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Quality Assessment of Formulated Table Wine from Blends of Starfruit (*Averrhoa carambola*) and Peter Mango (*Mangifera indica*) Fruits

Muotolu U.F*, Mbaeyi-Nwaoha I.E

Department of Food Science and Technology, University of Nigeria, Nsukka, Enugu state Nigeria
*Corresponding author: uf.muotolu@coou.edu.ng

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Abstract Table wine was produced from the juice of the starfruit and Peter mango. Fermentation of the juice lasted for 7days at 28±2°C. The juice samples were blended before fermentation (prefermented and coded as SMs) and other wine samples were obtained from individually fermented wine (postfermented and coded as SMp) at the ratio of starfruit to Peter mango 90:10, 80:20, 70:30, 60:40 and 50:50, aged for two weeks, bottled and corked. A commercial wine served as control. Sensory evaluation was carried out using a 9-point Hedonic Scale and the data were statistically analysed. The starfruit had 76.0% yield, 88.67% moisture, 9.33 °Brix total soluble solid, pH 2.20, 1.99% pectin 0.003% methanol 0.0031 and titrable acid while the Peter mango had 53.0% yield, 62.53% moisture, 38.4 °Brix total soluble solids, pH 3.90, pectin 4.26%, methanol 0.0376 % and titrable acidity 0.20%. The prefermented wine had decrease in alcohol from (8.10 - 7.33%), total soluble solids (4.00 - 17.90 °Brix), titratable acidity (0.29 - 0.26), pectin (4.13 - 4.40%), methanol (0.0190 - 0.0201%) and pH (2.30 to 3.00). There were decreases in moisture (96.40 - 82.93%), protein (0.42 - 16.10%), ash (0.60 - 0.027%), fat (0.10 - 0.13%), carbohydrate (2.68 - 16.10%) and crude fiber was not detected. There were increases in provitamin A content (12.57 - 22.37mg/100ml), Vitamin B_1 (0.00260 - 0.0410mg/100m)l Vitamin C (11.76 - 14.00mg/100ml) and carotenoid (21.03 - 62.17mg/ml). There were increases in iron (0.009 - 0.06mg/ml), potassium (2.05 - 7.95mg/100ml) and decrease in magnesium content (2.10 - 0.83mg/100). The total viable count ranged from ($1.0x10^1$ to $2.8x10^1$cfu/ml) while mould count ranged from $0.4x10^1$ to $1.7x10^1$cfu/ml. For the postfermented wine, alcohol content ranged from (8.70 - 11.70%), methanol (0.0199 - 0.0200 %) and decrease in pH from (3.50 - 3.33). There was decrease in moisture content 90.17 - 84.07%, protein 0.33 - 0.43%, ash 0.17 - 0.27% carbohydrate 8.91 - 15.10% and crude fiber not detected. There were decreases in the provitamin A content (44.23 - 19.27mg/100ml), vitamin B_1 (0.0290 - 0.0373mg/100ml), vitamin C (11.28 - 14.65m/100ml) and decrease in carotenoid content (63.30 - 30.07mg/100ml). There were increase in the iron content (0.005 - 0.01mg/100ml), potassium (3.11 - 9.84mg/100ml) and magnesium content (0.83 - 0.83mg/100ml). There was decrease in total viable count from $3.0x10^1$ - $2.3x10^1$cfu/ml and mould count ($2.8 x10^1$ to $1.4 x10^1$ cfu/ml). The control sample was most preferred with highest score in colour (7.65) and flavor (6.50). The postfermented wine of the ratio 80:20 was more preferred by the panelists and had highest score in after taste (5.95) and overall acceptability (6.10). There were no significant ($p>0.05$) differences in most of the attributes because the formulated wines compared favourably with the control in taste, aftertaste, mouth feel and overall acceptability.

Keywords: *table wine, starfruit, peter mango, fermentation, physicochemical, proximate, micronutrients, microbial load*

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1. Introduction

Grapes are the main raw materials that have been used for wine production for the past few decades. However, many research groups have investigated the suitability of fruits other than grapes like guava, pineapple, watermelon, apple, starfruit, mango, soursop orange among others for wine production [1]. Wine is an alcoholic beverage made from grapes generally, fermented without addition of sugars, acids, enzymes, water or other nutrients [1]. As a part of normal diet, wine provides the body with energy, with substances that aid digestion, and with small amount of minerals and vitamin [2]. Table wine is the wine whose alcoholic content is between 6 to 14% by volume [3].

Starfruit (*Averrhoa carambola*) is an attractive tropical fruit of *Oxalidaceae* family also known as golden star.

Startfruit in green when unripe, the fruit vary from pale yellow to deep amber when ripe. When the fruit is cut crosswise each slice is shaped like a star, hence its named "starfruit''. The fruit is mostly consumed fresh or as juice, is rich in vitamins (provitamin A), B and C, also has high iron and high fiber contents [4]. The ripe fruit may be processed into unfermented and fermented drink (wine), jelly, can be eaten fresh as a dessert. The unripe fruits can be eaten as vegetable [5]. The taste varies from sour to sweet, the sweet type in processed into wine [6]. Several studies have described the toxic effects of star fruit and provide evidence to suggest a recommendation against the consumption of this fruit by patients with chronic kidney disease (CKD). [7].Given the increased availability of starfruit and its growing popularity worldwide, it is important to raise awareness of the harmful effects that its consumption can have on kidney function, not only in patients with impaired renal function but also in apparently healthy persons. It has also been shown that starfruit has a high content of oxalates that can cause acute oxalate nephropathy in rats. [8] Neurotoxic effects are due to caramboxin, a nonproteinogenic amino acid, which has an agonist effect on NMDA glutamate receptors and that normally does not cross the blood-brain barrier. [9] Symptoms such as hiccups, altered states of consciousness, seizures, and coma are due to the inability of the kidney to excrete these toxic components of starfruit. Patients with already diagnosed kidney failure should be told to avoid starfruit. More problematic is to address the risk of acute renal failure, which has been described in a few participants with previously normal renal function [8,10].

Peter mango (*Mangifera indica*) is one of the eight varieties of mango cultivated in Benue state, middle belt of Nigeria. It is a specie of tropical tree belonging to the flowering plant cultivated mostly for their edible fruit. Peter variety mango is a member of the family *Anacardiaceae* [11]. The mango is usually green in colour when unripe and yellow or still retain its green colour when ripe. Peter mango is large in size and is sweet like sugar when is ripe. The pulp from ripe Peter mangoes are used to make jam called mangada, also used to make juices, nectar, fermented into wine and as a flavouring and major ingredient in ice cream and sorbetes [12]. The name Peter mango was originated from Peter Johnson, a horticulturist from Department of Agriculture and Food in Kununura and an expert in the field of mangoes [13]. Peter mango contains a high concentration of sugar that makes it suitable for wine production also contains good concentrations of vitamins A, C, and β-carotene which are helpful as cancer preventing agents [13]. Wines are mostly produced from grapes, which are not grown in Nigeria, hence, there is need for use of alternative fruit for wine production. In Nigeria, there is availability of suitable fruits which could be exploited for wine making such as guava, pineapple, watermelon, apples, starfruit, mango, soursop among others. These fruits are highly perishable, and susceptible to both bacterial and fungal contamination as a result they fail to reach the market due to spoilage, mechanical damage and over ripeness [14]. Utilization of fruit in Nigeria and most developing countries is limited due to inadequate processing and preservation methods [15]. The production of fruit crops in Nigeria is seasonal, thus, there is need to preserve and store them from time of harvest to the period of scarcity (in and out of season), for the purpose of retaining them as foods and articles of trade [16]. This study will add value to these fruits, create a stable market for farmers and improve the economy of the country.

The aim of this research work was to produce single strength starfruit and Peter mango fruit juices, evaluate the quality characteristics of table wine from blends of starfruit (*Averrhoa carambola*) and Peter mango (*Mangifera indica*), determine the physicochemical composition, proximate composition, micronutrient composition, microbiological and organoleptic properties of wines produced from starfruit and Peter mango fruit juices

2. Materials and Methods

2.1. Procurement of Raw Materials

The starfruits (*Averrhoa carambola)* were harvested from Farm Operation Unit, Faculty of Agriculture, University of Nigeria, Nsukka and the Peter mangoes (*Mangifera indica)* were procured from a local market in Makurdi, Benue State, Nigeria.

