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Research Article

EFFECT OF TYPES OF PACKAGING MATERIALS ON THE PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF AFRICAN BUSH MANGO - SOURSOP FRUIT BAR DURING STORAGE

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ABSTRACT

Objective: The aim of this study was to produce and evaluate fruit bar produced from the blends of African bush mango (*Irvingia* spp.) and soursop (SP) (*Annona muricata*).

Methods: African bush mango (*Irvingia* spp.) and SP (*A. muricata*) were blended in the ratio of 100:0, 0:100, 90:10, 80:20, 80:20, 70:30, 60:40, and 50:50. The blends were properly mixed with the ingredients (citric acid and honey), heated at a temperature of 70-80°C in a water bath until it formed solid. It was then poured into a greased tray and oven dried at a temperature of 55-60°C for 8 hrs in an oven dryer. The formulated fruit bar was allowed to cool and then packaged in three different packaging materials (low-density polyethylene [LDP], high-density polyethylene [HDP], and foil). The different formulated fruit bars were subjected to sensory evaluation, proximate composition, micronutrient (vitamin C, phosphorus, and calcium), microbial (total viable and mold counts), and physicochemical properties (brix, pH, and titratable acidity) using standard procedures.

Results: Result showed that the overall acceptability of the formulated fruit bars differed significantly ($p<0.05$). In the proximate composition of the fruit bar, the moisture (2.56-11.85%), protein (2.17-2.98%), fiber (5.48-13.63%), crude fat (0.14-1.07%), and carbohydrate (71.41-86.32%) content of the fruit bar were not significantly different ($p>0.05$) among some samples, whereas there was no significant different ($p<0.05$) among some other samples. The micronutrient composition of the fruit bar differs significantly ($p<0.05$) from each other. Furthermore, the phosphorus (0.54-0.84 mg/100 g) and calcium (11.20-20.12 mg/100 g) content were high, whereas the vitamin C (48.50-84.50 mg/100 g) content increased with the increase in the proportion of the blends. The microbial count of the products increased during storage. The total viable count (TVC) of the sample showed that majority of the samples stored in HDP had high growth of microorganisms (2.7×10^9 colony forming unit [cfu]/ml) and the least from the LDP (1.4×10^5 cfu/ml). Based on the mold count, the majority of the samples stored in the foil had values ranging from 1.0×10 to 7.0×10^2 cfu/ml and the least from the LDP (no growth). During the 4 weeks storage, the titratable acidity of the samples increased progressively, with the samples stored in the LDP having the highest value (1.50%) and the HDP having the least value (1.43%). The pH of the stored samples decreased, with samples stored in the LDP having the highest value (3.57%) and least value obtain from the HDP (3.69%). The sugar level of the stored sample increased, with the samples stored in the LDP having the highest value (9.40%) and the HDP has the least value (9.90%).

Conclusion: From the study, the incorporation of SP to the fruit bar increased the nutritional profile significantly by providing higher amount of vitamin C as its blend increased. The storage of the fruit bar in the different packaging materials (HDP, LDP, and foil) did not have any effect on the physicochemical characteristics (titratable acidity, pH, and sugar level) of the products. Sample SP + ugiri (100:0) was rated highest probably in terms of its pleasant aroma and taste as preferred by the panelists.

Keywords: African bush mango (*Irvingia* spp.), Fruit bar, Microbes, Packaging materials, Soursop (*Annona muricata*).

INTRODUCTION

Fruits are generally liked by the majority of the people from all age groups, but these perishable fruits are available only during a specific season in surpluses and are wasted in large quantities due to the absence of facilities and the technical know-how for proper handling, distribution, marketing, and most especially storage. The quality of fruit in pre- and post-harvest influences consumers' acceptance. The changes that occur in various physical and chemical characters determine the quality, and in turn, the economic returns to the producer and processor [1]. Hence, there are many ways of preserving fruits making sure they are consumed even after the season of availability. One of such ways is the processing of fruits into confectionery products such as jams, jellies, fruit bar among others. Fruit processing is necessary when it ensures fair returns to the cultivators to improve their economic condition. It also helps to mitigate the problem of underemployment during off seasons in the agricultural sector.

Although if the quality of processed fruit products is to be retained, it depends largely on a primary factor of preservation known as packaging. Packaging an important innovation can effectively extend the shelf life of processed fruit products. It provides microclimate that arrests or reduces action of microorganisms and other conditions that lead to food deterioration. Many packaging materials such as polyethylene, polypropylene, polyester, and foil are used for packaging. These materials have varying degrees of strength, barrier, and stretch properties, which enhance their use for packaging food products. However, polyethylene is the most used polymer. It has the simplest chemical composition of all polymers, that is, a straight chain hydrocarbon which is produced by addition polymerization of ethylene. It is widely used in films, blow-molded items, and laminations [13].

Fruit bar, also known as fruit roll or fruit leather, is one of the processed products of fruits; hence, it is classified as a dehydrated fruit-based confectionery dietary product which is often eaten as snack or dessert [22]. Fruit bars are considered to be hygienic as they are produced mechanically. It is chewy and flavorful, naturally low in fat and high in fiber and carbohydrates. It is also lightweight, easily stored, and packed [30]. The consumption of fruit bar is an economic and convenient value-added substitute for natural fruits as a source

of various nutritional elements. Furthermore, fruit bar has far fewer calories <100 Kcals per serving, than many other snacks [10]. Fruit bar is often considered as a healthy food and healthy food marketing images such as "pure," "sun-dried," or "rich in vitamins" are used to describe them [28]. There are large numbers of fruit bar products available on the market, such as mango leather, apricot fruit leather, grape leather, berry leather, kiwifruit leather, and jackfruit leather. In addition, mixed fruit leathers such as guava and papaya fruit leather are also available.

However, there are some underutilized tropical fruits such as soursop (SP) (*Annona muricata*) and "ugiri (UG)" (African bush mango), which are naturally endowed with promising potentials in the production of fruit bars. UG belongs to the family of the Irvingia. This Africa bush mango comes in two varieties the *Irvingia gabonensis* and *Irvingia wombolu.* Both varieties are found in the tropical rain forest and some part of the savannah zone in Nigeria. However, *I. gabonensis* variety has an edible sugary pulp which is eaten raw when ripe while the pulp of *I. wombolu* variety is not eaten. The pulp of UG is an excellent source of calcium (262 mg/100 g) and vitamin C (66.7 mg/100 ml).

On the other hand, the SP a tropical fruit of the Annonaceae family can be found to be abundant in the West Indies and northern South America. SP is usually consumed fresh. It can be made into a fruit jelly, juice (with the addition of sugar), nectar, or syrup. Sometimes, mature but firm fruit may be made into candies of delicate flavor and aroma. SP is a good source of vitamin B (0.07 mg/100 g pulp) and C (20 mg/100 g pulp) and a poor to fair source of calcium and phosphorus. The most desirable characteristic of the SP is its extremely pleasing flavor and aroma.

Fruit bar is a dehydrated fruit-based confectionery dietary product which is often eaten as snack or dessert is made from fruit endowed with pulp. Hence, the production of fruit bar from the blend of African bush mango and SP has so many advantages attached to it. First, since both fruits are rich in pulp, it saves the cost of production in terms of spending more on fruits unlike when fruits such as guava are used. It was quoted by Bentley and Trimen [4], "let food be thy medicine and medicine be thy food" based on this relationship between food and medicine; the consumption of fruit bar made from the blends of African bush mango and SP would be very medicinal since research on African bush mango revealed the beneficial effects on diabetes and obesity while the juice of the ripe fruit SP would improve the therapeutic or health benefits of the product since it is said to be diuretic and a remedy for hematuria and urethritis just to mention a few benefits.

Furthermore, variety is created and added to the existing fruit bar, and the use of SP would improve the organoleptic properties of the product since the most desirable characteristics of the SP is its extremely pleasing fragrance and flavor. The use of African bush mango and SP in fruit bar production would create a stable market for farmers, thereby improving the economy of the country.

