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Evaluation of Nutrient Composition, Physicochemical and Sensory Properties of Mixed Fruit Juice Produced from Shaddock (*Citrus maxima*), Watermelon (*Citrullus lanatus*) and Pawpaw (*Carica papaya*) Blends

J. I. Okoye [a*] and P. C. Uke [b]

[a] Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria.
[b] Department of Agricultural Economics and Extension, Enugu State University of Science and Technology, Enugu, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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**Corresponding author: E-mail: okoyejoseph6@gmail.com;*

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ABSTRACT

The study was carried out to evaluate the effect of addition of watermelon and pawpaw juices on the proximate, mineral, vitamin, physicochemical and sensory properties of shaddock-based mixed fruit juice samples. The shaddock, watermelon and pawpaw juices were blended in the varied ratios of 100:0:0, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25, respectively to produce mixed fruit juice samples, while the sample prepared from 100% shaddock juice was used as control. The mixed fruit juice samples produced were analysed for proximate, mineral, vitamin, physicochemical and sensory properties using standard methods. The proximate composition of the mixed fruit juice samples were 78.34 to 85.50% moisture, 1.11 to 1.37% ash, 0.28 to 0.40% crude fibre, 0.10 to 0.29% fat, 1.05 to 1.18% protein, 10.71 to 18.67% carbohydrate and 50.46 to 81.81KJ/100g energy. The mineral composition showed that the mixed fruit juices had a range of 13.26 to 37.77mg/100g calcium, 18.89 to 54.71mg/100g magnesium, 21.11 to 47.36mg/100g phosphorus, 12.67 to 44.22mg/100g potassium, 2.15 to 2.68mg/100g iron and 1.42 to 2.05mg/100g zinc. The vitamin composition also showed that the thiamine, niacin, riboflavin, vitamin A and ascorbic acid contents of the samples ranged from 2.36 to 3.57mg/100g, 2.14 to 3.56mg/100g, 1.21 to 2.76 mg/100g, 2.33 to 3.77mg/100g and 4.55 to 5.22mg/100g, respectively. Results showed that the ash, crude protein, carbohydrate, energy, mineral and vitamin contents of the mixed fruit juice samples produced from the composite blends increased with increase in the addition of watermelon and pawpaw juices to the products. The physicochemical properties of the mixed fruit juices revealed that the pH, titratable acidity, total soluble solids and viscosity ranged from 3.04 to 4.17, 1.97 to 2.16%, 2.11 to 2.42% and 1.27 to 1.65cP, respectively. The result also showed that the pH and total soluble solids of the samples increased with increase in substitution of watermelon and pawpaw juices, while the titratable acidity and viscosity decreased. The sensory properties of the mixed fruit juice samples showed that the control (Juice made with 100% shaddock) was the most acceptable by the judges and also differed significantly ($p<0.05$) in colour, taste, aroma, consistency and mouthfeel from the mixed fruit juice samples produced from shaddock, watermelon and pawpaw blends. Generally, both the control and the mixed fruit juice samples were generally acceptable by the judges because they were rated high in all the sensory attributes evaluated in this study.

Keywords: Mixed fruit juice; nutrient composition; physicochemical properties; sensory properties.

1. INTRODUCTION

"Fruit juices are rich sources of nutrients such as vitamins, minerals and other naturally occurring phytochemicals that are of health and therapeutic benefits, hence, they have recently become indispensable part of peoples' diet" [1,2]. "Fruit juices are becoming an important part of modern diet in many communities and their consumption is popular in Nigeria because of their health and invigorating benefits" [3]. "They act as nutritious beverages and play significant roles in healthy diets since they offer good taste and varieties of nutrients are found naturally in fruits" [4]. "In Nigeria, different kinds of seasonal fruits are available including apple, orange, pineapple and grape etc., which provide a wide range of vitamins, minerals, antioxidants and fibres that are essential for human health" [5]. "Fruit juice intake is a convenient way by which people receive the benefits of various fruits when whole fruit is not readily available or desired" [6]. "Properly extracted juices are very similar to the fruits because they contain most substances which are found naturally in fruits. Fruit juices are always 100% fruit products and should not be confused with soft drinks or other refreshing drinks" [7]. "Juices are available either in their freshly prepared form or industrially processed form. In either case, it is expected to be free from contaminants and contain most substances which are found in the original ripe and sound fruit from which the juice is extracted, with no added sugar or preservative" [8]. "Fruit juices contain water and varying concentrations of carbohydrates such as sucrose, fructose, glucose and sorbitol" [9]. "They are rich in phytochemicals, minerals, vitamins and contain small amount of protein, but without fat, cholesterol and fibre. The micronutrients and phytochemicals contained in fruit juices are responsible for the several health benefits associated with their consumption. However, excessive consumption of fruit juice in recent times has been associated with the development of type-2-diabetes, dental caries and obesity which are all attributed to its high sugar content" [10]. "The minerals that are found naturally in fruit

juices include sodium, potassium, magnesium, phosphorus, calcium and iron which are essential for good health if present in adequate concentration but are harmful when in excess or deficient, hence the need for their proper representation. The liquid nature of fruit juice and the availability of several raw fruit materials offer many mixing options and a blending opportunity which lead to a variety of fruit juice products" [3, 1].

The nutritional and health benefits of continuous consumption of adequate amount of fruits and vegetables generally are well recognized. Fruits and vegetables contain essential nutrients that promote the body growth. They are great sources of vitamins, minerals and fibre [11]. A diet which is rich in fruit and vegetable can promote eye health, lower blood pressure, prevent the risk of heart diseases, stroke, cancer, and digestive problems [12,13,14,15].Fruits which are generally used for making fruit juices include orange, grape, apple, watermelon, pineapple and mango etc., while some of the fruits are widely consumed fresh. Mixed fruit juice can be produced by blending together of various fruits such as orange, pineapple and pawpaw among others in order to combine all the basic nutrients in them.