2.2. Sample Preparation

The fruits were sorted manually by removal of the soft ones and picking out the firm ones for wholesomeness. The sorted fruits were washed with clean water and drained. Peeling and cutting were done with stainless knives. The skin of the Peter mangoes were peeled off with stainless knives, the peeled mangoes and starfruits were cut into small parts. The starfruits and mangoes parts were crushed with a blender (Binatone model 350, Japan). The crushed fruits were squeezed in muslin to obtain the juice. The must (extracted juice) consisting of 5000ml starfruit and 2000ml. Peter mangoes juice were inoculated with the 10g wine yeast and allowed to ferment in 10 and 5liters black gallon at a temperature of 25±2°C for 7 days in fermentation room. Another 5000ml starfruit and 2000ml Peter mango juices were blended in proportion and allowed to ferment at temperature 25±2°C for 7 days in fermentation room. The wine which was blended in various ratios (90:10, 80:20, 70: 30, 60:40 and 50: 50) starfruit:Peter mango as shown in Table 3 were filled into sterilized bottles, sealed/corked. The table wine was also processed by blending of the individually fermented juices in various proportions (90:10, 80:20, 70:30, 60: 40 and 50:50 starfruit: Peter mango and were also filled into sterilized bottles, sealed/corked, all the samples were aged for two weeks in fermentation room to allow the development of characteristic flavour of the wines. (Figure 1)

2.3. Starter Culture Preparation

Pour into a conical flask 700ml (extracted juice consisting of 500ml starfruit and 200ml Peter mango) and was added to the ten grammes (10g) of wine yeast and 10g of sugar. The starter culture was incubated for 2days at room temperature before inoculation into the must.

Plate A:FLOWER OF STARFRUIT

Plate B:UNRIPE STARFRUIT

Plate C: SLICED UNRIPE STARFRUIT

Plate D: RIPE STARFRUIT (*Averrhoa carambola*)

Plate E: SLICED RIPE STARFRUIT

Plate A-E. Star fruit from Flowering stage to unripe (Whole), sliced and ripe (whole and sliced) (Source: [17])

Plate A. Unripe Peter mango

Plate B. Ripe Peter variety (Source: [18])

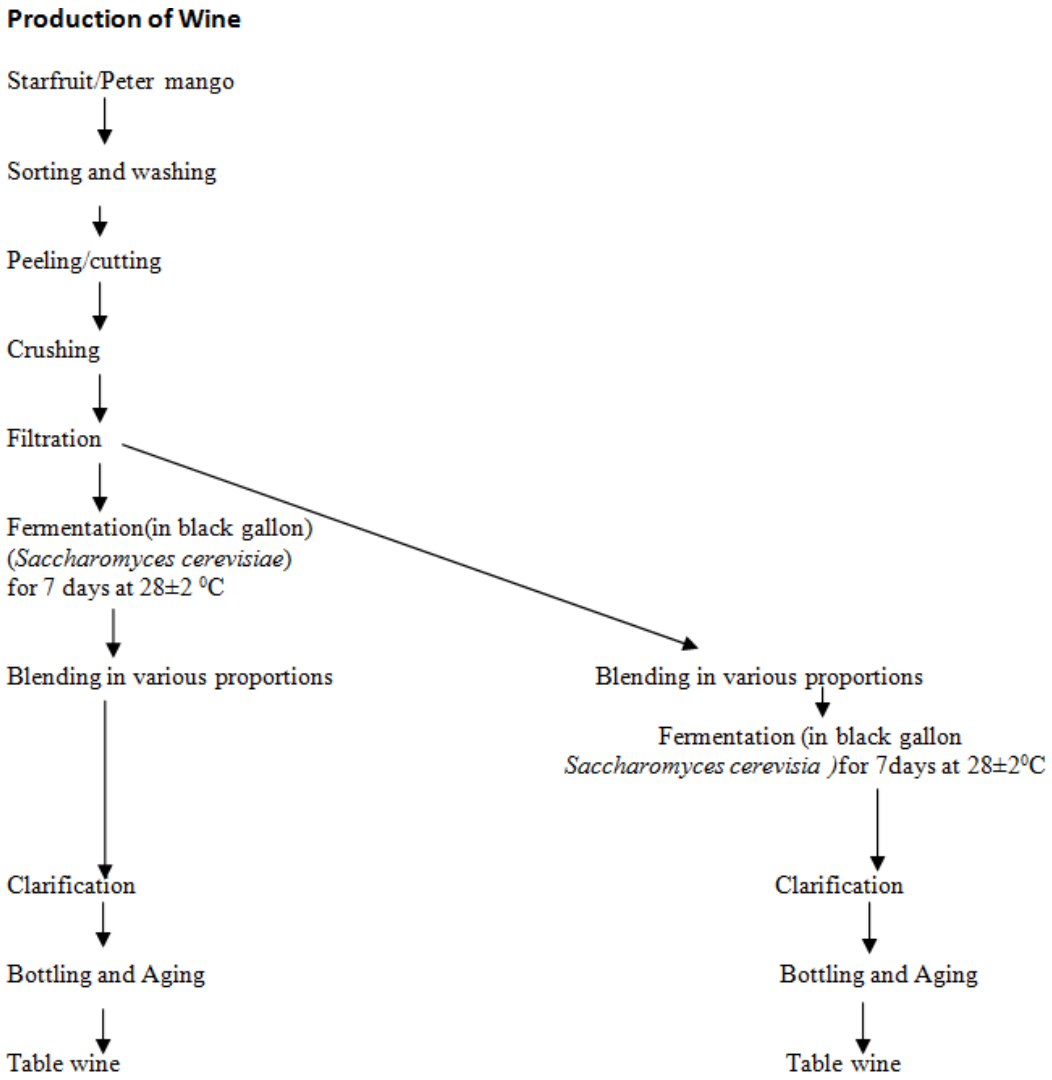

Figure 1. Flow chart for the production of table wine from prefermented and postfermented blends of starfruit and Peter mango

Table 1. Formulation of table wine from prefermented and postfermented starfruit and Peter mango blends

Sample code	Proportion (m1)
G (Control)	100: 0
SMs	90: 10
SMs	80: 20
SMs	70: 30
SMs	60:40
SMs	50:50
SMp	90:10
S Mp	80:20
S Mp	70: 30
SMp	60: 40
SMp	50:50

Keys: G = Grape wine, SMs = Prefermented starfruit and Peter mango juice before blends, SMp = Postfermented starfruit and Peter mango after wine blends.

2.4. Analytical methods

2.4.1. Chemical and Physical Analyses

The following analyses were carried out on the fresh juices and wine samples

2.4.2. Determination of Percentage Yield

The yield ($^{o}/_{o}$) of the wine percentage ($^{o}/_{o}$) was calculated using the method described by [19]

$$Yield = \frac{Weight\ of\ wine}{Weight\ of\ the\ whole\ fruit} \times 100.$$

2.4.3. Determination of Total Soluble Solids

This was determined using standard [19] method. Ten milliliters (10 ml) of the sample was pipetted into a washed, and weighed crucible. The dish and the content (crucible containing ten milliliters of the sample) were put into an oven and dried at 70°C for 3 hours at pressure not exceeding 100 mmHg. It was cooled in a desiccator and the weight of the total soluble solids was determined.

$$percentage\ total\ soluble\ solid = \frac{Weight\ of\ dried\ solid}{Volume\ of\ sample} \times 100.$$

2.4.4. Determination of pH

The pH was determined using a pH meter as described by [19]. Five milliliters (5 ml) of the sample was

measured into a beaker and the glass electrode was inserted inside the beaker and the reading was taken.

2.4.5. Determination of Titratable Acidity

Determination of titrable acidity of the wine was carried out in accordance with the method described [19]. Ten milliliters (10 ml) of the wine was diluted to 250 ml using distilled water and titrated with standardized 0.1N NaOH (sodium hydroxide) solution using 0.3 ml phenolphthalein for each 100ml solution being titrated indicator to a pink end point, which persisted for 30 seconds. This was expressed in terms of NaOH/100 ml of the sample.

The percentage titratable acidity was calculated using the equation

$$\%\ titratable = \frac{Number\ of\ NaOH}{Number\ of\ milliters\ of\ sample} \times 0.75.$$

2.4.6. Determination of Alcohol Content

The alcohol content was determined using the standard distillation method described by [19]. A sample containing 100ml of wine was measured into a distillation flask and the apparatus was set up. The alcohol was distilled at 78°C and the volume was calculated as:

$$\%\ alcohol\ content = \frac{Volume\ of\ distillate}{Original\ volume\ (ml)}.$$

2.4.7. Determination of Pectin Content

The percentage pectin content was determined by the method described [20]. Then, 10milliliters (10ml) of the sample (starfruit/peter mango pulp) was extracted using cold water; the mixed extract was boiled and filtered with filter paper (Whatman No.1). An aliquot of the filtrate was diluted to 300ml, 100ml of 0.1M NaOH was added and allowed to stand overnigh. Thereafter, 50ml acetic acid was added, followed after 5 minutes by 50ml calcium chloride solution. This was allowed to stand overnight, boiled for a few minutes and then 50ml calcium chloride solution was allowed to stand for one hour, boiled for a few minutes and filtered. The residue was washed with boiling water until freed of chlorides, boiled with water and filtered on a gooch crucible, washed, dried and weighed as calcium pectate. The percentage pectin content was calculated using the equation:

$$\%\ Pectin = \frac{Weight\ of\ pectin}{Original\ weight\ of\ sample} x100.$$

2.4.8. Determination of Methanol Content

The methanol content was determined using the method described by [20]. Twenty milliliters (20ml) of the sample was distilled and two milliliters (2ml) of potassium permanganate and 2ml of sulphuric acid and mixture were put into 5 milliliters (5ml) of the distillate. This mixture was allowed to stand for 10 min and 2 milliliters (2ml) of oxolatin and sulphuric acid mixture was added and allowed to develop colour. The colour developed was measured and compared with the pure methanol and the methanol content was calculated.