Principally, tropical fruits undergo post-harvest losses due to poor harvesting and storage. However, certain factors affecting post-harvest food losses of perishables vary widely from place to place and become more and more complex as system of marketing become more complex. Notwithstanding, the benefits of direct consumption of fresh fruit like UG and SP, processing reduces post-harvest losses and spread the availability throughout the year [18]. Although processing is a way of preserving fruit, a better way of preservation is suggested, that is, the use of packaging materials. Packaging is a very essential and an important innovation that could effectively extend the shelf life of processed fruit products. There are different types of packaging materials such as polyethylene, foil, polystyrene among others. Packaging requirements of the product determines the film to be used. For instance, fresh beef requires fairly porous films to maintain the red pigments. Cost is another factor considered in choosing the packaging material to be used. Some materials may have the very close strength or barrier properties but may be more expensive likewise it has superior stretch property. In Nigeria, polyethylene is the most widely used of all packaging material because of its availability and cheapness. This work, therefore, investigated the suitability of different packaging materials in extending the shelf life of processed fruit bar from UG and SP blends.

METHODS

Procurement of raw materials

The raw materials, Africa bush mango (*Irvingia* spp.), SP (*A. muricata*), honey, and preservative (citric acid) were purchased from Ogige main market in Nsukka Local Government area of Enugu State, Nigeria.

Sample preparation

The fruits (African bush mango and SP) were sorted to remove any unripe or overripe fruit. The fruits were then washed with clean water to remove any sources of contaminations and peeled with a stainless steel knife. The pulp from the fruits was extracted using a kitchen knife. The extracted puree was blended (Table 1) and mixed with the ingredients and heated at a temperature of 70-80°C in a water bath until a final solid content was obtained. The hot puree was poured into an already greased tray with edges worked well. The greasing was done to prevent the bar from sticking to the surface of the tray. The tray was placed inside an oven until a final moisture content of 15% was obtained. Two sheets of the bar were placed on top of each other and cut using a knife and a ruler into 4 cm^2×4 cm^2. Each square was wrapped in three different packaging materials (high-density polyethylene [HDP], low-density polyethylene [LDP], and foil) and stored in a cool, dry place for analyses (Fig. 1).

Sample analyses

Proximate analyses of the formulated fruit bar from African bush mango and SP blends

Determination of moisture content of the formulated fruit bar

The moisture content of the formulated fruit bars produced from the blend of African bush mango and SP fruit were determined using the hot oven method of AOAC [2]. The crucibles were washed, oven dried, and allowed to cool in a desiccator and then weighed (W_1). 2 g of the samples were placed into the weighed crucible, the weight noted (W_2). The samples were dried in the oven, set at 105°C for 4 hrs. The sample was removed from the oven after this period and then cooled in a desiccator and weighed. The process of drying, cooling, and weighing was obtained (W_3). The weight loss was calculated as the moisture content as:

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

Where; W_1 = Initial weight of empty crucibles, W_2 = Weight of crucibles + sample before drying, and W_3 = Final weight of crucibles + sample after drying.

Determination of the crude fiber content of the formulated fruit bar

The fiber content of the samples was determined using the method described by AOAC [2]. 2 g of the samples was weighed into a 600 ml beaker each and 150 ml of preheated 0.128 M H_2SO_4 was added. The beaker containing the mixture was heated for 30 minutes, filtered

Table 1: Proportion for the formulation of fruit bars from African bush mango and SP blends

Sample	SP (%)	UG (%)
SP+UG (100:0)	100	0
SP+UG (0:100)	0	100
SP+UG (90:10)	90	10
SP+UG (80:20)	80	20
SP+UG (70:30)	70	30
SP+UG (60:40)	60	40
SP+UG (50:50)	50	50

UG: African bush mango (Ugiri), SP: Soursop

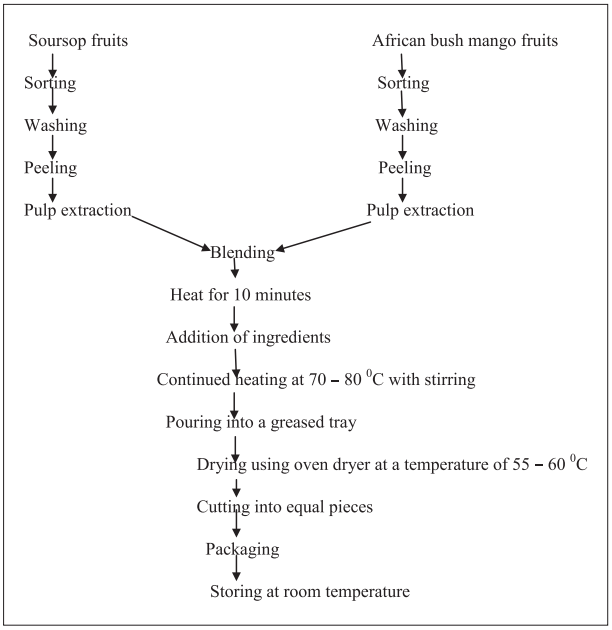

Fig. 1: Production of fruit bar from the blends of African bush mango and soursop. Source: Vidya and Narain (2011) [29]

under suction, and washed with hot distilled water until the washings were no longer acidic. The residues were then transferred to another clean beaker and boiled with 150 ml of preheated KOH (0.223 M) for 30 minutes after which filtration was carried out and followed by washing the residue with hot water until it is no longer alkaline. The residue was put into labeled, weighed crucibles (W_1), dried in an oven for 2 hrs at 105°C, cooled in a desiccator, weighed (W_2), and then ashed in a muffle furnace at 500°C for 4 hrs. The ashed samples were cooled in a desiccator and later weighed (W_2). The percentage crude fiber was calculated using the expression;

$$(\%)\ \text{Crude fiber} = \frac{W_2 - W_1}{W_1} \times 100$$

Where; W_1 = Weight of the sample, W_2 = Weight of the dried residue, and W_2 = Weight of the ashed residue.

Determination of ash content of formulated fruit bar
The ash content of the sample was determined by the method described by AOAC [2]. A porcelain crucible was heated to about 600°C in a muffle furnace, cooled in a desiccator, weighed and designated as W_1. 2 g of the samples were weighed into the porcelain crucibles and weight noted (W_2). The crucibles containing the samples were transferred to the muffle furnace. The temperature of the furnace was then allowed to reach about 525°C after placing the crucibles in it. The temperature was maintained until whitish gray was obtained. The dish was transferred from the furnace to a desiccator for cooling after which it was re-weighed as W_3. The percentage ash content was then calculated using the expression;

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

Where; W_1 = Weight of empty crucibles, W_2 = Weight of empty crucibles + samples before ashing; W_3 = Weight of dish + ash.

Determination of crude fat content of formulated fruit bar
The solvent extraction method as described by AOAC [2] was used. This involves the use of Soxhlet extraction apparatus. This method involves continuous extraction of crude fat from the samples with organic solvent such as petroleum ether for 4 hrs or depending on the volume of sample. Extraction flasks of 250 ml volume were washed, dried, cooled, weighed, and designated as B. 2 g of the samples was weighed out into a labeled thimble (A). The thimbles were slightly plugged with cotton wool and placed inside the extractor. The extraction flask was filled with petroleum ether with (boiling point of 40-60°C). The condenser and the flask were connected to the extractors. The whole units were placed on a heating mantle for 4 hrs after which the petroleum ether was recovered for reuse using rotary evaporator. The flask extract containing the extract was dried in an oven at 105-110°C for 1 hr after which it was cooled in a desiccator and weighed (C). The difference in weight of empty flask and the flask with the oil gave the crude ether extract which was calculated as a percentage with the expression;

$$(\%)\ \text{Fat content} = \frac{C - B}{A} \times 100$$

Where; A = Weight of sample, B = Weight of empty flask, and C = Weight of flask.

Determination of crude protein of the formulated fruit bar
The crude protein content of the samples was determined by the semi micro - Kjeldahl technique described by AOAC [2]. The samples were weighed into a Kjeldahl flask, and 3 g of hydrated cupric sulfate (catalyst) was added to the flask. 20 ml of anhydrous sodium sulfate and concentrated tetraoxosulphate IV acid were added. Each of the flasks was swirled, put in a digestion chamber, and heated until a clear liquid was obtained. The clear liquid was then cooled and made up to 100 ml with distilled water, and 5 ml of the digest was collected for distillation. 5 ml of 60 % NaOH was put into a distillation flask and distilled for 15 minutes. The distillate (ammonia) was absorbed by boric acid indicator which was titrated with 0.1 ml HCl. The titer value at the point when the color changed from green to pink was taken. The percentage crude protein was calculated using the expression.

$$(\%)\ \text{Crude protein} = \frac{T \times 0.00001410 \times 6.25 \times 100}{W \times 5}$$

Where; W = Weight of sample taken; T = Titer value at the end point; % N = Percentage nitrogen.