"Shaddock (*Citrus maxima*) is the largest of all *Citrus* varieties. The pulp is usually white or pinkish red in colour with spindle-shaped juice sacks that separate easily from one another and has a sweetish-acidic flavour" [16]. "The interest in *Citrus* fruits has greatly increased because of their different important roles like nutritive, antimicrobial, antioxidant and many other properties" [17]. "These protective roles could be mainly attributed to various nutrient and non-nutrient bioactive compounds such as vitamins, minerals and phytochemicals present in them.

The intake of shaddock (Citrus maxima) fruit has been observed to be low compared to other citrus fruits"[18,19].

Watermelon (*Citrullus lanatus*) is a tropical fruit that is mainly eaten in its raw form. However, its consumption pattern in many developed countries especially USA has shifted from fresh fruit to the processed forms like juice, wine, jam and preserves etc for the purpose of convenience, availability all year round and uniform quality, when compared to developing countries like Nigeria, where it is consumed fresh and raw due to inadequate processing and storage technologies [20,21,22]. Nutritionally, watermelon contains 0.61g protein, 0.4g dietary fibre, 7.55g carbohydrate and 0.15g fat. It is relatively rich in minerals and vitamins such as calcium, iron, magnesium, phosphorus, manganese, sodium, zinc, thiamine, niacin, vitamin B_6, vitamin A, ascorbic acid, pantothenic acid and choline. It is also a rich source of carotenoids including lycopene, phytoene, beta carotene, lutein and neurosporene [23]. "Lycopene is made up of the majority of the carotenoids in watermelon. The carotenoid content varies depending on the variety of the watermelon. Watermelon is largely consumed as a refreshing summer fruit and is also used to make a variety of fruit-based products such as jam, salad, fruit juice and wine" [24].

"Paw-paw or Papaya (*Carica papaya*) is an important fruit crop throughout the tropical and sub-tropical Africa. It is used by people in the tropics as breakfast and is also an important ingredient in the manufacture of jellies and preserves. It is rich in vitamins and minerals and the fruit has pronounced bactericidal effects" [13]. "The preservation of pawpaw fruit poses a big problem particularly in rural areas where there are no steady electricity supply and inadequate storage facilities like cold store rooms or refrigerators. As a result, farmers are compelled to either let them rot away or dispose them at giveaway prices during glut season" [25,26,27]. "The papaya fruit, as well as all other parts of the plant contain a milky juice in which an active principle known as papain is present. This enzyme papain is widely used for tenderization of meat, treatment of dyspepsia and in the clarification of beer in breweries" [28,2]. "The unripe fruit is used as a remedy for ulcer and impotence. It cleans bacteria from the intestine and hence encourages the absorption of vitamins and minerals, especially vitamin B_{12} in humans" [18]. The objective of this study was to evaluate the nutrient composition, physiochemical and sensory properties of mixed fruit juice produced from shaddock, watermelon and pawpaw blends.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

The shaddock, watermelon and pawpaw fruits used for this study were purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria. The chemicals used for the analyses were of analytical grade.

2.2 Preparation of Shaddock Fruit Juice

The shaddock juice was prepared according to the method described by Aadil *et al*. [7] with slight modifications. Two kilogrammes (2kg) of shaddock fruits was sorted to separate the wholesome from the unwholesome fruits. The fruits were rinsed and washed manually with 2.5 litres of potable water after which they were peeled, cut and deseeded. The edible parts of the shaddock fruits were separated from the non-edible parts. Then, the peeled and deseeded edible parts of the shaddock fruits were blended in a Kenwood blender (Model, BLP10, 4500W, Germany) to obtain the juice. The shaddock juice obtained was filtered thoroughly with a well cleaned muslin cloth to obtain a clear juice. The juice produced was packaged in a sterilized airtight plastic container, labelled and stored in a refrigerator until needed for further use.

2.3 Preparation of Watermelon Juice

The watermelon juice was prepared according to the method described by Dia [29] with slight modifications. Two kilogrammes (2kg) full head of watermelon fruits was washed with 3 litres of potable water. The washed watermelon fruits were cut into two parts with a kitchen knife and peeled to remove the epicarp. The peeled watermelon fruits were deseeded and sliced into smaller slices of 2 cm in diameter. The watermelon slices were blended in a Kenwood blender (Model BLP10, 4500W, Germany) to obtain the juice. The resultant juice was filtered using a well cleaned muslin cloth. The clear juice obtained was packaged in a sterilized airtight plastic container, labelled and stored in a refrigerator until needed for further use.

2.4 Preparation of Pawpaw Juice

The pawpaw juice was prepared according to the method described by Elochukwu and Onyekwelu [30]with slight modifications. Two kilogrammes (2kg) full head of pawpaw fruits was washed with 3 litres of potable water. The washed pawpaw fruits were peeled with a kitchen knife to remove the epicarp. After peeling, the fruits were cut into two parts, deseeded and sliced into smaller slices of 2 cm in diameter. The pawpaw slices were blended in a Kenwood blender (Model BLP10, 4500W, Germany) to obtain the juice. The resultant juice was filtered using a well cleaned muslin cloth. The clear juice obtained was packaged in a sterilized airtight plastic container, labelled and stored in a refrigerator until needed for further use.

2.5 Preparation of Mixed Fruit Juice Samples

The mixed fruit juices were prepared according to the method described by Bailey *et al* [12]. After the extraction of the juices from their respective fruits, the shaddock, watermelon and pawpaw juices were blended in the ratios of A- 100:0:0, B- 90:5:5, C- 80:10:10, D- 70:15:15, E- 60:20:20 and F- 50:25:25, respectively. Thereafter, 3g of sugar (sucrose) and 0.05g of citric acid were added to the mixed juice fruit samples and the mixture was then mixed thoroughly in a Kenwood blender (Model BLP10, 4500W, Germany) for 10 min to improve the taste and extend the shelf-life of the products. The mixed fruit juices obtained were packaged separately in sterilized airtight plastic bottles and pasteurized at 90°C for 15 sec. The pasteurized mixed fruit juices were allowed to cool under ambient conditions and after cooling, they were labelled and kept in a refrigerator until needed for analysis.