The percentage methanol content was calculated using the equation:

$$\%\ methanol = \frac{Weight\ of\ methanol}{Original\ weight\ of\ sample} x100.$$

2.5. Proximate Analysis

2.5.1. Determination of Moisture Content

The moisture content was determined by hot air oven drying method described by [19]. Stainless steel oven rushes were cleaned and dried in the oven (Fulton, Model NYC - 101 Sheldon Manufacturing Incorporation, Oregon, USA) at 100 °C for one hour (W_1). The oven dishes were cooled in a desiccator and then weighed. Ten milliliters (10 ml) of each of the samples was placed in the oven dish and dried at 100 °C (W_2). The sample was removed from the oven and placed in a desiccator to cool to room temperature (27 ± 2 °C) before weighing. The oven dishes were put back into the oven and weighed intermittently until a constant weight (W_3) was recorded. The loss in weight from the original sample weight was calculated as the moisture content.

$$\%Moisture = \frac{Moisture\ loss}{Weight\ of\ sample} x100 = \frac{W_2 - W_3}{W_1} x100$$

Where: W1= Weight of empty oven dish
W_2= Weight of oven dish+ sample before drying
W_3= Weight of oven dish + sample after drying.

2.5.2. Determination of Protein Content

The protein content of the samples was determined according to the standard methods [19] using Kjeldahl method.

A. Digestion of the sample

Two milliliters (2 ml) of the sample was weighed into the Kjeldahl flask and anhydrous sodium sulphate (5g) was added. Twenty five milliliters (25ml) of concentration H_2SO_4 was added with few boiling chips. The content of the flask was heated in the fume chamber until clear solution was obtained. The solution was cooled and transferred into 250ml volumetric flask and made up to the level with distilled water.

B. Distillation

The distillation was carried out using a well cleaned Markham's apparatus (100ml conical flask) (receiving flask) containing 5ml of 2% boric and 2 drops of methyl red indicator was placed in the condenser. Then, 5ml of the digest was pipetted into the apparatus through the small funnel on the unit. The digest was washed down with distilled water and followed by addition of 10ml of 60% sodium hydroxide.

C. Titration

The solution in the flask was titrated with 0.01N HCl until the first permanent pink colour appears. The blank was titrated in the same way. The % Nitrogen was calculated as:

$$\%Nitrogen = \frac{Vs - V_s - V_b}{W}\ x\ Normality\ of\ acid\ x\ 100$$

Where, V_s= Volume (ml) of acid required to titrate sample, W=Weight of sample in gram (g)
V_b= Volume (ml) of acid required to titrate the blank: N (acid = Normality of acid (0.1N) W = Weight of sample in gram (g)

The protein content was calculated as:

$$Protein\ (\%) = N\ x\ 6.25(conversion\ factor\ for\ protein).$$

2.5.3. Determination of Ash Content

The ash content of the samples was determined according to the standard method of [19]. A preheated and cooled crucible was weighed (W_1). Two milliliters of the sample were weighed into the crucible (W_2). The sample was charred on a Bunsen flame inside s fume cupboard. The charred sample was placed in a Muffle furnace set at 550°C and heated for 2 hours until a white or light grey ash was obtained (W_3). The sample was removed, cooled in desiccator and weighed. The ash content was calculated as:

$$Ash\ content = \frac{W_2 - W_3}{W_1} x100$$

Where W_1 = Weight of empty crucible
W_2= Weight of crucible + weight of sample before drying
W_3 = Weight of crucible + sample after drying.

2.5.4. Determination of Fat Content

The fat content of the sample was determined using the standard [19] method. A Soxhlet extractor with a reflux condenser and a 500 ml round bottom flask was set up. About 300ml of petroleum ether was poured into the round bottom flask. The sample (2ml) was weighed into labeled thimble and sealed with cotton wool, then fitted into the extraction tube of the Soxhlet extractor. The Soxhlet extractor after assembly was allowed to reflux for about 6 hours, after which the thimble was removed with care and the petroleum ether (40 - 60°C) collected on top and drained into a container for re-use. The flask and its content were dried at 60°C in a hot air oven. It was then removed from the oven and cooled in a desiccator and weighed. The fat content was calculated as :

$$Fat\ (\%)\ content \cong \frac{Weight\ of\ fat}{Weight\ of\ sample} x100.$$

2.5.5. Determination of Crude Fibre Content

The crude fibre content was determined according to [19]. The sample (3ml) of juice was weighed into 1 liter conical flask. Petroleum ether was added, swirled and left to stand and carefully decanted. This was repeated twice preferably leaving the last quantity of solvent in contact overnight, with a small watch glass over the mouth of the conical flask. The solvent was carefully decanted avoiding loss of particles of fibre and then warmed gently to remove visible solvent. Then, 200milliliters (200ml) of 0.255Normality of acid was added and flask was placed on a hot plate, so as to return the solution to boil as quickly as possible. A funnel of 10cm was placed in the mouth of the flask to reduce evaporation. Heating was controlled as soon as the liquid started to boil as to maintain gentle ebullition for 30±2mins. A Buchner flask and funnel connected through a trap to vacuum pump was prepared and a Whatman filter No.52 paper was placed in the funnel. The flask was removed from the heat at the end of the boiling period. The flask was allowed to settle a few moments and then decanted through the buchner funnel, applying gentle suction such that the funnel was not permitted to empty completely until most of the flask content was transferred. The flask was dried in an oven, cooled in a desiccator and weighed using a weighing balance. The loss in weight represented the fibre content. The fibre residue from the test consists mainly of cellulose with some lignin, but not all the cellulose was determined.

Calculation:

$$\%Fibre = \frac{\text{Loss in weight from incineration}}{\text{Weight of sample before deffating}} \text{x100.}$$

2.5.6. Determination of Carbohydrate Content

The carbohydrate content was determined by difference as described by [19] method. The carbohydrate content was calculated as:

$$carbohydrate = 100 - (+ash + protein + fat + crude\ fiber).$$

2.6. Determination of Vitamin Contents

2.6.1. Determination of Provitamin A and Total Carotenoids Contents

Vitamin A was determined using [19] method. Five milliliters of the sample were pipetted in duplicate into a glass stopper test tube in equal volume. Two milliliters of ethanol were added drop wise with mixing to give 50 % solution. At this concentration, the protein precipitated (free from retinol and retinol esters) and was extracted by addition of 3 ml hexane. The tube was stoppered and the contents mixed vigorously on the vortex for 2 minutes to ensure complete extraction of carotene for 5-10 minutes at 600 (rpm) x g to obtain a clean separation of phases. Two milliliters (2) ml of the upper hexane extract was pipetted. Absorbance due to carotenoids at 450 nm was read against a hexane blank (A450). A standard curve was plotted from the A 620 values on ordinary rectangular coordinate paper, where the ordinate was at the A620 values and the abscicissa the µg vitamin A per tube and a factor (FA620) calculated as:

$$FA620 = \frac{\mu g\ vitamin\ A / tube}{A_{620}}$$

Vitamin A was calculated using the formula:

$$Total\ carotenoid\ (as\ lycopene / dl) = A_{620} Fc_{450} 150$$

Where Fc_{450} = constant determined on the laboratory, 150 = dilution factor

Likewise, provitamin A was calculated as follows:

$$\left| A_{620} - \frac{2 \times A_{450} \times Fc_{450}}{Fc_{620}} \right| \times FA_{620} \times 75.$$

2.6.2. Determination of Vitamin B_1 Content

Thiamin content was determined using the sealer analyzer method [19]. Each of 5 ml of the samples was homogenized in 5 ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up to 100 ml with the extract solution. A ten (10) milliliter aliquot to the extract was dispensed into a flask and 10 ml of potassium dichromate solution was added. The resultant

solution was incubated for 15 minutes at room temperature (25±1°C). The absorbance was read from the spectrophotometer (Jenway, 6305 UV, United State) at 360nm using a reagent blank to standardize the instrument at zero. Thiamin content was calculated as follows:

$$Thiamin\ (mg/100ml) = \frac{100}{w} \times \frac{au}{as} c \times d$$

Where;
w =Weight of sample analyzed; au = absorbance of the sample solution; as = absorbance of standard solution; c = concentration of standard solution; d = dilution factor

2.6.3. Determination of Vitamin C Content

The 2,6 dichlorophenol titrimetric method as described by [19]. Two milliliters of the sample were extracted by homogenizing the sample in acetic acid solution. The standard solution was prepared by dissolving 50 mg of ascorbic acid in 100 ml of water. The solution was filtered to get a clear solution. Then, 10ml of the filtrate was put into a flask in which 2.5 ml acetone had been added. This was titrated against indophenol solution (2,6, dichlorophenol indophenols) to a faint pink colour which persisted for 115 seconds. The standard was treated in similar way.

