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SELECTED QUALITY ATTRIBUTES AND MICROBIAL EVALUATION OF KETCHUP FROM BLENDS OF HOG PLUM (*Spondias mombin*) AND TOMATOES (*Solanum lycopersicum*)

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ABSTRACT

Blend ratios (Tomatoes: Hog plum): HPK (0:100); TPK (100:0); THK (90:10); HTK (80:20); TKP (70:30) were studied to determine the effect of partial substitution of hog plum on the proximate, physicochemical, sensory, colour, energy value, and viscosity in ketchup blends. Significant difference ($p \leq 0.05$) was observed in the treatment for proximate composition. Mean score values for physicochemical properties: week one TTA (29.87 – 47.03 %); Ascorbic acid (9.33 – 32.67 mg/100g); pH (4.00 – 5.46); Brix (45.00 – 60.00 ^{o}B). for week two, TTA (6.40 – 14.36 %); Ascorbic acid (7.00 – 11.67 mg/100g); pH (3.46 – 4.59); Brix (44.00 – 60.00 ^{o}B). for week three, TTA 932.00 – 149.63 %); Ascorbic acid (11.67 – 23.33 mg/100 g); pH (2.78 – 4.40); Brix (45.00 – 57.00 ^{o}B) for week four TTA (25.60 – 155.33 %); Ascorbic acid (9.33 – 23.33 mg/100 g), pH (2.72 – 4.42); Brix (45.00 – 58.00 ^{o}B). The mean score value for Sensory parameters ranged between: (2.47 – 4.10); (3.23 – 4.00); (3.20 – 4.23); (3.43 – 4.97); (3.20 – 4.43) for colour, aroma, texture, taste and overall acceptability respectively. 1 represented Like Extremely and 9 represented Dislike Extremely. No significant ($p \geq 0.05$) difference was observed between treatments in samples THK, HTK and TKP respectively. Significant ($p \leq 0.05$) difference was however observed for colour, with, chroma (ΔC), colour intensity (ΔE) and hue angle ranging between: 38.22 – 42.89; 45.06 – 49.99 and 49.04 – 60.55 respectively. Mean value for energy (12.02 – 12.90 Kcal). Significant ($p \leq 0.05$) difference was observed between treatments for viscosity. By the fourth week showed that the treatment blends did not meet up with permissible limits for microbial indicators shelf life.

KEYWORDS: Ketchup, Hog plum, Tomato, Microbial evaluation

INTRODUCTION

Hog plum (*Sponidas mombin*) also known as yellow mombin, is a small drupe fruit with characteristic properties of a slightly thick skin and thin pulp encapsulating its cork-like seed (Oladunjoye *et al*., 2021). The fruit varieties are available a range of colours, including green, purple, red, orange and yellow (Ayoka *et* al., 2008). Amongst the Yoruba (Western Nigeria), it is known as "Iyeye" or "Ebo". In some parts of eastern Nigeria, it is known as *Ngulungu* and *Isada* in Hausa (Northern Nigeria). Its taste varies from sweet and sour. The fruit can be eaten raw or processed to make jams and jellies, blended to make ice cream and cold drinks. The green fruits can be pickled by fermentation to produce vinegar and consumed like olives with salt in combination with chili pepper (Kitchenbutterfly, 2016).

Hog plums are rich in dietary fiber which is important in promoting a healthy digestive system.

It is generally rich in vitamins, minerals and phytochemical properties that perform oxidation functions in the body system. It is rich in iron which helps in the production of hemoglobin and myoglobin which transfer

oxygen throughout the body systems (Oladunjoye *et al*., 2021). The juice of the fruit is said to have a cooling effect that can normalize and control a high body temperature and heart conditions. It is a fat-free, sodium-free, cholesterol-free and good source of vitamin K that helps in proper bone health. It has thiamine content which plays an important role in muscle contraction and conduction of nerve signals. It also contains polyphenols, sterols, flavonoids, quinones, tannins and saponins. Research indicates that hog plums contain copper that maintains the bone and other connective tissues in the body system and is also needed for proper assimilation of vitamin C (Ayoka *et* al., 2008; Adedokun *et al.*, 2010).