Determination of carbohydrate content of the formulated fruit bar
This was determined as the nitrogen-free extraction calculated by difference as described by AOAC [2] which was done by subtracting the sum of protein, fat, moisture, crude fiber, and ash from 100.

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

Physicochemical analyses of the formulated fruit bar from African bush mango and SP blends

Determination of pH of the formulated fruit bar
The pH was determined using a pH meter as described by AOAC [2]. 5 ml of the sample solution was pipetted into a beaker, and the pH was determined by dipping the electrodes into the sample and reading off the value on the screen of the meter.

Determination of titratable acidity of the formulated fruit bar
Total titratable acidity was determined by the method described by AOAC [2]. 5 ml of the sample solution was taken and titrated with 0.1 N alkali (NaOH) using 0.5 ml phenolphthalein as an indicator. Titration continued until there was a change in color to a pink end point. The titration was repeated to an average result.

$$(\%)\ \text{Titrable acidity} = \frac{M\ (\text{NaOH}) \times N\ (\text{NaOH}) \times 0.09 \times 100}{\text{Volume of sample}}$$

Determination of brix level of the formulated fruit bar
This was determined using hand refractometer at 20°C and by reference to standard tables expressed as percentage sucrose by weight (brix).

Determination of micronutrient content of formulated fruit bar from African bush mango and SP blends

Determination of vitamin C content of formulated fruit bar
This was determined using the method described by AOAC [2]. 15 g of trichloroacetic acid was dissolved in 40 ml acetic acid and 200 ml distilled water. It was diluted to 500 ml and filtered. Then, 60 ml of the

extraction solution was added to 5 g of the sample and the mixture was homogenized and filtered under suction. The filtrate was poured into 250 ml volumetric flask and made up to the mark with distilled water. Furthermore, 10 ml of the resulting solution was pipetted into a conical flask and titrated against the standard indophenols solution. The titer value was recorded and the vitamin C content calculated as:

Vitamin C (mg/100 g) of sample = 20 k.

$$K = \frac{\text{Titre value} \times 3.60 \times 25 \times 100}{\text{Weight of sample}}$$

Determination of calcium content of formulated fruit bar
It was determined by titration method according to Kirk and Sawyer [15]. 2 g of the ashed sample was diluted with 3 ml of distilled water and 1 ml of 50 % ammonium oxalate. One drop of methyl red indicator was made alkaline with ammonia drops of glacial acetic acid until color changes to pink. It was stood for 4 hrs and centrifuged for 5 minutes followed by decantation of the supernatant. Then, 1 ml of hydrogen sulfate was added to the residue which was diluted with 4 ml of distilled water. The solution was boiled and titrated with 0.02 N potassium permanganate.

$$\text{Calcium content } (\%) = \frac{\text{Volume of EDTA} \times \text{Atomic weight of calcium} \times \text{DF} / 100}{\text{Weight of sample}}$$

Where; DF = Dilution factor.

Determination of phosphorus content of formulated fruit bar
Phosphorus content was determined using AOAC [2]. 5 ml of sample solution was pipetted into 50 ml graduated flask with 10 ml of molybdate mixture was added and diluted to mark with water. It stood for 15 minutes for color development. The absorbance at 400 nm against blank was measured. The ppm or mg/ml from the graph was calculated as well as the number of mg of equivalent to the absorbance of the sample and the blank determination.

Microbiological analyses of the formulated fruit bar from African bush mango and SP blends

Media preparation

Nutrient agar powder (7 g) was dissolved in distilled water (250 ml). 13 g sabouraud dextrose agar (SDA) was dissolved in distilled water (200 ml). The mixtures were stabilized by bringing them to boiling while homogenizing by shaking in a whorl motion. The mixtures were sterilized by autoclaving for 15 minutes at a temperature of 121°C. The medium was allowed to cool after sterilization to about 40-70°C.

Preparation of ringer solution

One ringer tablet was dissolved in distilled water (150 ml). The clear solution formed was sterilized by autoclaving for 15 minutes at temperature of 121°C. The ringer solution was allowed to cool completely to a temperature of about 28°C.

Determination of TVC of the formulated fruit bar
The TVC test was carried out using the method of Prescott *et al.* [21]. Using of the sample and sterilized quarter strength ringer solution as diluents, 1 ml of the sample and 9 ml ringer solution was made serial dilution (10^{-4}). The diluted sample was pipetted into a marked petri dish and sterile nutrient agar (20 ml) poured into the same petri dish and swirled to mix. When they solidified, they were turned upside down and cultured by incubating at the temperature of about 37°C for 24 hrs. At the end of incubation period, the colonies were counted using the colony counter and were calculated as cfu/g of sample.

TVC (cfu/g) = Number of colonies × reciprocal of dilution factor

Determination of mold count of the formulated fruit bar
This was determined using the method described by Prescott *et al.* [21] with sabourand dextrose agar (SDA) as the planting medium. The ringer solution was prepared by dissolving a tablet of quarter strength ringer's tablet in distilled water (500 ml) and autoclaving for 15 minutes at 121°C. 1 g of each sample was weighed and put in test tube prepared for serial dilution. Ringer's solution (9 ml) was added in all the test tubes and the mixtures were homogenized by shaking. 1 ml of stock solution was aseptically transferred serially into other test tubes. Serial dilution of 10^{-1} was used for mold count determination. Then, 1 ml of appropriate diluents was transferred into the sterile Petri dishes. SDA was used for culturing the organism for 48 hrs at room temperature. The mold colonies were enumerated and calculated as cfu/g of sample.

Mold count (cfu/g) = Number of colonies × reciprocal of the dilution factor.

Sensory evaluation of formulated fruit bar from African bush mango and SP blends

Organoleptic properties of formulated fruit bar from the blends of African bush mango and SP fruit sample with the control were evaluated by 20 untrained panelists, for various sensory attributes (color, taste, aroma, mouthfeel, after taste, chewiness, texture, and overall acceptability) using a 9-point Hedonic scale, where "9" represents extremely like and "1" represents extremely dislike [12].

Data analysis and experimental design

The experimental design used was completely randomized design, and data collected were analyzed using one-way analysis of variance. Means were separated by Duncan's new multiple range test, and the level of significance was accepted at ($p<0.05$) according to Steel and Torrie [26].

RESULTS AND DISCUSSION

Proximate composition of formulated fruit bar from African bush mango and SP blends

Table 2 shows the proximate composition of formulated fruit bar from African bush mango and SP blends. The moisture content of the formulated fruit bar ranged from 2.56% to 11.85% with sample SP + UG (50:50) having the lowest moisture content and sample SP + UG (70:30) having the highest moisture content. The moisture content of the samples differs significantly ($p<0.05$) from each other. This result was in disagreement with the findings of Rehman *et al*. [23], who observed that moisture content varied significantly among treatment of apricot date bars. They observed that moisture content ranged from 7.14% to 19.21% in apricot date bar. In general, there was an increase in the moisture content of the samples, but the increase did not follow a particular trend. Sanni *et al*. [24] reported that the lower the moisture content of a product to be stored, the better the shelf stability of such products. Higher moisture indicates lower shelf stability of fruit bar and higher susceptibility to microbial infestation and proliferation.

The fat content of the formulated fruit bar ranged from 0.14% to 1.07% with sample SP + UG (100:0) having the lowest fat content and sample SP + UG (0:100) having the highest fat content. There was no significant ($p<0.05$) difference between sample SP + UG (70:30) and sample SP + UG (50:50), whereas samples SP + UG (100:0), SP + UG (0:100), SP + UG (90:10), SP + UG (80:20), and SP + UG (60:40) differs significantly ($p<0.05$) from each other. In general, the fat content of the formulated fruit bar was low. Fasasi [7] reported that low-fat content in a dry product would help in increasing the shelf life of the sample by decreasing the chances of rancidity and also contribute to the low energy value of the food product while high-fat content product will have high energy value and promotes lipid oxidation.