Calculation

$$mg\ ascorbic\ acid / ml = C\ x\ V\ x\ DF / WT$$

Where C=mg ascorbic acid ml dye; V= Volume of dye used for titrating the diluted sample;
DF=DiIution factor; WT= Volume of sample in ml

2.7. Determination of Mineral Composition (Potassium, Magnesium and Iron)

The mineral analysis carried out using the method described by [21]. Two milliliters (2 ml) of the sample was weighed and ashed for five hours in well-cleaned porcelain crucibles at 550 °C in a Muffle fumace. The resultant ash was dissolved in five milliliters of HNO_3/HCl/$H_2$0 (1:2:3) and heated gently on a hot plate until brown fumes disappeared. Five milliliters (5) ml of deionized water was added and heated until a colourless solution was obtained. The solution in each crucible was filtered into 100 ml volumetric flask and the volume made up to 100 ml with deionized water. The solution was then used to determine potassium, magnesium and iron contents using atomic absorption spectrophotometer.

2.8. Microbiological Analysis

The total viable and mould count were determined using the pour-plate method as described by [22].

2.8.1. Determination of Total Viable Count (TVC)

This was carried out according to the method described by [22]. Then 26 g of nutrient agar was dissolved in five hundred milliliters of distilled water and sterilized. The sample and sterilized quarter of ringer solution were used. One milliliter of the sample and nine milliliters ringer solution was made for the serial dilutions. The diluted sample was pipetted into a marked petri dish, swirled to mix and incubated at 37°C for 24 hours. After incubation, the number of colonies were counted with colony counter and expressed as colony forming unit per milliter (Cfu/ml).

2.8.2. Determination of Mould Count

The mould count was determined using the method described by [22]. Fifteen milliliters of Sabouraud dextrose agar (SDA) was prepared with 32.5 g of it diluted in (500 ml) of distilled water. The SDA media solution was added (1 ml) of the sample in the petri dish. It was properly mixed and allowed to set before incubating at 37°C for 48 hours. After incubation, the number of colonies were counted with colony counter and expressed as colony forming unit per milliliter (Cfu/ml).

2.9. Sensory Evaluation

The sensory evaluation was carried out on the prefermented and postfermented samples using a 9-point Hedonic scale (where '9' was extremely liked, while 1 was extremely disliked). A- 20 member semi-trained panel of judges evaluated the products for flavour, taste, aftertaste, mouthfeel, color and overall acceptability. The samples were filled in disposable cups which were labelled prefermented and postfermented and the control was labelled as G. Potable water was provided for rinsing of their mouth in between evaluations [23]. The sensory evaluation was carried out in a sensory evaluation laboratory under standard condition or lighting and ventilation.

2.10. Experimental Design and Data Analysis

The experiment was repeated five(5) times to avoid error. The experimental design was Completely Randomized Design. The data generated from all analyses were subjected to Analysis of variance (ANOVA) using the Statistical Package for Service Solution (SPSS) version 20. Means were separated using the Duncan's Multiple Range Test and the significance was accepted at $p< 0.05$ [24].

3. Results and Discussion

3.1. Chemical Composition of Juices

The yield and chemical composition of juices from starfruit (*Averrhoa carambola*) and Peter mango (*Mangifera indica*) are shown in Table 1.

The percentage yield of starfruit and Peter mango juices were 76.0 % and 53.0%, respectively. The difference could be attributed to the fact that starfruit had higher moisture content (86.67 %) than the Peter mango (62.53 %). The yield of the starfruit juice (76.0%) was in agreement with that reported by [25] for the yield of starfruit juice while the (53.0 %) juice yield for the Peter mango obtained fell within the range of 52.9 - 72..8% for mango varieties reported by [26]. The high moisture content of starfruit juice (88.67 %) was in line with the work by [27] who reported that the moisture content of starfruit juice ranged between 87 and 90 %. The high moisture content makes the juice suitable as a refreshing and thirst-quenching product which is a characteristic of

good juice. The moisture content of Peter mango (62.53 %) was within the range 56.3 % - 86.0 % moisture content of mango juices reported by [28]. The ash content of starfruit was 0.50% and that of Peter mango 0.77 %. The ash content of starfruit juice was higher than the ash content of starfruit juice (0.43 %) reported by [28]. This could be attributed to harvesting season, climate among others factors [28]. Ash content of Peter mango (0.77 % observed was also higher than (0.66 %) of Julie mango juice reported by [29], probably due to the soil type, ripening time among other factors [29]. The fat content of starfruit juice was 0.55 % while that of Peter mango juice was 0.65%. The fat content of fresh starfruit juice (0.55 %) was higher than the range 0.29 - 0.32% reported by [30] for starfruit juice. This could be attributed to environmental conditions, ripening stage and harvesting season. The fat content of Peter mango (0.65%) was in agreement with that reported by [31] that the fat content of fresh mango juices ranged between 0.13 and 1.20 %. The protein content of starfruit juice was 2.44 %. [32] reported that the protein content of starfruit juices ranged between 0.15 and 4.04 % which was comparable with the result of the present study. The protein content of Peter mango 1.14 % fell within the range 0.09 - 1.18 % reported by [33] for mango juice. The fibre content of fresh starfruit and Peter mango juice were not detected.

This could be attributed to the fact that the samples were blended separately and sieved 3 times with muslin cloth. The carbohydrate content of fresh starfruit juice was 8.18% [34] reported 9.78 % which was higher than the result obtained from the present study. This could be due to whether, ripening stage and harvesting season. Carbohydrate content of the fresh Peter mango juice was 34.9%, [35] reported carbohydrate content within the range 32.16 - 63.80 %. The pH of the starfruit juice obtained was 2.20. This value was in agreement with the report by [25] that pH was 2.20. The pH of Peter mango juice obtained in the present study was 3.90. [36] reported similar value.

The starfruit juice and Peter mango juices had no alcohol. The total soluble solids of starfruit juice and peter mango were 9.33 °Brix and 38.4 °Brix, respectively. The total soluble solid of fresh starfruit juice (9.33 °Brix) was low compared to that of Peter mango juice (38.4 °Brix). This could be attributed to the fact that the starfruit juice had higher acidity but lower carbohydrate content than Peter mango juice [37,38] recommended 6.20 °Brix as the minimum for mango beverages which was lower than the 38.4 °Brix obtained in the present study. Also, [39] reported range between 66.80 - 67.00 °Brix which was higher than the total soluble solids of both juices.

The pectin content of the fresh starfruit juice was 1.99 %. This value was in agreement with the findings of [40], that the pectin content of starfruit juice ranged from 1.74 to 5.11%. The pectin content of Peter mango was 4.26 %. This fell within the range of 2.26 - 6.73 % reported by [41]. The methanol content of starfruit juice was 0.0031 %, [42] had reported that methanol content of fresh starfruit ranged from 0.0013 - 0.0108%. The methanol content of fresh Peter mango was 0.0376%. [43] reported that the methanol content of fresh mango juice ranged between 0.014 and 0.0677%.

The tritratable acidities of the starfruit juice and Peter mango were 0.31 and 0.20 %, respectively. These values are similar to those reported by [44] for pawpaw, banana and watermelon juices where the total acidity ranged from 0.21 - 0.63 %. Provitamin A of contents of the fresh starfruit and Peter juices were 0.53 mg/100 ml and 5.47 mg/100 ml respectively. [45] had reported that the provitamin A contents of six selected fresh tropical fruits range from 0.06 to 5.47 mg /100 ml

The vitamin B_1 (thiamine) contents of the fresh starfruits and Peter mango juices were 0.08 mg/100 ml and 0.08 ml/100 ml respectively. These were in agreement with those reported by [46] that ranged from 0.035 - 0.6 mg/100 ml. The vitamin C content of starfruit juice was 32.11mg/100 ml. [47] reported that vitamin C content of fresh juices ranged from 26.0 - 53.1mg/100 ml. The vitamin C content of the fresh Peter mango juice obtained was 29.09 mg/100 ml. [48] reported similar values that ranged from 21.66 - 51.54mg/100ml.

The magnesium content of starfruit juice was 5.77 ml/100 ml. [34] had reported that magnesium content of fresh starfruit juice ranged from 3.45 - 11.85 mg/10 ml. The magnesium content of Peter mango was 6.18 mg/100 ml. This also fell within the range 1.54 - 7.54mg/100ml reported for 10 varieties of mango juices [49].