Tomato (L*ycopersicum esculentum*) is a ubiquitous vegetable, grown copiously in the tropical and temperate regions of the world (Okorie *et al.*, 2004). This fruit vegetable is widely consumed in raw and/or processed form in human diets and a products of health related food supplements (Jumah *et al.*, 2004). It is one of the most important vegetables crops grown all over Nigeria, and the world largest crop consumed after potatoes and sweet potatoes, but it tops the list of canned vegetables. In Nigeria, tomato is regarded one of the most important vegetables, with high content of antioxidant compounds that reduces oxidative damage in the body (Beecher, 1998). Tomatoes are rich in lycopene (87%) and other carotenoids, worthy of note are carotenes, phytenes, phytofluene, lutein and L-ascorbic acids (Soma, 2013). Metabolic activity in humans is enhanced as tomatoes contains water, calcium, niacin all of which are of great importance to good health, also tomato is a good source of vitamin A, C and E and also contains minerals, that are good for the body and protect the body against disease (Taylor, 1987; Khaliukova, 2016).

Tomato ketchup (catsup) is a condiment made from ripe tomato, which usually consists of sugar, vinegar, salt and some addition spicy ingredients. It is one of the commercially available sauces. People of different age ranges consumes ketchup as complement to products like hamburger, French fries and chicken wings (Intelmann *et al.*, 2005). The glucose content and high dry matter contents contributes to an increase in water activity on the level from 0.93 to 0.95. The amount of added vinegar results in 0.8 and 1.0% acetic acid in product. These products also have extensive shelf life time and with relatively heat treatments can be store for one or more years at ambient temperature (Rajchl, 2010).
The aim of this study is to produce ketchup from blends of Hog Plum and tomato and to determine the quality attributes of the resultant product.

MATERIALS AND METHODS

Materials

Tomatoes were purchased at mile 12 market, while the hog plum was picked in a garden at the University of Lagos.

Methods

The tomato and hog plum were cleaned, damaged and unwholesome ones were sorted out while the wholesome ones were steam blanched to loosen the skin. It was then cooled in cold water and the skin was removed manually exposing the pulp. The spices were tied loosely in a muslin cloth and plunged in the pulp. The pulp was boiled to below boiling point in a pan with continuous stirring until it has reduced to half the original volume. The muslin cloth was removed and sugar, salt and vinegar were added to the mixture, after which heating was continued for 10 minutes. The product was then hot filled into pre-sterilized bottles at a temperature of 80^{o}C, the lid was covered after cooling to ambient temperature.