The ash content of the formulated fruit bar ranges from 1.07% to 3.80% with sample SP + UG (0:100) having the lowest ash content, and sample SP + UG (100:0) having the highest ash content. There was no significant ($p<0.05$) difference between sample SP + UG (90:0) and sample SP + UG (70:30) while the ash content of samples SP + UG (100:0), SP + UG (0:100), SP + UG (80:20), and sample SP + UG (50:50) differs significantly ($p<0.05$) from each other. The increase in

Table 2: Proximate composition (%) of formulated fruit bar from African bush mango and SP blend

Sample	Moisture (%)	Crude fat (%)	Ash (%)	Protein (%)	Cruder fiber (%)	Carbohydrate (%)
SP+UG (100:0)	3.84^{c}±0.01	0.14^{a}±0.01	1.07^{a}±0.01	2.98^{g}±0.01	6.32^{b}±0.03	88.66^{e}±0.01
SP+UG (0:100)	6.67^{e}±0.01	1.07^{f}±0.02	3.89^{e}±0.37	2.17^{a}±0.02	13.63^{g}±0.04	72.68^{b}±0.41
SP+UG (90:10)	3.47^{b}±0.02	0.25^{b}±0.00	2.27^{c}±0.02	2.88^{f}±0.01	10.96^{e}±0.01	80.49^{d}±0.40
SP+UG (80:20)	5.78^{d}±0.01	0.61^{e}±0.01	1.43^{b}±0.00	2.63^{c}±0.01	8.57^{d}±0.01	80.99^{d}±0.03
SP+UG (70:30)	11.85^{g}±0.01	0.44^{c}±0.01	2.39^{c}±0.07	2.70^{d}±0.01	11.21^{f}±0.01	71.41^{a}±0.13
SP+UG (60:40)	9.61^{f}±0.01	0.51^{d}±0.01	1.39^{ab}±0.02	2.78^{e}±0.02	8.49^{c}±0.00	77.23^{c}±0.07
SP+UG (50:50)	2.56^{a}±0.01	0.43^{c}±0.01	3.02^{d}±0.04	2.21^{b}±0.28	5.48^{a}±0.02	86.32^{f}±0.00

Values are means±standard deviation of duplicate determinations. Values on the same row with different superscripts are significantly ($p<0.05$) different. SP: Soursop, UG: African bush mango (Ugiri)

ash content suggests that the product with high ash is a good source of mineral as observed by De Lumen *et al*. [6].

The protein content of the formulated fruit bar ranged from 2.17% to 2.98% with sample SP + UG (0:100) having the lowest protein content and sample SP + UG (100:0) having the highest protein content. The protein content of the samples differed ($p<0.05$) significantly from each other. In general, the protein content of the formulated fruit bar was low. This result was in close agreement with the findings of Ajaykumar *et al.* [3], who observed that the protein content varied significantly among treatment of sapota-papaya bars with a protein content ranged from 0.87% to 1.85%.

The fiber content of the formulated fruit bar ranged from 5.48% to 13.63% with sample SP + UG (50:50) having the lowest fiber content and sample SP + UG (0:100) having the highest fiber content. The fiber content of the samples differs significantly ($p<0.05$) from each other. In general, the fiber content of the formulated fruit bar was high. Fiber is known to aid digestion [12] indicating that fruit bar from this blends (African bush mango and SP) could be a good source of dietary fiber and may have the potential of alleviating gastrointestinal problems and easy bowel movement. The result regarding the change in crude fiber is in disagreement with the findings of Rehman *et al*. [23].

Table 2 showed that the carbohydrate content of the formulated fruit bar ranged from 71.41% to 86.32% with sample SP + UG (70:30) having the lowest carbohydrate content and sample SP + UG (50:50) having the highest carbohydrate content. There was no significant ($p<0.05$) difference between sample SP + UG (90:10) and sample SP + UG (80:20). While sample SP + UG (100:0) sample SP + UG (0:100), sample SP + UG (70:30), sample SP + UG (60:40), and sample SP + UG (50:50). In general, the carbohydrate content of the formulated fruit bar is high.

Micronutrient composition of formulated fruit bar from African bush mango and SP blends

Table 3 shows the micronutrient of formulated fruit bar from African bush mango and SP blends.

The calcium content of the formulated fruit bars ranged from 11.20 mg/100 g in sample SP + UG (100:0) to 20.12 mg/100 g sample SP + UG (0:100). The calcium content of the sample differed ($p<0.05$) significantly from each other. In general, the calcium content of the formulated fruit bar was high. Although very high calcium intakes have the potential to cause hypercalcemia [17], it is most commonly associated with hyperparathyroidism or malignancy. Furthermore, high calcium intake can cause constipation. It might also interfere with the absorption of iron and zinc, though this effect is not well established (Institute of Medicine, 2010). However, the daily recommended intake for children between the age bracket 9 and 13 years is 1300 mg while for adult between the age bracket 51 and 70 years is 1000 mg.

The phosphorus content of the formulated fruit bars ranged from 0.54 mg/100 g in sample SP + UG (100:0) to 0.84 mg/100 g in sample SP + UG (0:100). There was no significant ($p>0.05$) difference in samples SP + UG (100:0), SP + UG (90:10), SP + UG (80:20), SP + UG (60:40), and SP + UG (50:50). In general, the phosphorus content of the formulated fruit bar was high. Although the consumption of foods high in phosphorus is very important, too much of it decreases the level of calcium in the blood and can lead to bone disease [5]. However, the dietary intakes of phosphorus for children between the age bracket of 4 and 8 years are 500 mg/day while for adult is 700 mg/day.

Table 3: Micronutrient composition (mg/100 g) of formulated fruit bar from African bush mango and SP blends

Sample	Calcium (mg/100 g)	Phosphorus (mg/100 g)	Vitamin C (mg/100 g)
SP+UG (100:0)	$20:12^{g}$±0.02	0.54^{a}±0.02	88.00^{e}±0.00
SP+UG (0:100)	11.20^{a}±0.02	0.84^{d}±0.01	54.50^{b}±2.12
SP+UG (90:10)	17.75^{f}±0.01	0.56^{a}±0.00	84.00^{d}±0.00
SP+UG (80:20)	14.99^{c}±0.01	0.73^{c}±0.02	84.50^{d}±0.71
SP+UG (70:30)	16.58^{e}±0.01	0.66^{b}±0.01	74.50^{c}±2.12
SP+UG (60:40)	14.20^{b}±0.01	0.72^{c}±0.02	77.50^{c}±2.12
SP+UG (50:50)	15.54^{d}±0.01	0.56^{a}±0.01	48.50^{a}±2.12

Values are means±standard deviation of duplicate determinations. Values on the same row with different superscripts are significantly ($p<0.05$) different. SP: Soursop, UG: African bush mango (Ugiri)

The vitamin C content of the formulated fruit bars ranged from 48.50 mg/100 g in sample SP + UG (50:50) to 88.00 mg/100 g in sample SP + UG (100:0). There was no significant ($p<0.05$) difference in samples SP + UG (90:10) and SP + UG (80:20) as well as samples SP + UG (70:30) and SP + UG (60:40). The vitamin C content of the sample increased with increase in the proportion of SP in the blends. The increase in the vitamin C content could probably be due to the addition of SP, which has a high amount of ascorbic acid content (3.20 mg/100 g). This is related to the report by Persatuan [19] that SP fruit has vitamin C content as 20 mg/100 g, thus addition of the fruit extract increasing the levels of vitamin C in the SP leaves jelly candy. However, the daily recommended intake of calcium for children between the age bracket 9 and 13 years is 45 mg while for the male adult is 90 mg and for females is 75 mg.

Physicochemical composition of the formulated fruit bar from African bush mango and SP blends

Table 4 shows the effect of packaging materials on the sugar level of formulated fruit bar from African bush mango and SP blends during 28 days storage period.

The sugar level of the formulated fruit bar of sample SP + UG (100:0) ranged from 9.00 to 9.00 °Brix, 8.10 to 9.40 °Brix, and 8.25 to 9.60 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of the formulated fruit bar of sample SP + UG (0:100) ranged from 8.00 to 9.70 °Brix, 7.05 to 8.20 °Brix, and 7.05 to 8.20 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of the formulated fruit bar of sample SP + UG (90:10) ranged from 6.55 to 7.30 °Brix, 7.55 to 8.55 °Brix, and 7.00 to 8.30 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The sugar level of the formulated fruit bar of sample SP + UG (80:20) ranged from 7.85 to 8.85 °Brix, 7.50 to 8.25 °Brix, and 7.00 to 8.00 °Brix

during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of the formulated fruit bar of sample SP + UG (70:30) ranged from 6.95 to 7.90 °Brix, 8.05 to 9.00 °Brix, and 6.80 to 8.15 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of the formulated fruit bar of sample SP + UG (70:30) ranged from 6.95 to 7.90 °Brix, 6.80 to 8.15 °Brix, and 6.80 to 8.15 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of the formulated fruit bar of sample SP + UG (60:40) ranged from 6.90 to 7.65 °Brix, 7.35 to 7.94 °Brix, and 7.00 to 7.75 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The sugar level of the formulated fruit bar of sample SP + UG (50:50) ranged from 6.60 to 7.60 °Brix, 7.35 to 8.15 °Brix, and 6.80 to 7.60 °Brix during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The sugar level of fruits is a major quality parameter, which is correlated with the texture and composition [14]. The increase in sugar level of the formulated samples was in disagreement with the findings of Pota *et al.* [20] where there is no significant ($p<0.05$) change in total soluble solid during storage of pomegranate fruits but was in agreement with the results where there was an increase in total soluble solid of amla jam during storage [27]. The total soluble solid of the products was the index of sweetness.