The iron content of fresh starfruit and Peter mango juices were 0.05 mg/100 ml and 0.07 mg/100 ml, respectively. These values were within the range 0.02 and 0.61 mg/100 ml iron content reported for eight selected tropical fruit juice [50]. The potassium content of starfruit and Peter mango juices were 13.1 mg/100 ml and 9.75mg/100ml, respectively. [49] reported that some varieties of mango juice ranged between 10.29 and 64.04 mg/100 ml. The (13.1 mg/100 ml) for the present study fell within the range, while that of peter mango (9.75 mg/100 ml) was below the range. This could be attributed to the type of soil, climate, ripening stage and harvesting season.

Table 2. Yield and chemical composition of juices from starfruit (*Averrhoa carambola*) and Peter mango (*Mangifera indica*)

Parameters	SJ	MJ
Juice yield (%)	76.0	53.0
Moisture (%)	88.67±2.08	62.53±1.50
Ash (%)	0.50±0.10	0.77±0.12
Fat (%)	0.55±0.07	0.65±0.10
Protein (%)	2.44±0.69	1.14±0.38
Fibre (%)	Not detected	Not detected
Carbohydrate (%)	8.18±1.82	34.90±1.67
pH	2.20	3.90
Alcohol (%)	Not detected	Not detected
TSS (°Brix)	9.33±0.70	38.4±0.76
Pectin (%)	1.99±0.27	4.26±0.45
Methanol (%)	0.0031±0.009	0.0376±0.002
Titratable acidity (%)	0.31±0.06	0.20±0.06
Provitamin A/mg/100ml	0.53±0.40	5.47±0.14
Vitamin B_1 (mg/100ml)	0.08±0.02	0.08±0.03
Vitamin C (mg/100ml)	32.11±0.04	29.09±0.01
Magnesium (mg/100ml)	5.77±0.83	6.18±0.82
Iron (mg/100ml)	0.05±0.01	0.07±0.01
Potassium (mg/100ml)	13.10±0.12	9.75±0.33

Values are means ± standard deviation of triplicate determinations
Key SJ = Starfruit juice; MJ = Peter mango juice; TSS = Total soluble solids.

3.2. Physicohemical Properties of Wine from Single Strength Juice, Blends of Star Fruit and Peter Variety Mango

The physiochemical constituents of wine from single strength juices, and blends of starfruit and Peter mango are shown in Table 2.

3.2.1. Alcohol Content

The alcoholic content of the wine from the single strength juice, commercial and blends of starfruit and Peter mango ranged from 7.33 - 11.70 %. There was no significant ($p>0.05$) difference between the commercial wine (11.50 %) and postfermented samples SMp (80:20) (11.30 %) and sample SMp (50:50) (11.70%). The sample SMp (50:50) had the highest alcohol content. There was increase in the alcohol content from 0 % in the fresh juices to 11.70 % after fermentation. [1] reported that fermentation increased alcoholic content of wines. There was an increase in alcoholic content of prefermented wine SMs (90:10) to SMs (70:30) (8.10 - 9.30 %) and postfermented wine SMp (70:30) to SMp (50:50) (9.00 - 11.70). The range of alcohol values 7.33 - 11.70 % fell within the range of alcohol content of table wine 6 to 14 %) reported by [3].

3.2.2. Total Soluble Solids (TSS)

The total soluble solids content of the wines from single strength juices, commercial and blend of starfruit and peter mango ranged from 2.30 - 17.90 °Brix. There was no significant ($p>0.05$) difference between the total soluble solids of the commercial wine (3.20 °Brix) and postfermented sample SMp (3.40 °Brix). There was an increase in total soluble solid of prefermented SMs (90:10) to SMs (50:50) (4.00 - 17.90 °Brix) and postfermented samples SMp (80:20) to SMp (50:50) (3.40 - 10.70 °Brix). This was in agreement with that of [51] who reported an increase in total soluble solid during fermentation of roselle wine. Prefermented sample SMs (50:50) had the highest total soluble solids (17.90 °Brix).

3.2.3. Titratable Acidity

The titratable acidity content of the wine sample ranged from 0.18 - 0.29 %. The titratable acidity of the wine samples increased and decreased throughout the fermentation period due to instability of the pH . There was decrease in the titratable acidity of prefermented samples SMs(90:10) to SMs(50:50) (0.29 - 0.25%) as the level of Peter mango was added to starfruit wine increased and also decrease in postfermented samples SMp (90:10) to SMp (50:50) (0.22 -0.21 %) as the level of Peter mango added to the starfruit wine increased. This may be attributed to the fact that starfruit is more acidic than Peter mango. There was no significant ($p>0.05$) difference among the samples G (0.21%) and postmixed SMp (60:40) (0.21%) and SMp (50:50) (0.21%). The prefermented sample SMs (90:10) (0.29 %) had the highest titratable acidity. This was in agreement with the work of [44] on pawpaw, banana and watermelon wine where the total acidity ranged from 0.21 to 0.63%.

3.2.4. Pectin Content

The pectin content of the wines from single strength juices, commercial and blends of starfruit and peter mango ranged from 0.48 - 4.60 %. The commercial wine sample had the lowest value (0.48 %) while prefermented SMs (70:30) had the highest value 4.60 %) pectin content. The pectin content of starfruit and Peter mango juices were 1.99 % and 4.26 %, respectively. This showed that there was increase in pectin content of single strength, prefermented and postfermented fruit wine during fermentation. It was also observed that there was significant increase in the pectin content of the premix sample SMs (90:10) to SMs (50:50) (4.13 - 4.40 %) and postmixed sample SMp (90:10) to SMp (50:50) (4.18 - 4.47%) as the level of Peter mango added to starfruit juice increased. This could be due to the fact that Peter mango had pectin content value (4.26 % and 4.54 %) of the juice and wine then starfruit (1.99 % and 3.67 %), respectively. This was in agreement with the work reported by [40] that the pectin content ranged between 1.74 and 5.11 %.

3.2.5. Methanol Content

The methanol contents of the wines from single strength, commercial and blends of starfruit and Peter variety mango ranged from 0.005 - 0.0201 %. The commercial wine sample G had the lowest methanol content (0.005 %) and lowest pectin content (0.48 %). This could be attributed to the fact that methanol in wine is primarily generated by enzymatic breakdown of pectins [36]. There was an increase in methanol content of prefermented samples SMs (90:10) to SMs (50:50) (0.0190 - 0.0201 %) and postfermented samples SMp (90:10) to SMp (50:50) (0.0199 - 0.0200 %) as the level of Peter mango added to the starfruit juice increased. This may be attributed to the fact that Peter mango had higher methanol content value for the juice and wine (0.0376 and 0.0201 %) than the starfruit (0.0031 % and 0.0195 %). [43] reported that methanol of mixed fruit wine ranged from 0.0014 - 0.0677 % which was in agreement with the present study. [52] recommended standard for methanol in wine to be 0.004 - 0.2% methanol contents obtained for the present study were below the recommended dosage.

3.2.6. pH

The pH value of the formulated wine ranged from 2.40 - 4.20. The pH of the wines fluctuated during fermentation. This may be probably due to variety of the fruits, weather, harvesting period among others factors [14]. There was no significant ($p>0.05$) different between the pH of commercial wine (3.00) and the prefermented sample SMs (50:50) (3.00). The wine from peter mango (M) had the highest pH (4.20). There was increase in the pH value of prefermented wine samples SMs (90:10) to SMs (50:50) (2.30 - 3.00) as the level of Peter mango is added to starfruit juice increase there was decrease in value of postfermented sample SMp (90:10) to SMp (50:50) (3.50 - 3.33) as the level of Peter mango added to starfruit juice increased. It was observed that the wine from single fruit, commercial, prefermented and postfermented samples had low pH and low level of acidity throughout the period of fermentation. Low pH is inhibitory to the growth of spoilage organisms but create conducive environment for the growth of desirable organism. Thus, table wines must have acidic content for longevity [53].

3.3. Proximate Composition of Wines

The proximate composition of wines from juice and their blends are presented in Table 6.

3.3.1. Moisture Content

The moisture content of wines from single fruit juices, commercial product and blends of starfriut and peter mango ranged from 73.33 - 97.60 %. The starfruit wine had the highest moisture content (97.60 %) and followed by the commercial wine (G) 97.00 %. There was no significant ($p>0.05$) difference between the commercial sample (97.00%) and prefermented sample SMs (90:10) (96.20 %) in their moisture content. There was a decrease in moisture content of the prefermented samples SMs (90:10) to SMs (50:50) (96.20 - 82.93%) and postfermented samples SMp (90:10) to SMp (50:50) (90.47 - 84.0 7%) as the level of Peter variety mango added to starfruit wine increased. This may be probably due to the fact that Peter variety mango had lower moisture content and was more concentrated. High moisture content makes beverage suitable as a refreshing and quench thirsting product which is a characteristic of good beverage [54].

3.3.2. Protein Content

The protein content of the wine samples ranged from 0.090 - 0.70 % (Table 4). The low protein contents may be attributed to the use of the protein by microorganisms for biosynthesis during the fermentation of the juice [55]. There was no significant ($p>0.05$) difference between the protein content of prefermented sample SMs (50:50) (0.44 %) and postfermented samples SMp (70:30) (0.44 %) and SMp (50:50) (0.43 %). The commercial wine sample (control) had the highest protein value (0.70%).