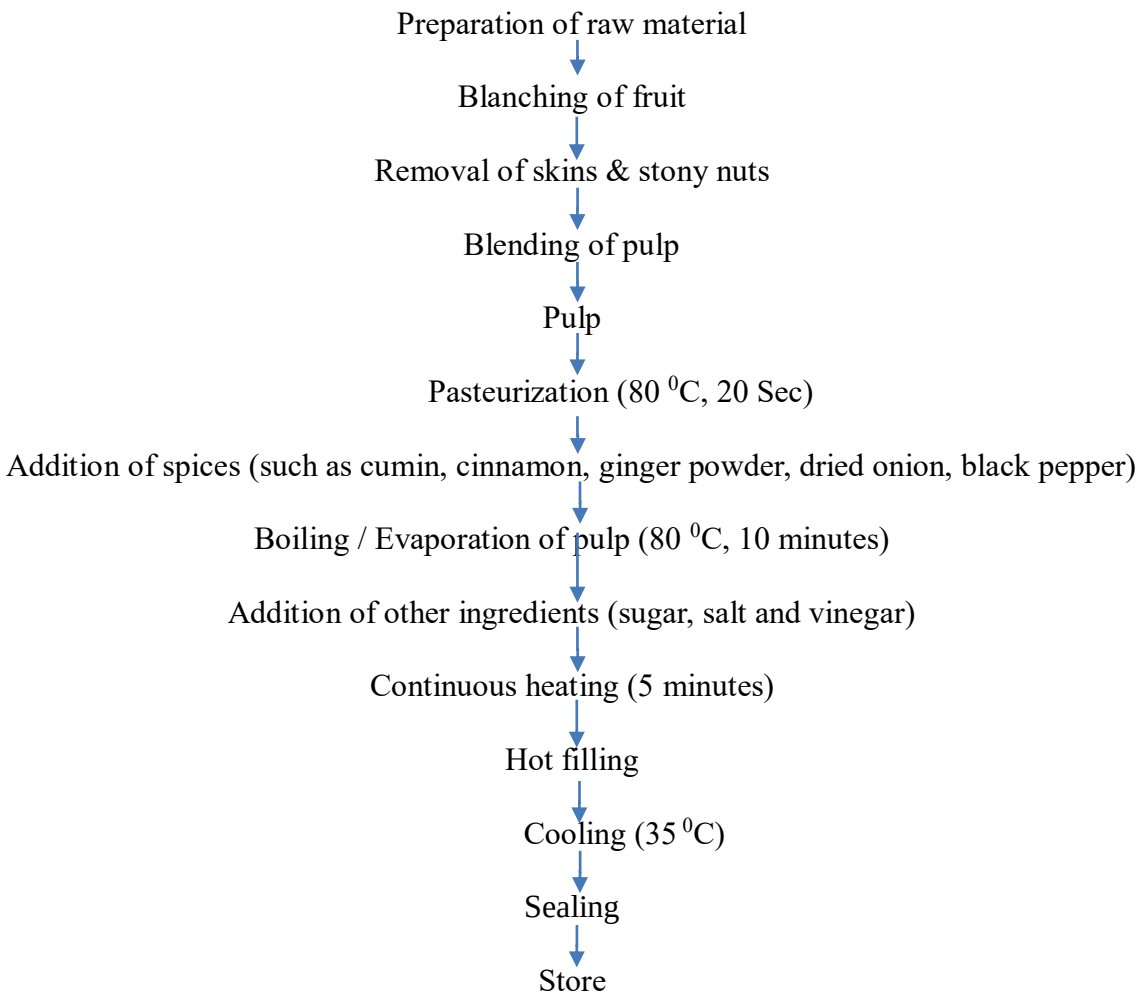

Figure 1: Flowchart for the Production of Ketchup
Source: (Modified from Azam-Ali, 2008)

Five different blend ratios were evaluated in this study:

(TPK): 100% tomato: 0 % *Spondias mombin*
(HPK): 0% tomato: 100% *Spondias mombin*
(THK): 90% tomato: 10% *Spondias mombin*
(HTK): 80% tomato: 20% *Spondias mombin*
(TKP): 70% tomato: 30% *Spondias mombin*

Determination of Physicochemical Properties

pH

The pH of the Ketchup was measured on weekly basis and readings were taken directly using a pH meter. Five grams of sample was dissolved in 50cm^3 distilled water in a beaker and vigorously mixed. The pH of the solution was then taken after the pH meter had been standardized with buffer solutions of pH 4 and 7 (Ibitoye, 2005).

Total Titratable Acidity (TTA)

The Total Titratable acidity was determined using the method described by AOAC (2002). Briefly, ten grams (10 g) of sample was weighed in a clean beaker and 25cm^3 of distilled water was added to it to make a solution. The solution was filtered using Whatman filter paper and 1ml of the filtrate was titrated with 0.1 M NaOH using 2 drops

of phenolphthalein indicator. Titratable acidity was expressed as percentage citric acid.

$$\textbf{Weight of citric acid} = \frac{\textbf{M x V x F}}{\textbf{3}}$$

Where;
V* = *volume of 0.1M NaOH used,
M* = *molarity of NaOH
F* = *factor of citric acid (192.43)

That is:

$$Weight\ of\ citric\ acid = \frac{\textbf{0.1}\boldsymbol{M\ NaOH\ x\ volume\ of\ NaOH\ (litre)\ x\ 192.43}}{\textbf{3}}$$

$$\%\ \textbf{TTA} = \frac{\textbf{Weight of citric acid x 100\%}}{\textbf{Weight of Sample}}$$

Total Soluble Solids (TSS)
The total soluble solids determination was according to Owoso, *et al.* (2000). The glass slide of the refractometer (Bellingham and Stanley Refractometer) which ranged between 0 – 40 and 40 – 85, was cleaned with water and dried with a clean napkin. The sample was smeared on the slide of the refractometer and the lid was replaced. The reading was taken on the graduated mark and recorded in degree brix (^{0}Brix)

