	1.14^{d}±0.01	48.46^{c}±0.02
WAGA	3.25^{d}±0.02	53.50^{g}±0.02	1.15^{d}±0.01	46.52^{a}±0.01
WATU	3.20^{e}±0.02	52.50^{b}±0.02	1.20^{c}±0.02	43.75^{g}±0.02
WAGGT	3.11^{g}±0.01	50.25^{g}±0.01	1.21^{c}±0.01	41.53^{k}±0.02
PI	3.20^{e}±0.01	59.27e±0.02	1.16^{d}±0.02	51.09^{t}±0.01
PIGI	3.15^{f}±0.02	55.27^{c}±0.01	1.41^{a}±0.01	39.47^{o}±0.02
PIGA	3.15^{t}±0.01	53.10^{a}±0.02	1.40^{a}±0.02	37.92^{n}±0.02
PITU	3.15^{f}±0.01	52.10^{d}±0.02	1.14^{d}±0.01	45.70^{b}±0.01
PIGGT	3.17^{f}±0.02	50.00^{h}±0.02	1.15^{d}±0.01	43.48^{h}±0.02
AP	3.20^{e}±0.01	59.00^{e}±0.02	1.21^{c}±0.02	48.76^{k}±0.02
APGI	3.30^{c}±0.02	56.00^{h}±0.02	1.20^{c}±0.01	46.67^{m}±0.02
APGA	3.30^{c}±0.02	54.01^{f}±0.01	1.20^{c}±0.02	45.00^{j}±0.02
APTU	3.40^{b}±0.01	52.10^{d}±0.01	1.21^{c}±0.01	43.06^{i}±0.02
APGGT	3.50^{a}±0.02	50.30^{e}±0.01	1.22^{c}±0.01	41.23^{l}±0.01
CNTP	3.10^{g}±0.01	69.80^{i}±0.01	1.13^{b}±0.02	61.22^{n}±0.01

**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
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CNTP- Reference sample

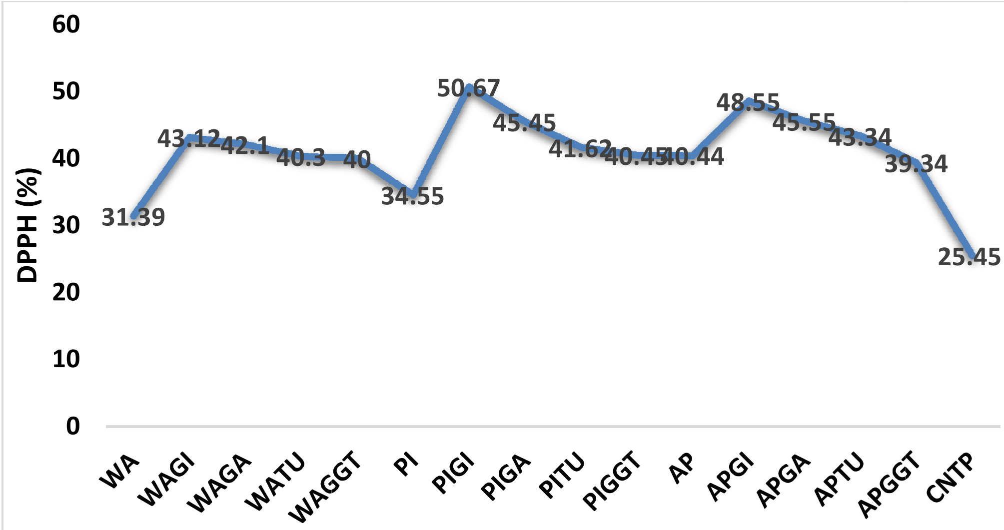

Fig. 1. Antioxidant activity of the spiced jams

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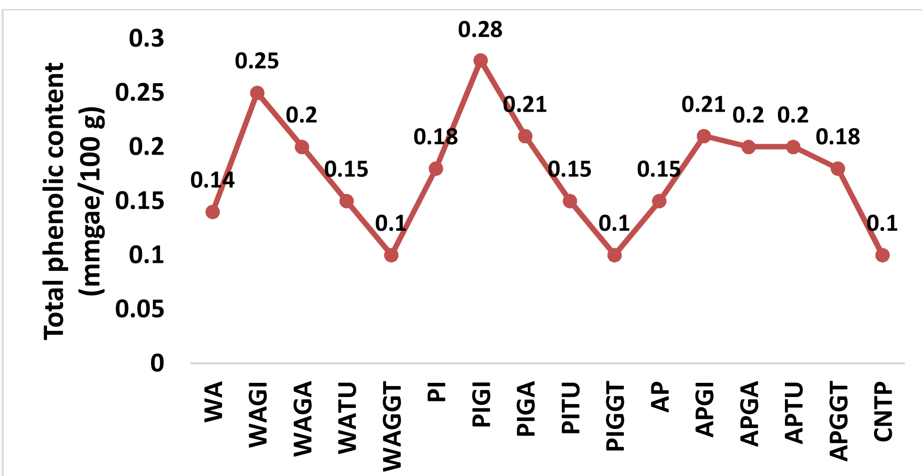