3.3.3. Ash Content

The ash contents of the wine from the starfruit and Peter mango juices, commercial product and their blends ranged from 0.17 - 0.60%. There was no significant ($p>0.05$) difference among the ash content of the commercial sample (0.23 %), prefermented samples SMs (80:20) (0.23%), SMs(70:30) (0.23%), SMs (60:40) (0.30%), SMs (50:50) (0.27%) and postfermented samples SMp(70:30) (0.23 %) and SMp (50:50) (0.27 %). The prefermented sample SMs (90:10) had the highest ash content value (0.60 %) followed by the Peter mango wine (0.53 %). The ash contents ranged from 0.17 - 0.60% which fell within the range (0.02 - 0.70 %) for pawpaw and banana wines reported by [56].

3.3.4. Fat Content

Table 4 shows that the fat content of wine from starfruit, Peter mango,commercial sample and their blends ranged from 0.10 - 0.13 %. There was no significant ($p>0.05$) difference among the fat content of the commercial (0.10%),prefermented SMs (90:10) to SMs(50:50) (0.10 to 0.10 %) and postfermented SMp (90:10) to SMp (60:40) (0.10 - 0.10 %) except SMp (50:50) (0.13%) which had the highest fat content. Similar report on baobab, pineapple and carrot wine had fat content that ranged from 0.10 - 0.20% as reported by [57]. The low fat content of wine showed that they have low risk of developing rancidity [58].

3.3.5. Carbohydrate Content

The carbohydrate content of wines from single fruit, commercial product and formulated wines ranged from 2.00 - 25.70 % (Table 4). Sample M had the highest carbohydrate content value (25.70%). There was increase in the carbohydrate content of prefermented SMp (90:10) to SMs (50:50) (2.68 -16.10 %) and postfermented samples SMp (80:20) to SMp (50:50) (3.95 - 15.10 %). This may be attributed to the fact that sample M (Peter mango) had the highest carbohydrate content and the level added to starfruit wine increased. There was no significant ($p>0.05$) difference between the commercial sample (2,00 %) and starfruit wine (2.04 %) in their wine content. [56] reported the carbohydrate contents of pawpaw and banana wine that ranged from 6.10 - 6.20 %.

3.3.6. Crude Fiber Content

The crude fiber was not detected in the wines produced from single fruit, commercial sample and their blends of starfruit and Peter mango. This agreed with the work on pawpaw and banana wine reported by [56].

Table 3. Physiochemical properties of wine from single strength juice and the blends of starfruit and Peter mango juices

Samples Starfruit: Peter mango	Alcohol (%)	TSS (°Brix)	Titratable acidity (%)	Pectin (%)	Methanol (%)	pH
S	$10.40^{b}\pm0.32$	$2.30^{j}\pm0.12$	$0.23^{de}\pm0.01$	$3.67^{g}\pm0.02$	$0.0195^{cd}\pm0.001$	2.40
M	$10.28^{b}\pm0.29$	$2.70^{j}\pm0.06$	$0.28^{ab}\pm0.02$	$4.54^{a}\pm0.26$	$0.0201^{a}\pm0.001$	4.20
G	$11.50^{a}\pm0.50$	$3.20^{i}\pm0.15$	$0.21^{f}\pm0.01$	$0.48^{h}\pm0.02$	$0.0050^{f}\pm0.000$	3.00
SMs(90:10)	$8.10^{f}\pm0.17$	$4.00^{h}\pm0.06$	$0.29^{a}\pm0.01$	$4.13^{f}\pm0.01$	$0.0190^{e}\pm0.001$	2.30
SMs(80:20)	$8.50^{ef}\pm0.06$	$4.70^{g}\pm0.10$	$0.26^{bc}\pm0.20$	$4.40^{c}\pm0.02$	$0.0191^{de}\pm0.002$	2.30
SMs (70:30)	$9.30^{c}\pm0.29$	$7.30^{e}\pm0.57$	$0.26^{bc}\pm0.20$	$4.60^{a}\pm0.01$	$0.0196^{bc}\pm0.001$	2.60
SMs(60:40)	$8.20^{ef}\pm0.29$	$10.40^{bc}\pm0.57$	$0.25^{cd}\pm0.01$	$4.50^{b}\pm0.00$	$0.0198^{abc}\pm0.002$	2.90
SMs(50:50)	$7.33^{g}\pm0.29$	$17.90^{a}\pm0.42$	$0.26^{bc}\pm0.01$	$4.40^{c}\pm0.03$	$0.0201^{ab}\pm0.001$	3.00
SMp(90:10)	$8.70^{de}\pm0.29$	$6.30^{f}\pm0.06$	$0.22^{ef}\pm0.001$	$4.18^{e}\pm0.01$	$0.0199^{abc}\pm 0.003$	3.50
SMp(80:20)	$11.30^{a}\pm0.29$	$3.40^{i}\pm0.25$	$0.20^{f}\pm0.001$	$4.17^{e}\pm0.01$	$0.0196^{bc}\pm 0.001$	3.30
SMp (70:30)	$9.00^{de}\pm0.06$	$8.30^{d}\pm0.32$	$0.18^{g}\pm0.001$	$4.22^{d}\pm0.43$	$0.0196^{bc}\pm0.001$	3.03
SMp(60:40)	$9.20^{cd}\pm0.29$	$10.20^{c}\pm0.32$	$0.21^{f}\pm0.001$	$4.38^{c}\pm0.01$	$0.0200^{abc}\pm0.002$	3.40
SMp(50:50)	$11.70^{a}\pm0.29$	$10.70^{b}\pm0.21$	$0.21^{f}\pm0.01$	$4.47^{b}\pm0.02$	$0.0200^{abc}\pm0.002$	3.33

Values are means± of standard deviation of repricates. Means with different superscripts within a column were significantly $p<0.05$ different.
S=Starfruit wine; M=Peter mango; G= Commercial grape wine; SMs = Prefermented starfruit-Peter mango wine; SMp = Postfermented starfruit-Peter mango wine; TSS = Total soluble solids.

Table 4. Proximate composition (%) of wine from starfruit juice, Peter mango commercial and their blends

Samples Starfruit: Peter mango	Moisture	Protein	Ash	Fat	Carbohydrate	Crude fiber
S	97.60^{a} ±0.10	0.090^{h}±0.01	0.17^{cd}±0.06	0.10^{b}±0.00	2.04^{h}±0.14	ND
M	73.33^{h}±0.15	0.41^{bc}±0.05	0.53^{a}±0.58	0.10^{b}±0.00	25.70^{a}±0.16	ND
G	97.00 ^{ab}±0.17	0.70^{a}±0.02	0.23^{bc}±0.57	0.10^{b}±0.00	2.00^{h}±0.17	ND
SMs(90:10)	96.20^{ab}±0.17	0.42^{bc}±0.03	0.60^{a}±0.10	0.10^{b}±0.00	2.68^{gh}±0.28	ND
SMs(80:20)	95.40^{b}±0.20	0.25^{g} ±0.10	0.23^{bc}±0.06	0.10^{b}±0.00	4.02 ^{g}± 0.20	ND
SMs(70:30)	92.30^{c}±0.27	0.39^{cde}±0.03	0.23^{bc}±0.06	0.10^{b}±0.00	6.98^{f}±0.28	ND
SMs(60:40)	88.70^{e}±2.00	0.38^{de}±0.03	0.30^{bc}±0.00	0.10^{b}±0.00	10.50^{d}±1.98	ND
SMs(50:50)	82.93^{g} ±1.00	0.44^{b}±0.01	0.27^{bc}±0.15	0.10^{b}±0.00	16.10^{b}±0.90	ND
SMp(90:10)	90.47^{d}±0.21	0.33^{f}±0.27	0.17^{cd}±0.06	0.10^{b}±0.00	8.91^{e}±0.24	ND
SMp(80:20)	95.73^{b}±0.90	0.25^{g}±0.01	0.10^{d} 0.00	0.10^{b}±0.00	3.95^{g}±0.93	ND
SMp(70:30)	91.83^{cd} ±1.43	0.44^{b}±0.01	0.23^{bc}±0.58	0.10^{b}±0.00	7.40^{ef}±1.49	ND
SMp(60:40)	86.20^{f} ±1.60	0.36^{ef}±0.02	0.37^{b}±0.06	0.10^{b}±0.00	13.00^{c}±1.68	ND
SMp(50:50)	84.07^{g} ±0.15	0.43^{b}±0.02	0.27^{bc}±0.06	0.13^{a}±0.05	15.10^{b}±0.15	ND

Values are means ± standard deviation of 3 replicates. Means with different superscript within a was significantly same column are significantly $p<0.05$ different.
S = Starfriut wine; M = Peter mango wine; G = Commercial grape wine; SMs = Prefermenteded starfruit-peter mango wine ; SMp = Postfermented starfruit-Peter mango wine; ND = Not detected.