Ascorbic Acid Content
For the determination of ascorbic acid content, ascorbic acid solution was made by weighing 50 mg of it into a 50 ml volumetric flask and made up to mark with oxalic acid solution (0.4 %). This solution was kept in a cool place for 24 hrs before use. Dye to be used as titrant was also made by dissolving 50 mg of 2, 6, Dichlorophenol indophenol dye and 42 mg sodium bicarbonate($NaHCO_4$) in a beaker using distilled water. The solution was filtered and volume made up to 250 ml, stored in a clean bottle and placed in a cool place. Five (5) mL of the prepared standard ascorbic acid solution in a conical flask was titrated against dye solution till light pink colour persisted for 15 seconds

Dye factor (f) =

$$\frac{\textbf{ml of ascorbic acid solution taken}}{\textbf{Volume of dye used}}$$

Dye factor was determined separately for each determination.
To a 100 mL volumetric flask, 0.5 ml of sample was added and volume was made up to mark with 0.4% oxalic acid solution. 10 mL of this solution was taken into a conical flask and titrated against the dye solution till light pink appeared which persisted for 15 seconds. This was repeated twice and the three readings recorded for each sample (Tariq *et al.*, 2015). Ascorbic acid content was calculated by using the following formula:
Ascorbic acid (mg/100 g) =

$$\frac{\textbf{L x F x 100 x 100}}{\textbf{D x P}}$$

L = Volume of dye (ml) used
F = dye factor
D = WL (g) of sample taken for dilution
P = Volume (ml) of sample taken for dilution.

Microbiological Analysis
Ten gram of each sample was dispersed in 90 ml sterile distilled water. Serial dilutions of 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4} was prepared by diluting 10 mL of previous dilution to 90 ml of diluent. 1ml each of the 10^{-2} diluent was then pipetted into four separate petri dishes appropriately labelled. Nutrient agar, Potato dextrose agar (PDA) and Eosin methylene blue (EMB) agar were poured into appropriate petri dishes. Sample and agar medium were immediately mixed thoroughly and uniformly and agar allowed to solidify. The nutrient agar and EMB petri dishes was inverted and incubated promptly for 24hrs at 37 ^{0}C while the PDA plates were incubated at 28 ^{0}C (FDA, 2013).

Sensory Analysis

The subjective method of quality evaluation was used to determine: colour, flavor, taste, texture. Sensory properties of the various blend ratios produced were determined after production. Parameters evaluated during the sensory evaluation were colour, taste, aroma, flavor, texture and overall acceptability. This was done by semi-trained panelists, composing of 30 members, selected amongst students and staff of Yaba College of Technology, who knows the quality attributes of ketchup. A ranking test was used to score the samples, using a scale was graduated from 1 representing like extremely and 9 representing dislike extremely. Sample was presented in 3- digits codes and panelist was arranged such that they are independent of each other, the judgements of panelist were converted to numerical values and analyzed using analysis of variances (ANOVA) Version 21(Akinjaiyeju, 2009).

Determination of Colour

The colour of Ketchup was measured objectively using a colourimeter (Model 45/0 LAV, Colour Flex, Firmware VI.32.16.014A) according to the method described by Matthew & Ojo (2013), and the values expressed in terms of L*, a*, b* values. Where L* represent lightness from 0 (black) to 100 (white); a* and b* represent redness (+a) to greenness (-a) and yellowness (+b) to blueness (-b), respectively. Twenty grams (20g) of the ketchup produced was put in clean transparent glass test cup and placed on the sensor rays of light passage of the colour flex and allowed to read through the sample and result was obtained directly from the digital display of the colour flex.