2.6 Proximate Analysis

The moisture content was determined by hot air oven drying of the samples at a temperature of 105^0C to constant weight according to the method of AOAC [31]. The ash, crude protein (Nx6.25), crude fibre and fat (solvent extraction) were determined using the standard analytical methods [31]. Carbohydrate was calculated by difference as 100% - (% Moisture + %Fat + %Ash + % Protein + % Crude Fibre). The energy content was calculated by multiplying the percentage values of protein, fat and carbohydrate of the samples by the Atwater factors of 4, 9 and 4 respectively, [31]. All determinations were carried out in triplicate samples and on wet weight basis.

2.7 Mineral Analysis

The mineral elements were extracted by dry ashing of the samples in a muffle furnace at 550^0C to constant weight followed by the dissolution of the ash obtained from each sample in a volumetric flask by the addition of 50mL of de-ionised water and a few drops of Hydrochloric acid. The calcium, magnesium and phosphorus contents of the samples were determined on wet weight basis by the use of atomic absorption spectrophotometer. The potassium and iron contents were also determined using the Techcomp AA600 atomic absorption spectrophotometer and further confirmed by the use of digital flame photometer according to the

methods of AOAC [31]. All determinations were carried out in triplicate samples.

2.8 Vitamin Analysis

The thiamine, niacin and ascorbic acid contents of the samples were determined on wet weight basis using the atomic absorption spectrophotometer (Perkin-Elmer, Model 300, Norwalk, CT, USA) after extraction. The riboflavin content was determined by the use of the digital fluorimeter. The vitamin A content was determined using the ultraviolet absorption spectrophotometer after extraction with chloroform. All determinations followed the AOAC [31] methods and were carried out in triplicate samples.

2.9 Physicochemical Analysis

The pH of the samples was determined using the digital pH meter (Model pH 500, Clean) Instrument Co. Ltd, Shanghi, China). The total soluble solids content was determined by the use of the digital refractometer (Model DR 301-95, A, Kruss Optronic Co. Ltd, Germany). The viscosity was determined using Rion –viscotester (Model VA – 04F, Kruss Optronic Co. Ltd, Germany). The titratable acidity was determined after centrifugation and dilution followed by the titration of the diluent against 0.1N Sodium hydroxide solution using phenolphalthalein as an indicator. All determinations followed the AOAC [31] procedures and were carried out on wet weight basis in triplicate samples.

2.10 Sensory Evaluation

The mixed fruit juices produced were cooled for 2 h at room temperature after pasteurization and evaluated by a panel of fifteen (15) semi-trained consumer panellists consisting of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology (ESUT), Enugu, Nigeria. The criteria for selection were that the panellists were 18 years and above, regular consumers of fruit juices and not allergic to any food. The panellists filled a consent form approved by the University Institutional Review Board and received instructions on how to carry out the sensory test. The juice samples were separately coded and served to the panellists in white plastic cup of similar sizes. The panellists were asked to taste, assess and score each sample using a nine (9) point Hedonic scale for the attributes of colour, consistency, colour, taste, and overall acceptability. A cup of drinking water and unsalted crackers were also provided to each panellist to rinse his or her mouth after testing each sample to avoid residual effect. The panellists evaluated and scored the juice samples based on their preference and acceptability of each sample.

2.11 Statistical Analysis

The data were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 23) software. Significant means were separated using the Tukey's test at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Mixed Fruit Juice Samples

The proximate composition of the mixed fruit juices are presented in Table 1.

The moisture content of the mixed fruit juice samples ranged from 78.34 to 85.50%. The control sample (Juice made from 100% shaddock) had the highest moisture content (85.50%), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least value (78.34%). There were significant ($p<0.05$) differences in the moisture content of the samples. The values (78.34-85.50%) obtained in this study were similar to the moisture content (77.52-89.78%) reported by Akusu *et al*. [5] for mixed fruit juice produced from orange and pineapple blends. The high content of moisture in the samples suggested that they could not be kept under ambient conditions for a prolonged period of time [32]. The moisture content of the samples was within the acceptable range of 80 – 90% moisture for fruit and vegetable juices [33]. The moisture content of any food is used as an index of its shelf stability [34] and is used as a measure of the stability and susceptibility to microbial contamination [24]. This implies that the increase in the substitution of the shaddock juice with watermelon and pawpaw juices would increase its shelf-life due to its low moisture content.

The ash content of the mixed fruit juice samples ranged from 1.10 to 1.37% with the mixed fruit juice substituted with 25% watermelon and 25% pawpaw juices and the control (Juice made from 100% shaddock) having the highest (1.37%) and least (1.10%) values, respectively. The ash

content of the mixed fruit juice samples showed significant ($p<0.05$) variation between the samples. The increase in the addition of watermelon and pawpaw juices increased the ash content of the mixed fruit juice samples. This increase could be due to the variations in the ash contents of the individual fruits used for the production of the mixed fruit juice samples. The values (1.10-1.37%) obtained in this study were lower than the ash content (2.55-3.28%) reported by Adedeji and Oluwalana [35] for wine produced from watermelon and pawpaw blend. The ash content is an indication of mineral content [36]. The result showed that these fruits namely shaddock, watermelon and pawpaw contain low levels of minerals.

The crude fibre content of the mixed fruit juice samples ranged from 0.28 to 0.40%. The control (Juice made from 100% shaddock) had the highest value (0.40%), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least crude fibre content (0.28%). There were significant ($p<0.05$) differences in crude fibre content of the samples. The crude fibre content reported in this study (0.28-0.40%) was higher than that of the crude fibre content (0.01 %) reported by Ayodele and Aransiola[6] for watermelon and orange mixed fruit juice. The presence of fibre in a diet lessens serum cholesterol level [37] and if it is in a very high amount assimilates essential trace elements in the gut [38]. Fibre aids in bowel regulation, assists in maintenance of blood sugar levels, reduces constipation, and also averts heart diseases [39,32].