3.4. Vitamin Composition of Wines

The vitamin composition of wines from starfruit juice, Peter mango juice and their blends are presented in Table 7.

3.4.1. Provitamin A Content

The provitamin A content of the wines from starfruit juice Peter mango juice, commercial and their blends ranged from 3.03 - 44.23mg/100ml. There was no significant ($p>0.05$) difference between the commercial sample (3.63 mg/100ml) and prefermented SMs_3 (3.03mg/100ml). There was increase in the provitamin A content of the prefermented wine SMs (90:10) to SMs (50:50) (12.57 - 22.37 mg/100 ml) but decreased in postfermented wine sample SMp (90:10) to SMp (50:50) (44.23 - 17.27 mg/100 ml). This showed that the prefermented blends increased the content of provitamin A of the final product while postfermented blends decreased it. Postfermented sample SMp (90:10) had the highest provitamin A (44.23 mg/100 ml). [59] reported a range between 10.03 and 22.72 mg/100ml of provitamin A content.

3.4.2. Thiamine (Vitamin B_1)

The vitamin B_1 contents of the wines from starfruit juice, Peter mango juice, commercial and their blends ranged from 0.0260 - 0.0410 (Table 5). There was an increase in the vitamin B_1 contents of prefermented wine SMs (90:10) to SMs (50:50) (0.0260 - 0.0410) and postfermented SMp_1 to SMp_5 (0.0290 - 0.0373). The postfermented sample SMs (50:50) had the highest vitamin B_1 content (0.0410). According to [60], vitamin B_1 content of three fruits ranged from 0.73 - 10.09 mg/100 ml which was higher than the range obtained in the present study. This was probably due to harvesting period, soil type among other factors.

3.4.3. Ascorbic Acid Content

The vitamin C contents of the wines from starfruit juice and Peter mango juice, commercial product and their blends ranged from 0.74 - 15.48mg/100ml. There was decrease in vitamin C content of prefermented SMs (90:10) to SMs (80:20) (11.76 -10.46 mg/100 ml) and SMs_3 to SMs_4 (12.98 to 10.81mg/100 ml) but increase in postfermented SMp (90:10) to SMp (50:50) (11.28 to 14.65 mg/100 ml). The decrease in vitamin C with fermentation period could be attributed to the oxidation and vitamin C utilization by yeast during fermentation [59]. The control (sample G) had the lowest vitamin C content (0.74mg/100ml). The vitamin C content of the wine decreased significantly ($p<0.05$) during fermentation which was probably due to oxidation.

3.4.4. Carotenoid Content

The carotenoid contents of the wines from starfruit juice and mango juice, commercial wine and their blends ranged from 4.17 - 63.30mg/100ml. There was no significant ($p>0.05$) difference between the commercial sample G (4.20 mg/100 ml) and SMs (70:30) (4.17mg/100 ml). The carotenoid content of the prefermented samples SMs (90:10) to SMs (50:50) increased from 21.03 - 62.17 mg/100 ml but the postfermented (SMp (90:10) to SMp (50:50) decreased from 63.30 - 30.07 mg/100 ml. Sample SMp (90:10) had the highest carotenoid content (63.30mg/100ml). The carotenoid content of the formulated wine was similar to those reported by [61] for mango wine

3.5. Mineral Composition of Wines

The mineral composition of wines from single fruit juice, and blends of star fruit and Peter mango is shown in Table 6.

3.5.1. Iron Content

The iron content of the wine samples ranged from 0.003 - 0.06mg/100ml. There was no significant ($p > 0.05$) difference among the wine samples with the control G. There was increase in iron content of the prefermented SMs (90:10) to SMs (50:50) (0.009 - 0.06 mg/100 ml) and postfermented SMp (90:10) to SMp (50:50) (0.005 - 0.01mg/100ml) wine samples as the level of Peter mango increased. Similar resulis have been reported for watermelon and ginger wine that fermentation increased the availability of iron through hydrolysis according to [62]. The samples SMs (60:40) and SMs (50:50) had the highest iron content (0.06 mg/100ml).

3.5.2. Potassium Content

The potassium contents showed variations. The values ranged from 2.05 - 17.42mg/100ml There was increased in potassium content of the prefermented SMs (90:10) to SMp (50:50) (2.05 - 7.95 mg/100ml) postfermented SMp (90:10) to SMp (50:50) (3.11 - 9.84 mg/100ml) wine samples as the level of Peter mango added to starfruit wine increased [62] reported similar results for watermelon and ginger wines. The Peter mango wine had the highest potassium content (17.42 mg/100 ml).

3.5.3. Magnesium Content

The magnesium contents of the wines from single fruit, commercial and blends of starfruit and Peter mango ranged from 0.42 - 2.10 mg/100ml. There was no significant ($p>0.05$) difference among the control G (0.81 mg/100 ml) M (0.81mg/100 ml), prefermented SMs (60:40) (0.85 mg/100 ml), SMp (50:50) (0.83 mg/100 ml) wine samples. The sample SMs (90:10) had the highest magnesium content (2.10 mg/100 ml). There was decrease in the magnesium content in the prefermented SMs (90:10) to SMs (50:50) (2.10 - 0.83 mg/100 ml) and the postfermented SMp (90:10 to SMp (60:40) (0.83 - 0.42 mg/100 ml) wine samples as the level of Peter mango added to starfruit wine increased. This could be attributed to the utilization of magnesium by the fermenting organism [62].

3.6. Microbial Counts of Table Wines

The microbial load of the table wines from single fruit juices and blends of starfruit and Peter mango are shown in Table 7.

The total viable count (TVC) ranged from 1.0 x101 - 3.3 x101cfu/ml. Mould counts ranged from 0.4 x101 - 2.8 x101 cfu/ml. There was no viable count and mould detected in the commercial wine sample (G). There was an increase in TVC of the prefermented samples SMs (90:10) to SMs (50:50) (1.0 x101 - 2.8 x101cfu/ml) but decreased for the postfermented samples SMp (90:10) to SMp (50:50) (3.0 x101 - 2.3 x101cfu/ml). There was increase in mould counts for the postfermented sample SMs (90:10) to SMs (50:50) (0.4 x101 - 1.7x101cfu/ml) and decrease for postfermented samples SMp (90:10) to SMp (50:50) (2.8 x101 - 1.4 x 101cfu/ml). There were presence of few microorganisms and this could be due to the fact that most of them are known to thrive in medium rich in fermentable sugsars, which led to the production of acids after fermentation [63]. The average total viable and mould counts were generally below the maximum available limit in foods to be marketed for consumption (103 cfu/ml) according to [64].

Table 5. Vitamin composition of wines from starfruit juice, Peter mango juice and their blends

Samples Starfruit: Peter mango	Provitamin A (mg/100ml)	Thiamine (B_1) (mg/100ml)	Ascorbic acid (mg/100ml)	Carotenoid (mg/100ml)
S	17.33^{ef}±0.90	0.327^{def}±0.002	8.02^{j}±0.09	29.73^{e}±1.15
M	28.37^{c}±2.98	0.533^{a}±0.001	15.78^{a}±0.05	41.70^{c}±4.45
G	3.63^{i}±0.25	0.0300^{f}±0.001	0.74^{k}±0.03	4.20^{g}±0.56
SMs(90:10)	12.57^{h}±0.65	0.0260^{g}±0.003	11.76^{f}±0.05	21.03^{f}±1.46
SMs(80:20)	15.50^{fg}±3.08	0.0297^{fg}±0.003	10.46^{i}±0.59	33.73^{d}±1.15
SMs(70:30)	3.03^{i}±1.92	0.0362^{cd}±0.001	12.98^{e}±0.11	4.17^{g}±0.15
SMs(60:40)	32.80^{b}±1.35	0.0347^{cde}±0.003	10.80^{h}±0.03	51.17^{b}±1.60
SMs(50:50)	22.37^{d}±0.15	0.0410^{b}±0.001	14.00^{c}±0.06	62.17^{a}±1.83
SMp(90:10)	44.23^{a}±1.10	0.290^{fg}±0.001	11.28^{g}±0.03	63.30^{a}±1.20
SMp(80:20)	13.83^{gh}±0.32	0.310^{ef}±0.01	12.81^{e}±0.05	22.00^{f}±2.13
SMp(70:30)	18.50^{e}±0.96	0.0343^{cde}±0.001	13.30^{d}±0.03	27.57^{e}±2.06
SMp(60:40)	29.93^{c}±1.20	0.347^{cde}±0.001	13.80^{c}±0.03	51.70b±0.90
SMp(50:50)	19.27^{e}±1.21	0.0373^{c}±0.001	14.65^{b}±0.08	30.07^{e}±0.64

Values are means ± standard deviation of 3 repricates. Means with different superscript within a column were significantly $p<0.05$ different.
S = Starfruit wine; M = Peter mango wine; G = commercial grape wine; SMs = prefermented starfruit- Peter mango wine; SMp = Postfermented starfruit - Peter mango wine.