Proximate Composition of Ketchup

Moisture content determination

The determination of the moisture content was according to method described by AOAC (2005). The weights of the petri dishes were determined and recorded. To each petri dish, 5 g sample was weighed and dried in the oven at 105 ± 1 ^{0}C for 4 hours. The samples were then cooled in a desiccator and re-weighed. The moisture content was calculated as follows:

$$\text{Moisture content (\%)} = \frac{\boldsymbol{A-B\ x\ 100}}{\boldsymbol{C}} \quad \ldots\ldots (1)$$

Where:

A – B = represent change in weight

C = Initial weight of the food before drying

Protein content determination

The protein content was determined using micro-Kjedhal method AOAC (2005) by wet digestion, distillation and titration. Protein content was determined by weighing 3 g of the sample into a boiling tube that contains 25 ml concentrated sulphuric acid and one catalyst tablet containing 5 g K_2SO_4, 0.15 g $CuS0_4$ and 0.15 g TiO_2. Tubes were heated at low temperature for digestion to occur. The digest was diluted with 100 ml distilled water, 10 ml of 40 % NaOH and 5 ml $Na_2S_2O_3$, anti-bumping agent was added, and then the sample was diluted with 10 ml of boric acid. The NH_4 content in the distillate was determined by titrating with 0.1 N standard HCl using a 25 ml burette. A blank was prepared without the sample. The protein value obtained was multiplied by a conversion factor, and the result expressed as the amount of crude protein.

Calculation:

$$\textbf{\% crude protein} = \frac{\textbf{Actual titre value} - \textbf{Titre of the blank} \times \textbf{0.1N HCl} \times \textbf{0.014} \times \textbf{Cf} \times \textbf{100}}{\textbf{Weight of sample}} \quad .. (2)$$

Where:

Cf = Conversion factor (6.25)

Fat content determination

Fat content was determined using the method as described by AOAC (2005). Ten grams of the sample was wrapped in filter paper and weighed

using a chemical balance. It was then placed in an extrusion thimble that was previously clean, dried in an oven and cooled in the desiccator before weighing. Then, 25ml of petroleum ether was measured into the flask and the fat content was extracted. After extraction, the solvent was evaporated in the oven. The flask and the content were cooled in a desiccator and weighed.

Calculation:

$$\text{Percentage of Total fat content} = \frac{weight\ of\ fat\ extracted\ x\ 100}{weight\ of\ food\ sample} \quad \ldots\ldots\ldots (3)$$

Crude Fibre Determination

Crude fibre was determined using the method as described by AOAC (2005). Five grams of each sample was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and reflux for exactly 40 minutes from the start of boiling. The flask was removed from the heater, cooled a little and filtered through a 15.00 cm whatman paper no.4. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight 150 ^{o}C. After drying, it was a transferred to desiccator and weighed as W_1. It was then burnt in a muffle furnace at 500 ^{0}C for 6 hours, allowed to cool, and reweighed as W_2.

$$\%\ \text{crude fibre} = \frac{W_2 - W_1}{W_0} \quad \ldots\ldots (4)$$

W_1= Weight of crucible + fibre +ash
W_2 = Weight of crucible +ash
W_0 = Dry weight of food sample

Ash content determination

Ash content was determined using the method as described by AOAC (2005). Five (5 g) of each sample was weighed into crucibles in duplicate, and the samples were incinerated in a muffle furnace at 550 ^{0}C until a light grey ash and a constant weight obtained. The samples were cooled in a desiccator to avoid absorption of moisture and weighed to obtain ash content.

Calculation:

$$\textbf{\% Ash} = \frac{(\mathbf{A - B})\ \boldsymbol{x}\ \mathbf{100}}{\mathbf{C}} \ldots (5)$$

Where:

A = Weight of crucible with sample
B = Weight of crucible with ash
C = Weight of sample

Carbohydrate content determination

The carbohydrate content was calculated according to the equation below:

$$NFE = 100 - (M + P + F + A + C_f) \ldots (6)$$

Where:

M = Moisture content
P = Protein content
F = Fat content
A = Ash content
C_f = Crude fibre

Determination of Viscosity

The viscosity of the sample was determined using Rotary viscometer manufactured by NDJ-5S (2009-11) with rotor speed set at 4. The viscosity of samples was determined at a different temperature (37 ^{0}C, 70 ^{0}C, 50 ^{0}C and 30 ^{0}C) respectively, with varying temperatures achieved using water bath. Measurements on the sample were determined at a constant shear rate of 12 r.p.m. 10ml of the sample was used for all measurements. Duplicate sample was analyzed and the viscosity value was then obtained.