The fat content of the mixed fruit juice samples ranged from 0.10 to 0.29%. The sample substituted with 25% watermelon and 25% pawpaw juices had the highest fat content (0.29%), while the control sample (Juice made from 100% shaddock) had the least fat content (0.10%). The values (0.10-0.29%) obtained in this study were comparable with the fat content (0.16-0.34%) reported by Ikenebomeh and Omogbai [9] for mixed fruit juice produced from pawpaw and watermelon fruits. The low fat content observed in this study could be attributed to the fact that fruits generally are not good sources of fat [40]. Fats supply the body with more energy; approximately twice that of carbohydrate and protein and eases intestinal absorption and transfer of nutrients [41]. Fat is also important in diets because it promotes the absorption of fat-soluble vitamins [42].

The protein content of the mixed fruit juice samples ranged from 1.05 to 1.18% with the control (Juice made from 100% shaddock) having the highest protein content (1.18%), while the mixed fruit juice substituted with 25% watermelon and 25% pawpaw juices had the least protein content (1.05%). The crude protein content of the mixed fruit juice samples showed significant ($p<0.05$) variations between the samples. The differences could be due to variation in the levels of protein in the individual fruits used for the production of mixed fruit juices. The low protein content observed in all the mixed fruit juice samples is an indication that fruit juices are low in protein contents [43]. The values (1.05-1.18%) of the crude protein content obtained in this study were lower than the value (1.76 %) reported by Anitha *et al*. [44] for pawpaw juice. Dietary proteins are needed for the synthesis of new cells, enzymes, hormones and other substances required for the maintenance and development of the body [45]. Protein is also a crucial source of amino acids. Protein deficiency may lead to growth retardation, abnormal swelling of the belly, muscle wasting, and collection of fluids in the body [46].

The carbohydrate content of the mixed fruit juice samples ranged from 10.71 to 18.67%. The sample substituted with 25% watermelon and 25% pawpaw juices had the highest carbohydrate content (18.67%), while the control (Juice made from 100% shaddock) had the least value (10.71%). The carbohydrate content of the mixed fruit juices showed significant ($p<0.05$) variations among of the samples. The values (10.71-18.67%) obtained in this study were lower than the carbohydrate content (12.08-18.68%) reported by Abirami *et al*. [3] for tomato juice and cocktail juice produced from orange, tomatoes and carrots. Generally, the samples with low carbohydrate content might be ideally useful for diabetic and hypertensive patients that require low sugar diets. The function of carbohydrate is to provide energy to the body. Carbohydrate also add to the sweetness, appearance and textural attributes of many foods [47].

The energy content of the mixed fruit juice samples ranged from 50.46 to 81.81 KJ/100g. The sample substituted with 25% watermelon and 25% pawpaw juices had the highest value (82.81KJ/100g), while the control sample (Juice made from 100% shaddock) had the least value (50.46 KJ/100g). The energy content of the substituted samples were generally higher than

the energy value of the control sample. This could be due to substitution effect which led to increase in the energy content of the mixed fruit juice samples. Energy content is a parameter used to determine the quality of food, especially for the products that are meant for adults with high energy requirements [42]. The addition of watermelon and pawpaw juices to shaddock juice in the preparation of mixed fruit juice samples generally increased the ash, fat, carbohydrate and energy contents of the products with a remarkable decrease in their crude fibre and protein contents.

3.2 Mineral Composition of Mixed Fruit Juice Samples

The mineral composition of the mixed fruit juices are presented in Table 2.

The calcium content of the mixed fruit juice samples ranged from 13.26 to 37.77mg/100g. The mixed fruit juice sample substituted with 25% watermelon and 25% pawpaw juices had the highest calcium content (37.77 mg/100g), while the control (Juice made from 100% shaddock) had the least calcium content of 13.26 mg/100g. The calcium content of the samples increased sequentially with increase in the addition of watermelon and pawpaw juices to the products. The values (13.26-37.77mg/100g) obtained in this study were lower than the calcium content (120.11-390.77 mg/100g) reported by Arawande and Borokini [43] for mixed fruit juice produced from orange and watermelon blends. Calcium is very crucial in blood clotting, muscle contraction and for the activity of certain enzymatic processes [48]. Calcium is a crucial component of a healthy diet. It plays an important role in building healthy and dense bones and teeth. It is also needed for normal functioning of the heart, muscles, and nervous system [49].

The magnesium content of the mixed fruit juice samples ranged from 18.89 to 54.71mg/100g. The mixed fruit juice sample substituted with 25% watermelon and 25% pawpaw juices had the highest magnesium content (54.71 mg/100g), while the control (Juice made from 100% shaddock) had the least value (18.89mg/100g). The increase is an indication that watermelon and pawpaw are rich sources of magnesium [50]. The magnesium content (18.89-54.71 mg/100 g) obtained in this study were lower than the values (30.67 -72.45 mg/100 g) reported by Egbekum and Akubor [51] for beverage prepared from melon seed and orange juice. Magnesium is important for bone formation. It activates enzymatic systems responsible for metabolism of calcium. It also activates the electrical potential of the nerves [52].

The phosphorus content of the samples ranged from 21.11 to 47.36mg/100g. The increase in the incorporation of watermelon and pawpaw juices resulted in increase in the phosphorus content of the samples. The phosphorus content values (21.11 to 47.36 mg/100g) obtained in this study were lower than the values (48.58 – 66.42 mg/100g) reported by Adedeji and Oluwalana [35] for wine produced from watermelon and pawpaw blend. Phosphorus and calcium are related in their functions because they reciprocate each other. The complexion of these elements give rigidity to bones and teeth formation. Phosphorus helps in healthy bone formation. It also improves digestion and regulates the excretion and protein formation in the body [43].