Table 6. Mineral composition of wine from single fruits, and blends of starfruit and Peter mango

Samples Starfruit: Peter mango	Iron (mg/100ml)	Potassium (mg/100ml)	Magnesium (mg/100ml)
S	0.03^{a}±0.001	1.83^{k}±0.03	0.42^{d}±0.01
M	0.03^{a}±0.003	17.42^{a}±0.76	0.81^{c}±0.02
G	0.04^{a}±0.004	3.83^{f}±0.01	0.81^{c}±0.03
SMs(90:10)	0.009^{a}±0.004	2.05^{j}±0.24	2.10^{a}±0.05
SMs(80:20)	0.03^{a}±0.003	5.85^{e} ±0.20	1.25^{b}±0.01
SMs(70;30)	0.05^{a}±0.06	3.08^{h}±0.06	1.24^{b}±0.001
SMs(60:40)	0.06^{a}±0.09	2.97^{hi}±0.90	0.85^{c}±0.03
SMs(50:50)	0.06^{a}±0.09	7.95^{c} ±0.02	0.83^{c}±0.01
SMp(90:10)	0.005^{a}±0.001	3.11^{h}±0.14	0.83^{c}±0.01
SMp(80:20)	0.03^{a}±0.002	6.12^{d}±0.04	0.58^{c}±0.02
SMp(70:30)	0.006^{a}±0.001	3.45^{g}±0.01	0.82^{c}±0.02
SMp(60:40)	0.005^{a}±0.001	2.84^{i}±0.04	0.42^{d}±0.01
SMp(50:50)	0.01^{a}±0.01	9.84^{b}±0.03	0.83^{c}±0.02

Values are means ± standard deviation of 3 repricates Means with different superscripts within a column were significantly $p<0.05$ different.
S =Starfruit wine; M= Peter mango wine; G = commercial grape wine; SMs = Prefermented starfruit-Peter mango wine; SMp =Postfermented= starfruit-Peter mango wine.

Table 7. Microbial count of table wines from single fruit juices and the blends of starfruit and Peter mango

Samples Starfruit: Peter mango	Total viable count cfu/ml)	Mould (cfu/ml)
S	$2.3x10^1$	$1.2 x10^1$
M	$3.0 x10^1$	$1.4 x10^1$
G	Not detected	Not detected
SMs(90:10)	$1.0 x10^1$	$0.4 x10^1$
SMs(80:20)	$2.1 x10^1$	$1.2 x10^1$
SMs(70:30)	$3.1 x10^1$	$0.8 x10^1$
SMs(60:40)	$1.4 x10^1$	$1.2 x10^1$
SMs(50:50)	$2.8 x10^1$	$1.7 x10^1$
SMp(90:10)	$3.0 x10^1$	$2.8 x10^1$
SMp(80:20)	$2.3 x10^1$	$1.8 x10^1$
SMp(70:30)	$3.3 x10^1$	$1.8 x10^1$
SMp(60:40)	$3.3 x10^1$	$1.2 x10^1$
SMp(50:50)	$2.3 x10^1$	$1.4 x10^1$

S = Starfruit wine; M = Peter mango; G = Commercial grape wine (control); SMs = Prefermented starfruit - Peter mango wine; SMp = Postfermented starfruit - Peter mango wine.

Table 8. Sensory scores of the commercial, premixed and postmixed starfruit and Peter mango wine

Samples Starfruit:Peter mango	Colour	Flavour	Taste	Aftertaste	Mouth feel	Overall acceptability
G	7.65^{a}±0.81	6.50^{a}±0.69	5.35^{a}±1.57	5.65^{ab}±1.27	5.55^{a}±1.23	5.55^{a}±0.83
SMs(90:10)	5.85^{c}±0.67	5.70^{ab}±0.98	5.40^{a}±0.68	5.40^{ab}±1.57	5.50^{a}±1.19	5.95^{a}±1.23
SMs(80:20)	6.25^{bc}±0.91	5.50^{b}±1.61	5.05^{a}±1.93	5.50^{ab}±1.91	5.05^{a} ±1.9	5.50^{a}±1.79
SMs(70:30)	6.05^{bc}±0.94	5.20^{c}±1.20	4.85^{a}±1.46	5.00^{ab}±1.62	4.80^{a}±1.43	5.20^{a}±1.57
SMs(60::40)	6.60^{b}±1.23	4.95^{b}±1.28	5.15^{a}±1.39	5.15^{b}±1.23	5.00^{a}±1.38	5.50^{a}±1.40
SMs(50:50)	6.05^{bc}±1.10	5.60^{ab}±1.19	5.50^{a}±1.54	5.20^{ab}±1.70	5.15^{a}±1.53	5.75^{a}±1.71
SMp(90:10)	6.50^{bc}±1.05	5.75^{ab}±1.45	5.30^{a}±1.59	5.90^{a} ±1.29	5.65^{a}±1.52	6.00^{a}±1.38
SMp(80:20)	6.10^{bc}±0.12	5.75^{ab}±1.29	5.55^{a}±1.23	5.95^{a}±1.10	5.55^{a}±1.35	6.10^{a}±1.08
SMp(70:30)	6.50^{bc}±0.89	5.75^{ab}±1.52	5.45^{a}±1.15	5.55^{ab}±1.05	5.35^{a}±1.14	5.95^{a}±1.23
SMp(60:40)	6.60^{b}±1.19	5.25^{c}±1.68	4.85^{a}±1.84	4.75^{b}±1.97	4.90^{a}±1.77	5.05^{a}±2.00
SMp(50:50)	6.30^{bc}±0.66	5.35^{c}±1.79	5.60^{a}±1.73	5.25^{ab}±1.50	5.30^{a}±1.83	5.55^{a}±1.79

Values are means ± standard deviation of 20 replicates. Means with different superscripts within a column were significantly $p<0.05$ different.
G = Commercial grape wine (control); SMs = Prefermented starfruit-Peter mango wine: SMp = Postfermented starfruit- Peter mango wine.

3.7. Sensory Properties of the Wines

The sensory attributes of the commercial, premixed and postmixed starfruit and Peter mango wine are shown in Table 8.

There was increaase in the score for colour of the prefermented wine SMs (90:10) to SMs (50:50) (5.85 - 6.30) but the score decreased in the postfermented wine SMp (90:10) to SMp (50:50) (6.50 - 6.30) on the addition of Peter mango to starfruit wine. There was reduction in flavor of the prefermented wine SMs (90:10) to SMs (50:50) (5.70 - 5.60) and postfermented wine SMp (90:10) to SMp (50:50) (5.75 - 5.35).

There was increase in the score for acceptance of taste in the prefermented wine SMp (90:10) to SMp (50:50) (5.40 to 5.50) and postfermented wine SMp(90:10) to SMp(50:50) (5.30 - 5.60). There was a decrease in the score for after taste of prefermented wine SMs(90:10) to SMs (50:50) (5.40 - 5.20) and postfermented wine SMp (90:10) to SMp (50:50) (5.90 - 5.25). There was decrease in the score for mouthfeel of the prefermented wine SMs (90:10) to SMs (50:50) (5.50 - 5.00).

Based on overall acceptance, there was decrease in the score for the prefermented wine SMs (90:10) to SMs (50:50) (6.95 - 5.55) on the addition of Peter mango to starfruit wine. The control (G) was the most preferred with the highest scores for colour (7.65) and flavor (6.50). This might be as a result of familiarity of the panelist with the grape wine.

The sample SMp (80:20) was more preferred and had the highest scores for aftertaste (5.95) and overall acceptability (6.10.). The sample SMp (50:50) had the highest score for taste (5.60). There was no significant ($P > 0.05$) difference between the commercial wine and the formulated fruit wine for taste, mouthfeel and overall acceptability for those attributes compared favourably with the reports for other tropical fruit wines, [65,66,67,68,69]. Sensory scores showed that the formulated wines were acceptable in comparism with the sample G (control).

4. Conclusion

The commercial production of starfruit and Peter mango wine in Nigeria throughout the year might not be feasible due to lack of storage facilities for fresh starfruit and Peter mango. Hence, if wine making from starfruit and Peter mango powder could be explored commercially, it might ultimately help to reduce the annual wastage of starfruit and Peter mango and also increase the income of their farmers. Based on sensory evaluation carried out the judges were habitual wine consumers because they consumed plenty of the wine as they like the taste, mouthfeel and aftertaste.

There was slight significant ($p<0.05$) difference in colour, flavour and aftertaste of different blends which made some samples more acceptable than the other. The postfermented sample SMp (80:20) was the most preferred but commercial wine was the best in terms of colour and flavour. The formulated wine compared favourably with grape (control), since they had similar properties with grape wine and were organoleptically acceptable to the potential consumers.

Therefore, it was recommended that for one embarking on wine production on small scale industry that postfermented sample SMp (80:20) was the best in terms of organoleptic properties or attributes and total soluble solid content.

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