Table 5 shows the effect of packaging materials on the titratable acidity level of formulated fruit bar from African bush mango and SP blends during 28 days storage period. The titratable acidity of the formulated fruit bar for sample SP + UG (100:0) ranged from 0.82% to 0.87%, 0.95% to 1.03%, and 0.89% to 0.97% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The titratable acidity of the formulated fruit bar for sample SP + UG (0:100) ranged from 0.22% to 0.31%, 0.33% to 0.42%, and 0.30% to 0.36% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The titratable acidity of the formulated fruit bar for sample SP + UG (90:10) ranged from 0.88% to 1.07%, 1.10% to 1.18%, and 1.06% to 1.15% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The titratable acidity of the formulated fruit bar for sample SP + UG (80:20) ranged from 1.33% to 1.43%, 1.45% to 1.50%, and 1.41% to 1.48% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The titratable acidity of the formulated fruit bar for sample SP + UG (70:30) ranged from 0.63% to 0.70%, 0.68% to 0.78%, and 0.63% to 0.71% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The titratable acidity of the formulated fruit bar for sample SP + UG (60:40) ranged from 0.97% to 1.13%, 0.92% to 1.22%, and 0.96% to 1.20% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The titratable acidity of the formulated fruit bar for sample SP + UG (50:50) ranged from 0.92% to 1.01%, 0.94% to 1.04%, and 0.92% to 1.04% during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. Acidity value is a measure of stability and shelf life of jam and fruit bar. It is due to the organic acid in fruits and those which are added while making the fruit bar. The increase in the acidity was in disagreement with the findings of Sidhu *et al.* [25], where there was a negligible change in titratable acidity and the acidity was maintained, during storage of tomato juice for a period of 60-day. However, in agreement with the findings of Gowda *et al.* [9] where acidity of guava fruit bar increased during storage.

Table 6 shows the effect of packaging materials on the pH level of formulated fruit bar from African bush mango and SP blends during 28-day storage period.

The pH of the formulated fruit bar of sample SP + UG (100:0) ranged from 3.24 to 3.15, 3.12 to 3.01, and 3.17 to 3.06 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The pH of the formulated fruit bar of sample SP + UG (0:100) ranged from 3.65 to 3.62, 3.55 to 3.43, and 3.63 to 3.48 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The pH of the formulated fruit bar of sample SP + UG (90:10) ranged from 3.29 to 3.17, 3.10 to 2.94, and 3.21 to 3.05 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The pH of the formulated fruit bar of sample SP+UG (80:20) ranged from 3.10 to 2.92, 2.87 to 2.80, and 2.99 to 2.90 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

The pH of the formulated fruit bar of sample SP + UG (70:30) ranged from 3.46 to 3.46, 3.27 to 3.21, and 3.39 to 3.22 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The pH of the formulated fruit bar of sample SP + UG (60:40) ranged from 3.22 to 3.14, 3.02 to 2.48, and 3.09 to 2.99 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The pH of the formulated fruit bar of sample SP + UG (50:50) ranged from 3.61 to 3.50, 3.60 to 3.51, and 3.57 to 3.42 during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively.

Fruit products are being effectively preserved at low pH [25]. The pH estimation was done to find out whether a low pH was maintained throughout the study which could be an effective preservation. The decrease in pH observe during the storage period was in disagreement with the findings of Sidhu *et al.* [25], where there was no change in the pH during the entire storage of tomato juice for 90 days.

Microbial count of formulated fruit bar from African bush mango and SP blends

Table 7 shows the effect of packaging materials on the TVC of formulated fruit bar during 28 days storage period.

The TVC of the formulated fruit bar of sample SP + UG (100:0) was observed to be different for the HDP, LDP, and foil. For the week 0 to 4th week, samples packaged in the HDP ranged from 2.4×10^5 to 2.0×10^9 cfu/ml. Those in LDP ranged from 1.8×10^5 to 1.6×10^9 cfu/ml while the formulated fruit bar stored in foil ranged from 2.0×10^5 to 1.8×10^9 cfu/ml.

The TVC of the formulated fruit bar of sample SP + UG (0:100) ranged from 1.5×10^5 to 1.5×10^9 cfu/ml, 1.4×10^5 to 1.2×10^9 cfu/ml, and 1.1×10^5 to 1.4×10^9 cfu/ml during the storage period for the week 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the HDP had the highest growth followed by the LDP and foil. The TVC of the formulated fruit bar of sample SP + UG (90:10) ranged from 2.0×10^5 to 2.7×10^9 cfu/ml, 5.6×10^5 to 2.0×10^9 cfu/ml, and 1.3×10^5 to 2.4×10^9 cfu/ml during the storage period for the 0, 2nd, 3rd, and 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the LDP had the highest growth followed by the HDP and the foil.

The TVC of the formulated fruit bar of sample SP + UG (80:20) ranged from 1.6×10^5 to 1.4×10^9 cfu/ml, 1.4×10^5 to 1.1×10^9 cfu/ml, and 1.6×10^5 to 1.2×10^9 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the HDP followed by the foil and the LDP.

The TVC of the formulated fruit bar of sample SP + UG (70:30) were observed to be different from each other, with samples packaged in the HDP ranging from 6.7×10^4 to 1.9×10^9 cfu/ml. Those in the LDP ranged from 3.5×10^4 to 2.4×10^9 cfu/ml. while the formulated fruit bar stored in foil ranged from 4.4×10^4 to 1.5×10^9 cfu/ml during the 0 to 4th week. The fruit bar stored in the HDP had the highest growth followed by the foil and the LDP.

The TVC of the formulated fruit bar of sample SP + UG (60:40) ranged from 2.1×10^5 to 2.4×10^9 cfu/ml, 3.1×10^5 to 1.9×10^9 cfu/ml, and 4.8×10^4 to 1.6×10^9 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed by the LDP and the HDP. The TVC of the formulated fruit

Table 4: Effect of packaging materials on the sugar level (°Brix) of formulated fruit bar from African bush mango and SP blends during 28 days storage period

Weeks	SP+UG (100:0)			SP+UG (0:100)			SP+UG (90:0)			Samples/packaging materials											
										SP+UG (80:20)			SP+UG (70:0)			SP+UG (60:0)			SP+UG (50:0)		
	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil
0	9.00^{a}±0.00	8.10^{a}±0.14	8.25^{a}±0.07	8.00^{a}±0.00	7.05^{a}±0.07	7.50^{a}±0.00	6.55^{a}±0.07	7.55^{a}±0.00	7.00^{a}±0.00	7.85^{a}±0.07	7.50^{a}±0.00	7.00^{a}±0.00	6.95^{a}±0.07	8.05^{a}±0.01	6.80^{a}±0.00	6.90^{a}±0.00	7.35^{a}±0.07	7.00^{a}±0.07	6.60^{a}±0.14	7.35^{a}±0.07	6.80^{a}±0.14
1	9.10^{a}±0.14	8.30^{a}±0.00	8.65^{b}±0.07	8.30^{b}±0.14	7.55^{b}±0.07	7.85^{b}±0.01	6.80^{b}±0.00	7.85^{b}±0.07	7.30^{b}±0.07	7.90^{a}±0.00	7.85^{b}±0.07	7.25^{b}±0.07	7.10^{ab}±0.14	8.20^{b}±0.00	7.90^{b}±0.00	7.00^{a}±0.00	7.70^{b}±0.00	7.30^{b}±0.00	6.75^{a}±0.07	7.65^{b}±0.07	7.00^{b}±0.00
3	9.60^{b}±0.00	8.80^{b}±0.14	9.20^{c}±0.00	8.70^{c}±0.00	7.90^{c}±0.00	8.10^{c}±0.00	7.05^{c}±0.07	8.10^{c}±0.00	7.50^{c}±0.07	8.30^{b}±0.01	8.00^{c}±0.00	7.55^{c}±0.07	7.30^{b}±0.00	8.45^{c}±0.01	8.11^{c}±0.00	7.40^{b}±0.14	7.85^{c}±0.07	7.65^{c}±0.07	6.80^{a}±0.00	7.60^{b}±0.00	7.35^{c}±0.07
4	9.90^{c}±0.00	9.30^{c}±0.00	9.65^{d}±0.07	9.35^{d}±0.07	8.00^{c}±0.00	8.10^{c}±0.00	7.40^{d}±0.14	8.50^{d}±0.00	7.90^{d}±0.0c	8.60^{c}±0.00	8.00^{c}±0.00	7.80^{d}±0.00	7.60^{c}±0.14	8.70^{d}±0.00	8.14^{d}±0.01	7.60^{b}±0.14	7.93^{c}±0.01	7.90^{c}±0.01	7.35^{b}±0.21	7.90^{c}±0.00	7.60^{d}±0.00
5	9.00^{a}±0.00	9.40^{c}±0.00	9.60^{d}±0.00	9.70^{e}±0.00	8.20^{d}±0.14	8.55^{d}±0.01	7.30^{d}±0.00	8.55^{d}±0.07	8.30^{e}±0.00	8.85^{d}±0.07	8.25^{d}±0.07	8.00^{e}±0.00	7.90^{d}±0.00	9.00^{e}±0.00	8.15^{e}±0.00	7.65^{b}±0.07	7.94^{c}±0.01	7.75^{d}±0.01	7.60^{b}±0.00	8.15^{d}±0.07	7.60^{d}±0.00