The potassium content of the samples ranged from 12.67 to 44.22mg/100g. The mixed fruit juice substituted with 25% watermelon and 25% pawpaw juices had the highest potassium content (44.22mg/100g), while the control (Juice made from 100% shaddock) had the least value (12.67mg/100g). There were significant ($p<0.05$) differences in the potassium content of the samples. The samples substituted with higher proportions of watermelon and pawpaw juices had higher potassium contents compared to the control sample. The values (12.67-44.22mg/100g) obtained in this study were lower than the potassium content (62.34- 88.49 mg/100 g) reported by Akusu *et al*. [5] for mixed fruit juice prepared from orange and pineapple blend. Potassium is essential in the maintenance of cellular water balance and regulation of pH in the body. It is also associated with carbohydrate and protein metabolism as well as in the proper functioning of the muscles and nervous tissues [4,40]. It is also the main intracellular cation that maintains intracellular osmotic pressure. The low potassium in the blood is a life-threatening problem in human body [53,54].

Table 1. Proximate composition (%) of mixed fruit juice samples

Samples	Moisture	Ash	Crude Fibre	Fat	Protein	Carbohydrate	Energy (KJ/100g)
A	85.50^{a}±0.11	1.10^{f}±0.03	0.40^{a}±0.02	0.10^{b}±0.02	1.18^{a}±0.00	10.71^{f}±0.11	50.46^{f}±1.41
B	84.59^{b}±0.11	1.16^{e}±0.02	0.38^{b}±0.05	0.14^{e}±0.02	1.16^{b}±0.01	12.57^{e}±0.03	56.83^{e}±0.71
C	83.27^{c}±0.10	1.22^{d}±0.03	0.36^{c}±0.03	0.17^{d}±0.04	1.13^{c}±0.02	13.85^{d}±0.14	62.76^{d}±0.73
D	81.65^{d}±0.09	1.25^{c}±0.04	0.33^{d}±0.06	0.20^{c}±0.06	1.11^{d}±0.04	15.46^{c}±0.12	69.53^{c}±0.69
E	80.34^{e}±0.08	1.29^{b}±0.07	0.30^{e}±0.04	0.24^{b}±0.05	1.07^{e}±0.06	16.76^{b}±0.11	75.77^{b}±0.80
F	78.34^{f}±0.07	1.37^{a}±0.05	0.28^{f}±0.02	0.29^{a}±0.03	1.05^{f}±0.05	18.67^{a}±0.10	81.81^{a}±1.35

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly ($p<0.05$) from each other. A - Mixed fruit juice made with 100% shaddock, B - Mixed fruit juice made with 90% shaddock, 5% watermelon and 5% pawpaw, C - Mixed fruit juice made with 80% shaddock, 10% watermelon and 10% pawpaw, D - Mixed fruit juice made with 70% shaddock, 15% watermelon and 15% pawpaw, E - Mixed fruit juice made with 60% shaddock, 20% watermelon and 20% pawpaw and F- Mixed fruit juice made with 50% shaddock, 25% watermelon and 25% pawpaw.

The iron content of the samples which ranged from 2.15 to 2.68mg/100g increased significantly ($p<0.05$) with increase in substitution of watermelon and pawpaw juices in the products. The increase could be as a result of the high iron contents of watermelon and pawpaw juices used for the preparation of mixed juice samples. The iron contents of all the samples produced were lower than the recommended dietary allowance (RDA) of iron for all age groups of men and women which is 8 mg per day. The recommended dietary allowance of iron for men and postmenopausal women is 8 mg per day, while that of the premenopausal women is 18 mg / day. The median dietary intake of iron is approximately 16 to 18 mg/day for women and 12 mg/day for men, respectively [55]. Iron is used for transportation of oxygen from the blood to the tissue and for the formation of melanin in the body [42]. It is also a vital element in the diet of pregnant women, nursing mothers, infants, convulsive patients and elderly to avert anemia and other related diseases. However, over consumption of iron for a prolonged period of time results in liver failure [12,56].

The zinc content of the mixed fruit juice samples ranged from 1.42 to 2.05 mg/100g. The samples substituted with higher proportions of watermelon and pawpaw juices had the highest zinc contents than the control sample. This could be due to the substitution effect which is an indication that watermelon and pawpaw are rich sources of zinc [13,57]. The values (1.42 -2.05 mg/100 g) obtained in this study were lower than the zinc content (3.19 -5.62 mg/100 g) reported by Ijah *et al.* [24] for watermelon juice and watermelon-orange juice mix. Zinc is known to play a vital role in gene expression and regulation of cellular growth. It also participates as a co-factor of enzymes responsible for protein, carbohydrate and nucleic acid metabolism in human body [58]. Zinc is the basic element that is needed for the activation of specific enzymes. Zinc that possesses organic compounds is employed as anti-fungal and astringent agents. It also facilitates wound healing in human body [59]. Zinc deficiency in the developing countries is becoming a cause of worry because it has been shown that zinc deficiency is associated with not only stunted growth, but also increase in morbidity and impairment of immune functions [52].

The blending together of shaddock, watermelon and pawpaw juices in the preparation of mixed fruit juices greatly enhanced the mineral contents of the products.

3.3 Vitamin Composition of Mixed Fruit Juice Samples

The vitamin composition of the mixed fruit juices are presented in Table 3.

The thiamine content of the samples ranged from 2.36 to 3.57mg/100g. The mixed fruit juice samples substituted with watermelon and pawpaw juices at different stated levels had higher thiamine contents compared to the control sample. The values (2.36-3.57mg/100 g) obtained in this study were higher than the thiamine content (2.30-2.40mg/100g) reported by Arawande and Borokini[43] for mixed fruit juice produced from orange and watermelon blend. Thiamine (vitamin B_1) helps the body's cells to convert carbohydrates into energy. The main role of carbohydrate is to provide energy for the body, especially to the brain and nervous system. Thiamine also plays a role in muscle contraction and conduction of nerve signals [60, 2].

The niacin content of the mixed fruit juice samples ranged from 2.14 to 3.56mg/100g. The mixed juice sample substituted with 25% watermelon and 25% pawpaw juices had highest niacin content, while the control sample (Juice made from 100% shaddock fruit had the least value (2.14 mg/100g). This showed that watermelon and pawpaw are rich sources of niacin [61,62]. Niacin plays a vital role in the metabolism of carbohydrate, fat and protein. It also helps the nervous system to work properly. It is equally used by the body to produce sex and stress-related hormones. Niacin also improves the blood circulation and helps in the maintenance of the cholesterol level in human body [42].