Fig. 2. Total phenolic content of the spiced jams

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Table 4. Sensory parameters of the spiced jams

Samples	Color	Taste	Mouthfeel	Flavor	Spreadability	Overall acceptability
WA	$7.20^{d}\pm0.02$	$7.30^{d}\pm0.01$	$7.10^{d}\pm0.01$	$7.10^{d}\pm0.02$	$6.55^{f}\pm0.01$	$7.25^{c}\pm0.02$
WAGI	$7.45^{b}\pm0.01$	$7.70^{a}\pm0.02$	$7.25^{b}\pm0.01$	$7.25^{c}\pm0.02$	$7.17^{d}\pm0.01$	$7.35^{a}\pm0.02$
WAGA	$6.10^{g}\pm0.02$	$6.00^{i}\pm0.01$	$6.11^{g}\pm0.01$	$6.21^{f}\pm0.01$	$6.12^{j}\pm0.02$	$6.14^{f}\pm0.01$
WATU	$7.07^{e}\pm0.01$	$7.40^{c}\pm0.01$	$7.00^{e}\pm0.02$	$7.30^{b}\pm0.01$	$7.02^{e}\pm0.02$	7.05e±0.01
WAGGT	$4.30^{j}\pm0.01$	$4.00^{j}\pm0.02$	$4.45^{i}\pm0.02$	$5.00^{i}\pm0.01$	$6.00^{j}\pm0.02$	$6.15^{f}\pm0.02$
PI	$7.15^{e}\pm0.02$	$7.20^{e}\pm0.01$	$7.20^{c}\pm0.02$	$7.12^{d}\pm0.02$	$7.40^{b}\pm0.01$	$7.10^{d}\pm0.01$
PIGI	$7.85^{a}\pm0.01$	$7.80^{b}\pm0.01$	$7.45^{a}\pm0.02$	$7.48^{a}\pm0.01$	$7.45^{a}\pm0.02$	$7.88^{b}\pm0.02$
PIGA	$7.10^{e}\pm0.02$	$7.00^{f}\pm0.02$	$6.99^{f}\pm0.02$	$6.00^{h}\pm0.02$	$6.34^{g}\pm0.02$	$6.24^{g}\pm0.02$
PITU	$7.25^{c}\pm0.02$	$7.00^{f}\pm0.02$	$7.00^{e}\pm0.02$	$7.10^{d}\pm0.01$	$7.20^{c}\pm0.01$	$7.60^{a}\pm0.01$
PIGGT	$7.00^{e}\pm0.01$	$6.15^{g}\pm0.02$	$6.10^{g}\pm0.01$	$7.00^{e}\pm0.02$	$6.15^{j}\pm0.01$	$6.00^{g}\pm0.02$
AP	$6.50^{f}\pm0.02$	$6.15^{g}\pm0.01$	$6.11^{g}\pm0.01$	$6.12^{g}\pm0.01$	6.15j±0.01	$6.11^{h}\pm0.02$
APGI	$6.00^{h}\pm0.01$	$6.15^{g}\pm0.01$	$6.10^{g}\pm0.02$	$6.11^{g}\pm0.01$	$6.25^{h}\pm0.01$	$6.15^{h}\pm0.01$
APGA	$6.00^{h}\pm0.02$	$6.15^{g}\pm0.01$	$6.10^{g}\pm0.01$	$6.10^{g}\pm0.02$	$6.20^{i}\pm0.02$	$6.20^{h}\pm0.01$
APTU	$6.10^{g}\pm0.02$	$6.10^{i}\pm0.02$	$6.12^{g}\pm0.01$	$6.15^{g}\pm0.02$	$6.11^{j}\pm0.01$	$6.15^{h}\pm0.02$
APGGT	6.10g±0.02	$6.15^{g}\pm0.02$	$6.12^{g}\pm0.02$	$6.00^{h}\pm0.01$	$6.15^{j}\pm0.02$	$6.11^{h}\pm0.02$
CNTP	$5.55^{i}\pm0.02$	$6.12^{h}\pm0.02$	$5.55^{h}\pm0.02$	$6.23^{f}\pm0.02$	$5.00^{k}\pm0.01$	$5.89^{f}\pm0.02$

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4. CONCLUSION

The fruit spiced jam samples exhibits a high nutritional and antioxidant quality. The total soluble solid and total titratable acidity were found to be within recommended range by Codex Alimentarius. Antioxidant properties of the samples showed the functionality healthy attribute of the samples. However, the pineapple-ginger jam showed a more general acceptability by the panelist as against other samples. Conclusively, the pineapple-ginger jam showed a very high nutrient and bioactive component which make it to be functional and healthy foods for both children and adult alike.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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