Determination of Energy Value

The determination of the energy value was done using a bomb calorimeter. One gram of solid sample was weighed into a crucible and placed inside a stainless steel container filled with 30bar (435 psi) of oxygen. The sample was ignited through a cotton thread connected to an ignition wire inside the decomposition vessel and combusted.

RESULTS AND DISCUSSION

Physicochemical Properties

The physicochemical properties of the ketchup blends ratios are presented in Table 1, 2, 3 & 4 respectively. Samples TPK (100% tomato: 0% Hog plum) was the control. Storage was done for four weeks (week 1, week 2, week 3 and week 4 respectively).

Table 1: Physico-chemical Properties of Ketchup blends (Week 1)

Sample	TTA %	Ascorbic Acid (mg/100 g)	pH	^{O}Brix
HPK	$47.03^{a} \pm 3.70$	$30.33^{b} \pm 10.69$	$4.00^{a} \pm 0.03$	$60.00^{c} \pm 1.00$
TPK	$29.87^{a} \pm 3.70$	$32.67^{b} \pm 4.04$	$5.46^{e} \pm 0.03$	$46.00^{a} \pm 1.00$
THK	$44.87^{a} \pm 6.45$	$16.33^{a} \pm 4.04$	$5.10^{d} \pm 0.03$	$46.00^{a} \pm 1.00$
HTK	$37.83^{a} \pm 29.05$	$9.33^{a} \pm 4.04$	$5.04^{c} \pm 0.03$	$45.00^{a} \pm 1.00$
TKP	$39.10^{a} \pm 1.21$	$30.33^{b} \pm 4.04$	$4.82^{b} \pm 0.03$	$50.00^{b} \pm 2.00$

Values are means of triplicate determinations ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance

Table 2: Physico-chemical Properties of Ketchup blends (Week 2)

Samples	TTA %	Ascorbic (mg/100 g)	pH	Brix
HPK	$10.67^{ab} \pm 3.70$	$9.33^{a} \pm 4.04$	$3.46^{a} \pm 0.03$	$60.00^{c} \pm 2.00$
TPK	$14.36^{b} \pm 4.28$	$7.00^{a} \pm 0.00$	$4.59^{d} \pm 0.03$	$45.00^{a} \pm 2.00$
THK	$10.67^{ab} \pm 3.70$	$7.00^{a} \pm 0.00$	$4.10^{b} \pm 0.03$	$46.00^{a} \pm 0.50$
HTK	$6.40^{a} \pm 0.00$	$7.00^{a} \pm 0.00$	$4.16^{c} \pm 0.03$	$44.00^{a} \pm 2.00$
TKP	$10.67^{ab} \pm 3.70$	$11.67^{a} \pm 4.04$	$4.17^{c} \pm 0.03$	$50.00^{b} \pm 2.00$

Values are means of triplicate ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance.

Table 3: Physico-chemical Properties of Ketchup blends (Week 3)

Samples	TTA %	Ascorbic (mg/100g)	pH	Brix
HPK	145.07^{b} ± 6.87	11.67^{a} ± 4.04	4.18^{c} ± 0.03	57.00^{c} ± 1.00
TPK	32.00^{a} ±0.00	23.33^{b} ± 4.04	2.78^{a} ± 0.03	46.00^{c} ± 1.00
THK	36.97^{a} ± 4.43	16.33^{ab} ± 4.04	4.27^{d} ± 0.03	45.00^{a} ± 2.00
HTK	44.87^{a} ± 6.45	21.00^{b} ± 0.00	4.40^{e} ± 0.03	45.33^{b} ± 2.02
TKP	149.63^{b} ± 14.78	21.00^{b} ± 7.00	3.65^{b} ± 0.03	49.00^{b} ± 1.00

Values are means of triplicate ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance.