The riboflavin content of the samples which ranged from 1.21 to 2.76mg/100g increased significantly ($p<0.05$) with increase in addition of watermelon and pawpaw juices to the products. The increase in the addition of watermelon and pawpaw juices resulted in increase in the riboflavin content of the samples and this is an indication that watermelon and pawpaw are good sources of riboflavin [50,63]. The recommended dietary allowance (RDA) for vitamin B_2 (riboflavin) for adult is 1.2 mg per day [8]. The values (2.35-3.51mg/100g) obtained in this study were higher than the riboflavin content (0.22-0.85mg/100g) reported by Hassan *et al.* [4] for commercial fruit juices sold in Egypt. Riboflavin is a key component of coenzymes involved in the growth of cells, energy production and the

breakdown of fats, steroids, and medications in human body [17].

The vitamin A content of the samples ranged from 2.33 to 3.77 mg/100g. There were significant ($p<0.05$) differences in the vitamin A content of the samples. The samples substituted with higher proportions of watermelon and pawpaw juices had higher vitamin A contents than the control sample (Juice made from 100% shaddock). The values (2.33-3.77mg/100g) obtained in this study were higher than the vitamin A content (0.29-0.45mg/100g) reported by Egbekun and Akubor [51] for melon seed-orange juice beverage. Vitamin A helps in the formation and maintenance of healthy teeth, skeletal and soft tissues, mucus membranes, and skin. It is also known as retinol because it produces the pigment that is naturally found in the retina of the eye. Vitamin A promotes good eyesight in the human body [38,64].

The ascorbic acid content of the mixed fruit juice samples which ranged from 4.55 to 5.22mg/100g was significantly ($p<0.05$) higher in mixed fruit juice samples substituted with different proportions of watermelon and pawpaw juices compared to the control (Juice made from 100% shaddock). The samples substituted with watermelon and pawpaw juices at different stated levels had higher ascorbic acid content than the control sample. The increase could be due to substitution effect which showed that watermelon and pawpaw are rich in ascorbic acid contents [65,24]. Vitamin C (ascorbic acid) is needed for the repair of tissues in all parts of the body. The important functions of vitamin C in human body also include the formation of proteins needed for healing of wounds and development of scar tissues in the skin, tendons, ligaments and blood vessels. It is equally essential in repair and maintenance of cartilages and in the absorption of iron [66,42].

The addition of watermelon and pawpaw juices to shaddock juice in preparation of mixed fruit juices generally increased the vitamin contents of the samples.

3.4 Physicochemical Properties of Mixed Fruit Juice Samples

The physicochemical properties of the mixed fruit juices are presented in Table 4.

The pH of the mixed fruit juice samples ranged from 3.04 to 4.17. The mixed fruit juice substituted with 25% watermelon and 25% pawpaw juices had the highest pH value (4.17), while the control sample (Juice made from 100% shaddock) had the least value (3.04). The increase in the pH of the sample might be due to the addition of watermelon and pawpaw juices which are known to contain higher fruit acids to the product compared to shaddock juice which has low fruit acid content. The observation is in agreement with the report of Ayodele and Aransiola [6] for watermelon juice and watermelon orange juice mix. The pH value of the mixed fruit juices showed significant ($p<0.05$) variations among the samples. The values (3.04 to 4.17) obtained in this study were lower than the pH (3.20-4.46) reported by Fatemeh *et al*. [67] for orange drink in which sugar was replaced with date syrup. The pH is a measure of the degree of acidity or alkalinity of a product. The pH value of 3 to 4 would give juice a good potential to inhibit the growth of pathogenic bacteria and other spoilage microorganisms in such a product.

The titratable acidity of the mixed fruit juice samples ranged from 1.97 to 2.16%. The control sample (Juice made from 100% shaddock) had the highest value of titratable acidity (2.16%), while the sample containing 25% watermelon and 25% pawpaw juices had the least value (1.97%). The titratable acidity of the juices showed significant ($p<0.05$) variations among the samples. The acidity of liquid foods dictates the dominant microflora in such foods. It also determines the shelf stability of the juice products and other liquid foods. The more acidic the juice is, the less susceptible it will be to bacterial action but becomes more susceptible to the action of yeasts and moulds [68,69]. The presence of fruit acids in fruits tend to influence the colour, flavour and gustative characteristics of the fruit juice products made from them.

The total soluble solids content of the mixed fruit juice samples which ranged from 2.11 to 2.42% was significantly ($p<0.05$) higher in sample substituted with 25% watermelon and 25% pawpaw juices compared to the other test samples. The sample substituted with 25% watermelon and 25% pawpaw juices had the highest value (2.42%), while the control sample had the least value (2.11%). The increase in total soluble solids could be due to variation in the composition of fruits used for the preparation of mixed fruit juice samples. The result is in consonance with the findings of Adedeji and

Oluwalana [35] for wine produced from watermelon and pawpaw blend. There were significant ($p<0.05$) differences in the total soluble solids content of the samples. The total soluble solids content of juice is used as the basis for characterizing the quality of juice and other beverage products [70,71,72].

The viscosity of the juice samples ranged from 1.27 to 1.65cP. The control sample (Juice made from 100% shaddock) had the highest viscosity value (1.65cP), while the sample substituted with 25% watermelon and 25% pawpaw juices had the lowest value (1.27cP). The viscosity of the juices showed significant ($p<0.05$) differences among the samples. The values (1.27-1.65cP) obtained in this study were lower than the viscosity (6.87- 9.45cP) reported by Anvoh *et al*. [68] for juice and marmalade made from mucilage of cocoa beans. Viscosity is a parameter used to measure the bulkiness of fruit juice and other liquid food products. The addition of watermelon and pawpaw juices to shaddock juice in the preparation of mixed fruit juices greatly increased the pH and total soluble solids content of the samples with a slight decrease in their viscosity and titratable acidity.