Value are means±SD of duplicate determinations. Values on the same row with different superscript are significantly (p>0.05) different. HDP: High-density polyethylene, LDP: Low-density polyethylene, SP: Soursop; UG: African bush mango (Ugiri), SD: Standard deviation

Table 5: Effect of packaging materials on the titratable acidity level of formulated fruit bar from African bush mango and SP blends during 28 days storage period

Storage period (week)	SP+UG (100:0)			SP+UG (0:100)			SP+UG (90:10)			Samples/packaging materials											
										SP+UG (80:20)			SP+UG (70:30)			SP+UG (60:40)			SP+UG (50:50)		
	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil
0	0.82^{a}±0.01	0.95^{a}±0.01	0.89^{a}±0.00	0.22^{a}±0.01	0.33^{a}±0.01	0.30^{a}±0.00	0.88^{a}±0.00	1.10^{a}±0.00	1.06^{a}±0.00	1.33^{a}±0.00	1.45^{a}±0.01	1.41^{a}±0.01	0.63^{a}±0.01	0.68^{a}±0.00	0.63^{a}±0.01	0.97^{a}±0.01	0.92^{a}±0.99	0.96^{a}±0.00	0.92^{a}±0.05	0.94^{a}±0.01	0.92^{a}±0.00
1	0.84^{b}±0.00	0.96^{b}±0.01	0.91^{b}±0.00	0.25^{b}±0.00	0.36^{b}±0.00	0.32^{b}±0.01	0.91^{b}±0.01	1.13^{b}±0.01	1.08^{b}±0.00	1.35^{b}±0.00	1.47^{b}±0.00	1.45^{b}±0.01	0.64^{a}±0.01	0.71^{b}±0.01	0.65^{b}±0.01	0.98^{b}±0.00	1.13^{b}±0.00	1.12^{b}±0.00	0.94^{ab}±0.00	0.97^{b}±0.00	0.94^{ab}±0.02
2	0.86^{c}±0.00	0.98^{c}±0.01	0.94^{c}±0.01	0.27^{c}±0.01	0.36^{b}±0.00	0.33^{c}±0.00	1.04^{c}±0.01	1.15^{c}±0.00	1.10^{c}±0.01	1.39^{c}±0.01	1.48^{ab}±0.00	1.47^{c}±0.07	0.66^{b}±0.00	0.74^{c}±0.01	0.68^{c}±0.01	1.10^{c}±0.00	1.18^{b}±0.01	1.16^{c}±0.01	0.95^{bc}±0.01	1.00^{c}±0.01	0.95^{ab}±0.00
3	0.86^{c}±0.00	1.01^{d}±0.00	0.95^{d}±0.00	0.30^{d}±0.00	0.40^{c}±0.00	0.35^{d}±0.00	1.05^{cd}±0.01	1.18^{d}±0.01	1.13^{d}±0.01	1.41^{d}±0.01	1.49^{cd}±0.00	1.48^{d}±0.00	0.68^{bc}±0.01	0.76^{d}±0.00	0.69^{cd}±0.00	1.11^{c}±0.0-1	1.20^{b}±0.01	1.17^{d}±0.00	0.97^{c}±0.00	1.02^{c}±0.00	0.97^{b}±0.00
4	0.87^{d}±0.01	1.03^{e}±0.00	0.97^{e}±0.00	0.31^{d}±0.01	0.42^{d}±0.00	0.36^{e}±0.00	1.07^{d}±0.00	1.18^{d}±0.00	1.15^{e}±0.00	1.43^{d}±0.01	1.50^{d}±0.01	1.48^{d}±0.00	0.70^{c}±0.01	0.78^{c}±0.01	0.71^{d}±0.01	1.13^{d}±0.00	1.22^{b}±0.00	1.20^{c}±0.01	1.01^{d}±0.02	1.04^{d}±0.00	1.04^{c}±0.01

Values are means±SD of duplicate determinations. Values on the same row with different superscripts are significantly (p<0.05) different. HDP: High-density polyethylene, LDP: Low-density polyethylene, UG: African bush mango (Ugiri), SP: Soursop, SD: Standard deviation

Table 6: Effect of packaging materials on the pH level of formulated fruit bar from African bush mango and SP blends during 28-day storage period

Storage period (week)	SP+UG (100:0)			SP+UG (0:100)			Samples/packaging materials														
							SP+UG (90:10)			SP+UG (80:20)			SP+UG (70:30)			SP+UG (60:40)			SP+UG (50:50)		
	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil
0	3.24^{d}±0.01	3.12^{d}±0.01	3.17^{a}±0.00	3.65^{a}±0.00	3.55^{e}±0.00	3.63^{e}±0.01	3.29^{e}±0.01	3.10^{e}±0.01	3.21^{e}±0.01	3.10^{d}±0.01	2.87^{a}±0.00	2.99^{c}±0.01	3.46^{c}±0.00	3.27^{b}±0.01	3.39^{a}±0.01	3.22^{c}±0.00	3.02^{a}±0.00	3.09^{c}±0.00	3.61^{e}±0.01	3.60^{C}±0.01	3.57^{d}±0.01
1	3.20^{c}±0.01	3.09^{c}±0.00	3.12^{b}±0.01	3.69^{b}±0.01	3.52^{d}±0.00	3.60^{d}±0.00	3.26^{d}±0.00	3.07^{d}±0.01	3.15^{d}±0.00	3.08^{d}±0.02	2.86^{a}±0.00	2.97^{b}±0.00	3.40^{a}±0.00	3.26^{b}±0.01	3.32^{b}±0.01	3.19^{bc}±0.00	2.99^{a}±0.01	3.07^{bc}±0.00	3.57^{d}±0.00	3.56^{b}±0.01	3.55^{d}±0.01
2	3.19^{b}±0.01	3.09^{c}±0.00	3.10^{bc}±0.00	3.65^{b}±0.01	3.47^{c}±0.01	3.53^{c}±0.01	3.24^{c}±0.01	3.01^{c}±0.01	3.12^{c}±0.01	3.03^{c}±0.01	2.83^{a}±0.01	2.95^{b}±0.01	3.44^{b}±0.00	3.23^{a}±0.00	3.28^{c}±0.01	3.17^{ab}±0.01	2.96^{a}±0.00	3.04^{b}±0.00	3.56^{c}±0.01	3.51^{a}±0.01	3.50^{c}±0.00
3	3.16^{a}±0.00	3.05^{b}±0.01	3.09^{c}±0.01	3.62^{c}±0.00	3.45^{b}±0.00	3.50^{b}±0.00	3.20^{b}±0.00	2.97^{b}±0.01	3.09^{b}±0.00	2.96^{d}±0.01	2.40^{a}±0.57	2.92^{a}±0.01	3.46^{c}±0.00	3.23^{a}±0.00	3.25^{d}±0.00	3.16^{a}±0.01	2.94^{a}±0.00	3.01^{a}±0.00	3.54^{b}±0.00	3.52^{a}±0.00	3.46^{b}±0.01
4	3.15^{a}±0.00	3.01^{a}±0.00	3.06^{d}±0.00	3.62^{d}±0.00	3.43±0.01	3.48^{a}±0.00	3.17^{a}±0.01	2.94^{a}±0.01	3.05^{a}±0.01	2.92^{a}±0.00	2.80^{a}±0.00	2.90^{a}±0.01	3.46^{c}±0.00	3.21^{a}±0.00	3.22^{e}±0.00	3.14^{a}±0.01	2.48^{a}±0.67	2.99^{a}±0.00	3.50^{a}±0.00	3.51^{a}±0.01	3.42^{a}±0.00

Values are means±SD of duplicate determinations. Values on the same row with different superscripts are significantly (p<0.05) different. HDP: High-density polyethylene, LDP: Low-density polyethylene, UG: African bush mango (Ugiri); SP: Soursop, SD: Standard deviation

bar of sample SP + UG (50:50) ranged from 2.3×10^5 to 1.8×10^9 cfu/ml, 1.5×10^5 to 1.4×10^9 cfu/ml, and 1.2×10^5 to 1.1×10^9 cfu/ml during the storage period for the 0, 2nd, 3rd, and 4th week in HDP, LDP, and foil, respectively. The formulated fruit bar stored in the HDP had the highest growth followed by the LDP and the foil.