3.5 Sensory Properties of Mixed Fruit Juice Samples

The sensory properties of the mixed fruit juices are presented in Table5.

The colour of the mixed fruit juice samples ranged from 6.16 to 7.47. The control (Juice made with 100% shaddock) had the highest value (7.47), while the mixed fruit juice substituted with 25% watermelon and 25% pawpaw juices had the least value (6.16). The scores of the colour attribute of the juice samples were generally high in all the samples evaluated in this study. However, the 100% shaddock fruit juice used as control was most acceptable by the judges and also differed significantly ($p<0.05$) from the other test samples in colour. The differences could be attributed to the unique quality of *Citrus* fruit in the preparation of fruit juice [56].

The taste of the mixed fruit juice samples which ranged from 6.00 to 7.50 showed that the control (100% shaddock fruit juice) had the highest score (7.50), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least score (6.00). The taste of the juice samples substituted with watermelon and pawpaw juices decreased with increase in the level of substitution. The control sample was rated higher by the judges than the composite juice samples in the attribute of taste. The differences could be attributed to the variations in the composition of the individual fruits used for the production of mixed fruit juices [35].

The aroma of the mixed fruit juice samples ranged from 6.10 to 8.10. The control (Juice made with 100% shaddock) had the highest value (8.10), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least value (6.10). There were significant ($p<0.05$) differences in the aroma among the samples. The juice prepared from 100% shaddock (control) was most acceptable to the panellists in terms of aroma compared to the other test samples. Aroma is a complex mixture of volatile compounds whose composition is specific to species and varieties[51]. The aroma volatiles are usually present at levels often measured in parts per million (ppm). The several types of aroma volatile components include monoterpenes, esters, organic acids, aldehydes, ketones and alkanes among others. The change in the aroma of the mixed fruit juice samples could be due to differences in composition of the individual raw materials used in their preparation [13,19,73].

The consistency of the mixed fruits juice samples ranged from 6.00 to 8.33. The control (Juice made with 100% Shaddock) had the highest value (8.33), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least value (6.00). The result showed that the juice made from 100% shaddock was rated highest in terms of consistency by the judges compared to the other test samples. The consistency of the mixed fruit juice samples substituted with watermelon and pawpaw juices at different stated levels was generally rated low compared to the control. This could be attributed to the ability of watermelon and pawpaw juices to reduce the consistency of the mixed fruit juice samples. Egbekun and Akubor [51] also reported a score of 8.10 for consistency of beverage made with 80% orange juice and 20% melon seed.

Table 2. Mineral composition (mg/100g) of mixed fruit juice samples

Samples	Calcium	Magnesium	Phosphorus	Potassium	Iron	Zinc
A	13.26^{f}±0.74	18.89^{f}±0.47	21.11^{f}±0.69	12.67^{f}±0.01	2.15^{f}±0.02	1.42^{f}±0.01
B	16.04^{e}±0.70	23.92^{e}±0.69	28.69^{e}±0.71	18.05^{e}±0.70	2.25^{e}±0.05	1.56^{e}±0.07
C	12.91^{d}±0.71	31.95^{d}±0.69	32.79^{d}±0.36	23.45^{d}±0.01	2.31^{d}±0.07	1.65^{d}±0.05
D	28.97^{c}±0.69	38.83^{c}±1.40	36.93^{c}±0.70	29.33^{c}±0.55	2.48^{c}±0.03	1.73^{c}±0.03
E	31.77^{b}±0.73	45.37^{b}±1.44	40.72^{b}±0.63	35.74^{b}±2.10	2.55^{b}±0.04	1.77^{b}±0.02
F	37.77^{a}±0.72	54.71^{a}±0.69	47.36^{a}±1.41	44.22^{a}±1.32	2.68±0.08	2.05^{a}±0.04

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Mixed fruit juice made with 100% shaddock, B - Mixed fruit juice made with 90% shaddock, 5% watermelon and 5% pawpaw, C - Mixed fruit juice made with 80% shaddock, 10% watermelon and 10% pawpaw, D - Mixed fruit juice made with 70% shaddock, 15% watermelon and 15% pawpaw, E - Mixed fruit juice made with 60% shaddock, 20% watermelon and 20% pawpaw and F- Mixed fruit juice made with 50% shaddock, 25% watermelon and 25% pawpaw.

Table 3. Vitamin composition (mg/100g) of mixed fruit juice samples

Samples	Thiamine	Niacin	Riboflavin	Vitamin A	Ascorbic acid
A	2.36^{e}±0.03	2.14^{f}±0.02	1.21^{a}0.06	2.33^{f}±0.06	4.55^{f}±0.03
B	2.54^{d}±0.08	2.20^{e}±0.05	1.51^{e}±0.04	2.54^{d}±0.07	4.63^{e}±0.04
C	2.59^{d}±0.07	2.45^{d}±0.03	2.04^{d}±0.02	2.65^{c}±0.08	4.71^{d}±0.03
D	2.67^{c}±0.05	2.53^{c}±0.04	2.33^{c}±0.05	3.23^{c}±0.04	4.79^{c}±0.03
E	3.27^{b}±0.02	3.27^{b}±0.02	2.67^{a}±0.03	3.47^{b}±0.03	5.09^{b}±0.02
F	3.57^{a}±0.04	3.56^{a}±0.06	2.76^{a}±0.07	3.77^{a}±0.02	5.22^{a}±0.05

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Mixed fruit juice made with 100% shaddock, B - Mixed fruit juice made with 90% shaddock, 5% watermelon and 5% pawpaw, C - Mixed fruit juice made with 80% shaddock, 10% watermelon and 10% pawpaw, D - Mixed fruit juice made with 70% shaddock, 15% watermelon and 15% pawpaw, E - Mixed fruit juice made with 60% shaddock, 20% watermelon and 20% pawpaw and F- Mixed fruit juice made with 50% shaddock, 25% watermelon and 25% pawpaw.

Table 4. Physicochemical properties of mixed fruit juice samples

Samples	pH	Titratable Acidity (%)	Total Soluble solids (%)	Viscosity (cP)
A	3.04^{f}±0.03	2.16^{a}±0.02	2.11^{f}±0.06	1.65^{a}±0.05
B	3.13^{e}±0.04	2.06^{b}±0.04	2.18^{e}±0.04	1.59^{b}±0.04
C	3.41^{d}±0.05	2.04^{c}±0.04	2.24^{d}±0.02	1.53^{c}±0.06
D	4.07^{c}±0.07	2.02^{d}±0.03	2.33^{c}±0.05	1.47^{d}±0.03
E	4.12^{b}±0.08	2.00^{e}±0.02	2.37^{b}±0.03	1.39^{e}±0.05
F	4.17^{a}±0.09	1.97^{f}±0.05	2.42^{a}±0.06	1.27^{f}±0.07

Data are mean ± standard deviation of triplicate determinations. Means in the same column bearing different superscripts differed significantly (p<0.05) from each other.

A - Mixed fruit juice made with 100% shaddock, B - Mixed fruit juice made with 90% shaddock, 5% watermelon and 5% pawpaw, C - Mixed fruit juice made with 80% shaddock, 10% watermelon and 10% pawpaw, D - Mixed fruit juice made with 70% shaddock, 15% watermelon and 15% pawpaw, E - Mixed fruit juice made with 60% shaddock, 20% watermelon and 20% pawpaw and F- Mixed fruit juice made with 50% shaddock, 25% watermelon and 25% pawpaw.

The mouthfeel of the mixed fruit juice samples which ranged from 6.61 to 7.23 showed that the control (Juice made from 100% shaddock) had the highest score (7.23), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least value (6.61). The mouthfeel of the mixed fruit juice samples substituted with watermelon and pawpaw juices decreased with increase in the level of substitution. According to Ijah *et al*. [24], mouth feel is a sensory attribute which is perceived by the taste buds of the tongue. There are four types of taste perception; sweet, salty, sour and bitter. In mouth feel, the nerves that are present inside the mouth are enthused by chemical or thermal responses such as sweetness or bitterness of juice, coldness of ice cream or the fiery impression of pepper [41,64].

Table 5. Sensory properties of mixed fruit juice samples

Samples	Colour	Taste	Aroma	Consistency	Mouthfeel	Overall acceptability
A	7.47^{a}±1.18	7.50^{a}±0.93	8.10^{a}±1.37	8.33^{a}±1.35	7.23^{a}±1.00	8.27^{a}±1.18
B	7.00^{b}±0.18	7.10^{b}±1.06	8.00^{b}±1.11	8.00^{b}±0.18	7.00^{b}±1.13	7.86^{b}±1.15
C	6.70^{c}±1.27	7.07^{c}±1.10	7.77^{c}±1.14	7.81^{c}±1.16	6.90^{c}±1.51	7.40^{c}±1.03
D	6.47^{d}±1.05	6.78^{d}±1.03	7.40^{d}±1.10	7.26^{d}±1.18	6.81^{d}±1.16	7.18^{d}±1.11
E	6.23^{e}±0.91	6.64^{e}±1.26	7.27^{e}±1.23	7.10^{e}±0.62	6.77^{e}±1.13	6.79^{e}±1.25
F	6.16^{f}±1.35	6.00^{f}±1.30	6.10^{f}±1.13	6.00^{f}±1.22	6.61^{f}±1.28	6.50^{f}±1.18

Data are mean ± SD of fifteen (15) semi-trained judges. Means in the same column bearing different superscripts differed significantly ($p<0.05$) from each other.

A - Mixed fruit juice made with 100% shaddock, B - Mixed fruit juice made with 90% shaddock, 5% watermelon and 5% pawpaw, C - Mixed fruit juice made with 80% shaddock, 10% watermelon and 10% pawpaw, D - Mixed fruit juice made with 70% shaddock, 15% watermelon and 15% pawpaw, E - Mixed fruit juice made with 60% shaddock, 20% watermelon and 20% pawpaw and F- Mixed fruit juice made with 50% shaddock, 25% watermelon and 25% pawpaw.

The overall acceptability of the mixed fruit juice samples ranged from 6.50 to 8.27. The juice made from 100% shaddock) had the highest value (8.27), while the sample substituted with 25% watermelon and 25% pawpaw juices had the least value (6.50). There were significant ($p<0.05$) differences among the samples in the overall acceptability. The scores of the sensory attributes were generally high in all the samples of mixed fruit juice evaluated by the judges. However, the juice made from 100% shaddock was rated higher in overall acceptability by the panellists than the other test samples. Generally, both the control and mixed fruit juices substituted with watermelon and pawpaw juices at different stated levels were also organoleptically acceptable because they were equally rated high in all the attributes evaluated by the judges in this study.

4. CONCLUSION

The study showed that the nutrient contents, physicochemical and sensory properties of mixed fruit juice samples could be improved by substituting shaddock juice with watermelon and pawpaw juices. The proximate composition of the mixed fruit juice samples showed that the ash, fat, carbohydrate and energy contents increased readily with increase in substitution of watermelon and pawpaw juices compared to the control (Juice made from 100% shaddock). The mineral content of the juice samples showed that the calcium, magnesium, phosphorus, potassium, iron and zinc contents of the samples increased significantly ($p<0.05$) with increase in the addition of watermelon and pawpaw juices to the products. The vitamin composition equally revealed that the thiamine, niacin, riboflavin, vitamin A and ascorbic acid contents of the juices increased with increase in the addition of watermelon and pawpaw juices to the samples. The physicochemical properties of the samples showed that the pH and total soluble solids content of the samples increased with increase in the addition of watermelon and pawpaw juices, while the titratable acidity and viscosity decreased drastically. The sensory properties of the mixed fruit juice samples also revealed that the control (Juice made with 100% shaddock) was the most acceptable by the judges in all the sensory parameters compared to the other test samples. Furthermore, the mixed fruit juice samples were also acceptable to the panellists because they were relatively rated high in all the sensory attributes evaluated in this study.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of the manuscript.

CONSENT

As per international standards or University standards, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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