In general, during the storage of the formulated fruit bar, the TVC of the products increased progressively in the packaging material (LDP, high-density polythene, and foil). However, the majority of the samples stored in HDP had the highest growth of micro-organisms and the least from the LDP. This could probably be due to the fact that the relative humidity of the storage room was high and also the handling condition of the products might have been poor. This result was in disagreement with the findings of Gargi *et al.* [8], who observed that after 1 month storage no microbial growth was observed in properly sealed jar.

Table 8 shows the effect of packaging materials on the mold count of formulated fruit bar during 28-day storage period.

The mold count of the formulated fruit bar of sample SP + UG (100:0) ranged from 0 to 8.0×10 cfu/ml, 0 to 7.0×10 cfu/ml, and 1.0×10 to 1.5×10^5 cfu/ml during the storage period for the 1st to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed by the HDP and the LDP.

The mold count of the formulated fruit bar of sample SP + UG (0:100) ranged from 2.0×10 to 1.2×10^2 cfu/ml, 3.0×10 to 1.0×10^2 cfu/ml, and 3.0×10 to 1.4×10^2 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed by the LDP and the HDP.

The mold count of the formulated fruit bar of sample SP + UG (90:10) ranged from 6.0×10 to 1.7×10^2 cfu/ml, 1.0×10 to 1.0×10^2 cfu/ml, and 2.0×10 to 1.2×10^2 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the HDP had the highest growth followed by the foil and the LDP.

The mold count of the formulated fruit bar of sample SP + UG (80:20) ranged from 3.0×10 to 1.5×10^2 cfu/ml, 4.0×10 to 1.4×10 cfu/ml, and 2.1×10^2 to 6.0×10 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed by the HDP and the LDP.

The mold count of the formulated fruit bar of sample SP + UG (70:30) ranged from 1.0×10 to 1.3×10^2 cfu/ml, 2.0×10 to 1.0×10^2 cfu/ml, and 1.0×10 to 7.0×10^2 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed the HDP and the LDP.

The mold count of the formulated fruit bar of sample SP + UG (60:40) ranged from 2.0×10 to 1.2×10^2 cfu/ml, 2.0×10 to 1.3×10^2 cfu/ml, and 2.0×10 to 9.0×10 cfu/ml during the storage period for the 0 to 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the LDP had the highest growth followed by the HDP and the foil.

The mold count of the formulated fruit bar of sample SP + UG (50:50) ranged from 2.0×10 to 2.1×10^2 cfu/ml, 1.0×10 to 1.5×10^2 cfu/ml, and 3.0×10 to 1.3×10^2 cfu/ml during the storage period for the 0, 2nd, 3rd, and 4th week in HDP, LDP, and foil, respectively. The fruit bar stored in the foil had the highest growth followed by HDP and the LDP.

In general, there was an increase in mold count, with the majority of the samples stored in the foil having a greater number of growth and the least from the LDP. This could probably be due to poor handling condition. Contamination of food by molds and bacteria is common. Hence, their presence in the finished products is considered unfit for consumption.

Sensory scores of formulated fruit bars from blends of African bush mango and SP blends

Table 9 shows the mean sensory scores of formulated fruit bars from African bush mango and SP blends. The mean scores for color ranged from 4.15 in sample SP + UG containing 50% SP to 7.90 in sample SP + UG containing 90% SP. There was an increase in the scores as SP in the blend increased. There was no significant ($p<0.05$) difference in the color observed in samples SP + UG (100:0), SP + UG (90:10), SP + UG (80:20), and SP + UG (60:40).

The mean scores for taste ranged from 4.00 in sample SP + UG containing 100% African bush mango to 7.30 in sample SP +

Table 7: Effect of packaging on the total viable count (cfu/ml) of the samples during 28-day storage period

Sample	0 week			1st week			2nd week			3rd week			4th week		
	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil
SP+UG (100:0)	2.4×10^5	1.8×10^5	2.0×10^5	1.8×10^6	1.3×10^6	2.6×10^6	2.3×10^7	1.6×10^7	1.2×10^7	2.3×10^8	1.8×10^8	1.4×10^8	2.0×10^9	1.6×10^9	1.8×10^9
SP+UG (0:100)	1.5×10^5	1.4×10^5	1.1×10^5	1.4×10^6	1.1×10^6	1.2×10^6	1.7×10^7	1.3×10^7	1.5×10^7	1.6×10^8	1.4×10^8	1.6×10^8	1.5×10^9	1.2×10^9	1.4×10^9
SP+UG (90: 10	2.0×10^5	5.6×10^5	1.3×10^5	1.6×10^6	1.0×10^6	1.2×10^7	2.7×10^7	1.5×10^7	2.7×10^7	2.5×10^8	1.9×10^8	2.2×10^8	2.7×10^9	2.0×10^9	2.4×10^9
SP+UG (80:20)	1.6×10^5	1.4×10^5	1.6×10^5	1.2×10^6	1.4×10^6	1.0×10^6	1.5×10^7	1.1×10^7	1.3×10^7	1.7×10^8	1.5×10^8	1.3×10^8	1.4×10^9	1.1×10^9	1.2×10^9
SP+UG (70:30)	6.7×10^4	3.5×10^4	4.4×10^4	2.7×10^6	1.3×10^6	2.6×10^6	2.3×10^7	1.5×10^7	2.0×10^7	2.0×10^8	1.7×10^8	1.9×10^8	1.9×10^9	2.4×10^9	1.5×10^9
SP+UG (60:40)	2.1×10^5	3.1×10^5	4.8×10^4	2.6×10^6	1.5×10^6	2.3×10^6	2.8×10^7	1.8×10^7	1.4×10^7	1.9×10^8	1.5×10^8	1.7×10^8	2.4×10^9	1.9×10^9	1.6×10^9
SP+UG (50:50)	2.3×10^5	1.5×10^5	1.2×10^5	1.3×10^6	1.5×10^6	1.1×10^6	1.6×10^7	1.2×10^7	1.0×10^7	2.3×10^8	1.6×10^8	1.3×10^8	1.8×10^9	1.4×10^9	1.1×10^9

Values are means±SD of duplicate determinations. HDP: High-density polyethylene, LDP: Low-density polyethylene, UG: African bush mango (Ugiri); SP: Soursop, SD: Standard deviation

Table 8: Effect of packaging on the mold count of formulated fruit bar during storage period

Sample	0 week			1stweek			2nd week			3rd week			4th week		
	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil	HDP	LDP	Foil
SP+UG (100:0)	-	-	1.0×10	1.0×10	1.0×10	1.0×10	2.0×10	2.0×10	2.0×10	5.0×10	5.0×10	5.0×10	8.0×10	7.0×10	1.5×10
SP+UG (0:100)	2.0×10	3.0×10	3.0×10	4.0×10	3.0×10	4.0×10	7.0×10	6.0×10	8.0×10	1.1×10^2	9.0×10	$1.1.\times10^2$	1.2×10^2	1.0×10^2	1.4×10^2
SP+UG (90: 10	6.0×10	1.0×10	2.0×10	7.0×10	3.0×10	2.0×10	9.0×10	5.0×10	5.0×10	1.5×10^2	7.0×10	7.0×10	1.7×10^2	1.0×10^2	$1.2.\times10^2$
SP+UG (80:20)	3.0×10	2.0×10	6.0×10	4.0×10	4.0×10	6.0×10	7.0×10	6.0×10	8.0×10	1.2×10^2	1.2×10	1.6×10^2	1.5×10^2	1.4×10	2.1×10^2
SP+UG (70:30)	1.0×10	2.0×10	1.0×10	1.0×10	4.0×10	2.0×10	2.0×10	8.0×10	4.0×10	6.0×10	1.2×10^2	6.0×10	1.3×10^2	1.0×10^2	7.0×10^2
SP+UG (60:40)	2.0×10	2.0×10	2.0×10	3.0×10	3.0×10	4.0×10	6.0×10	6.0×10	7.0×10	9.0×10	1.0×10	1.1×10^2	1.2×10^2	1.3×10^2	9.0×10
SP+UG (50:50)	2.0×10	1.0×10	3.0×10	1.1×10	2.0×10	5.0×10	3.0×10	7.0×10	4.0×10	1.1×10^2	1.4×10^2	1.3×10^2	2.1×10^2	1.5×10^2	1.3×10^2

Values are means of duplicate determinations. HDP: high-density polythene, LDP: low-density polythene, SP: Soursop, UG: African bush mango (Ugiri)

Table 9: Sensory scores of formulated fruit bars from SP and African bush mango blends blends

Sample	Color	Taste	Aroma	Texture	Chewiness	Mouthfeel	Aftertaste	Overall acceptability
SP+UG (100:0)	7.60^{d}±1.60	7.30^{b}±1.26	6.75^{b}±1.48	7.45^{c}±0.89	6.90^{c}±1.45	6.65^{c}±1.75	6.85^{d}±1.63	7.65^{d}±1.08
SP+UG (0:100)	5.25^{b}±1.94	4.00^{a}±2.05	5.40^{a}±1.88	4.75^{a}±1.94	3.85^{a}±1.95	3.75^{a}±2.22	3.25^{a}±2.27	4.25^{a}±1.10
SP+UG (90:10)	7.90^{d}±0.91	6.45^{b}±1.61	6.80^{b}±1.01	7.30^{c}±0.86	6.30^{c}±1.59	6.55^{c}±1.64	5.90^{cd}±2.19	6.60^{cd}±1.64
SP+UG (80:20)	6.65^{c}±1.25	6.70^{b}±1.30	6.35^{ab}±1.23	6.55^{bc}±1.09	5.90^{bc}±1.62	6.40^{c}±1.80	5.85^{ad}±1.50	6.75^{cd}±1.52
SP+UG (70:30)	7.00^{cd}±1.41	6.65^{b}±1.46	6.70^{b}±1.65	6.60^{bc}±1.54	6.05^{bc}±1.36	5.85^{bc}±1.63	5.30^{bc}±2.11	6.30^{bc}±1.81
SP+UG (60:40)	6.75^{c}±1.12	6.70^{b}±1.45	6.95^{b}±1.15	6.15^{b}±1.79	6.05^{bc}±1.28	6.05^{bc}±1.61	5.00^{bc}±1.86	6.05^{bc}±1.64
SP+UG (50:50)	4.15^{a}±2.35	4.75^{a}±2.14	5.45^{a}±2.50	6.05^{b}±1.85	5.10^{b}±2.07	5.00^{b}±2.25	4.15^{ab}±2.03	5.20^{ab}±2.24

Values are means±SD 20 panelists. Values with the same superscripts in a row are not significantly (p>0.05) different. SP: Soursop; UG: African bush mango (Ugiri), SD: Standard deviation

UG containing 100% SP. The scores for taste increased as the proportion of SP in the formulated African bush mango – SP fruit bar increased.

There was no significant (p<0.05) difference in the taste observed in samples SP + UG (100:10), SP + UG (90:10), SP + UG (80:20), SP + UG (70:30), and SP + UG (60:40). Furthermore, there was no significant (p<0.05) difference between sample SP + UG (100:0) and SP + UG (50:50).

The mean scores for aroma ranged from 5.40 in sample SP + UG containing 100% African bush mango to 6.80 in sample SP + UG containing 90% SP. The scores for aroma increased as the proportion of SP increased in the African bush mango - SP blends. There was no significant (p<0.05) difference in the aroma observed in samples SP + UG (100:0), SP + UG (90:10), SP + UG (70:30), and SP + UG (60:40). Furthermore, there was no significant (p<0.05) difference between the samples SP + UG (0:100) and SP + UG (50:50).

The mean scores for texture ranged from 4.75 in sample SP + UG containing 100% African bush mango to 7.45 in sample SP + UG containing 100% SP. The scores for texture increased as the proportion of SP increased in the fruit bar during blending. There was no significant (p<0.05) difference in the texture observed in samples SP + UG (100:0), SP + UG (90:10), SP + UG (80:20), SP + UG (70:30), SP + UG (60:40), and SP + UG (50:50).

The mean scores for chewiness ranged from 3.85 in sample SP + UG (0:100) to 6.90 in sample SP + UG (100:0). The scores for chewiness increased progressively as the proportion of SP increased during blending. There was no significant (p<0.05) difference in the chewiness observed in samples SP + UG (100:0), SP + UG (90:10), SP + UG (80:20), SP + UG (70:30), and SP + UG (60:40).

The mean scores for mouthfeel ranged from 3.75 in sample SP + UG (0:100) to 6.65 in sample SP + UG (100:0). The scores for mouthfeel increased as the proportion of SP in the samples increased. There was no significant (p<0.05) difference in mouthfeel observed in sample SP + UG (100:0), SP + UG (90:10), and SP + UG (80:20). Furthermore, there was no significant (p<0.05) difference between sample SP + UG (70:30) and SP + UG (60:40).

The mean scores for aftertaste ranged from 3.25 in sample SP + UG (0:100) to 6.85 in sample SP + UG (100:0). The scores for aftertaste increased progressively as the proportion of SP increased in the sample blends. There was no significant (p<0.05) difference in the aftertaste of sample SP + UG (70:30) and SP + UG (60:40).

The overall acceptability mean scores for the fruit bar ranged from 4.25 to 7.65 with sample SP + UG (0:100) having the lowest value and sample SP + UG (100:0) the highest value. Sample SP + UG (100:0) was rated highest probably due to the likeness for the fruit, its pleasant aroma, and taste as preferred by the panelists. While on the other hand, sample SP + UG (0:100) was rejected probably due to its bitter aftertaste.

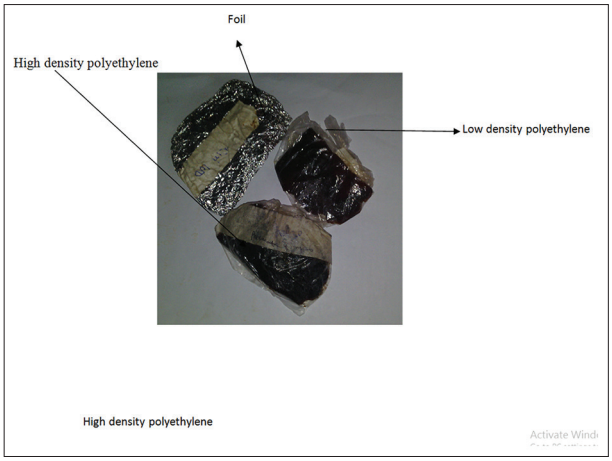

Plate 1: Formulated fruit bar ready for analysis

CONCLUSION

From the results, the incorporation of SP to the fruit bar increased the nutritional profile significantly by providing higher amount of vitamin C as its blend increased. The storage of the fruit bar in the different packaging materials (HDP, LDP, and foil) did not have any effect on the physicochemical characteristics (titratable acidity, pH, and sugar level) of the products. While the microbial load of the formulated fruit bar increased during the period of storage. Based on the overall acceptability, the fruit bar sample SP + UG (100:0) was rated highest probably due to the likeness for the fruit, its pleasant aroma, and taste as preferred by the panelists. While on the other hand, sample SP + UG (0:100) was rejected probably due to it bitter aftertaste.

It is recommended to use succulent tropical fruits such as banana, mango among others to increase the acceptability of this product in this part of the world. Moreover, moisture permeability studies should be done on the packaging material before storage studies. Furthermore, further storage studies should be carried out on the effect of packaging materials (HDP, LDP, and foil) on the proximate composition of the fruit bar. From the result obtained from the microbial count of the product stored for 4 weeks in a single package was not adequate, it is, therefore, recommended that double packaging material should be used for further storage which should not be in a humid environment.

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