Table 4: Physico-chemical Properties of Ketchup blends (Week 4)

Samples	TTA %	Ascorbic (mg/100g)	pH	Brix
HPK	138.67^{c}±9.71	18.67^{ab}±8.08	4.03^{c}±0.03	58.00^{c}±0.50
TPK	25.60^{a}±6.40	23.33^{b}±4.04	2.72^{a}±0.03	46.00^{a}±0.00
THK	34.00^{a} ±3.46	9.33^{a}±4.04	4.17^{d}±0.03	45.00^{a}±2.00
HTK	51.07^{b}±6.50	25.67^{b}±4.04	4.42^{e}±0.03	45.00^{a}±1.00
TKP	155.33^{d}±4.04	11.67^{a}±4.04	3.62^{b}±0.03	48.00^{b}±0.50

Values are means of triplicate ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance.

Total titratable acidity is an approximation of the total acidity of a solution. Titratable acidity is a better predictor of acids impact on flavour than pH (Tyl & Sadler, 2017). The total titratable acidity of samples was observed weekly. No significant ($p \geq 0.05$) difference for all the samples in week 1. The total titratable values ranged from 29.87 to 44.87 %. Sample TPK had the lowest value of total titratable acidity, while sample THK had the highest value of TTA. No significant ($p \geq 0.05$) difference was observed for TTA for all the samples in week 2. Sample HPK had an intermediate value between, sample HTK and sample TPK. Sample THK had an intermediate value between, sample HTK and sample TPK. Significant ($p \leq 0.05$) difference was observed among the samples for TTA, in week 3 with mean score values ranging between 32.00 and 149.63. Sample TPK had the lowest value of TTA, while sample TKP had the highest value of TTA. Significant ($p \leq 0.05$) difference was observed among the samples for TTA, with mean score values ranging between 25.60 and 155.33. Sample TPK had the lowest values of TTA, while sample TKP had the highest values of TTA. The result of total titratable acidity didn't comply with the standard of FDA (2013) which ranges from 0.7 – 1.2. The increases amount of titratable acidity obtained maybe as a result of the raw materials used (Hog plum) which contains high amount of acidity.

Ascorbic (vitamin C) is a natural water soluble vitamin occurring in foods and it is also consumed as dietary supplement. Its presence in food prevents scurvy, slowing down the oxidation thereby preserving colour and freshness of food (Naidu, 2003). Significant difference ($p \leq 0.05$) were observed amongst the samples for ascorbic

acid content in week 1. No significant ($p \leq 0.05$) difference was observed between sample HTK and THK. Samples HPK, TPK, and TKP also had no significant difference between the samples. In the second week (week 2), No significant ($p \geq 0.05$) difference was observed among the samples for ascorbic acid. The ascorbic acid values ranged from 7.0 % to 11.67 %. Sample TKP had the highest value of ascorbic acid while samples HTK, THK, TPK had the same least values of ascorbic acid. No significant difference ($p \geq 0.05$) was observed in week 3 among samples TPK, HTK, and TKP for ascorbic acid, however sample HTK was intermediate of samples THK, TPK, HPK and sample TKP. In the fourth week (week 4), no significant difference ($p \geq 0.05$) was observed among all samples for ascorbic acid values, however sample HPK was intermediate of samples TPK, HTK, TKP and sample HTK. The ascorbic acid values for all samples showed slight reduction except in sample HTK whose vitamin C content increased. The reduction in vitamin C content was due to temperature changes which occurred in the storage atmosphere. The result obtained in this study are similar to the findings of Famurewa *et al.* (2013) who reported that increased temperatures normally results in high percentage loss of ascorbic acid.

The soluble solid is a measure of the refractive index of the paste, depending on the concentration and temperature of solutes in solution. Product quality may attract the buyers but eating quality keeps them, the brix influences the sweetness or taste of a product according to Matthew *et al.* (2013). The soluble solid of the samples was observed weekly for a period of four weeks. No significant difference ($p \geq 0.05$) was observed for brix among samples TPK, THK, and sample HTK in week 1, week 2 and for week 4. In the third week (week 3) there was no significant difference for brix between sample HPK and sample TPK as well as between sample HTK and sample TKP. The results obtained are similar to that of Anandsynal *et al.*, (2018) who reported a brix range of 31-55 (TSS%)

The pH is a measure of active acidity or alkalinity of solution as contrasted with the titratable acidity or alkalinity. Ketchup contains pectin, pectin is more stable at pH of 3.5 therefore, the more the pH value the less viscous the gel. Significant difference ($p \leq 0.05$) was observed for pH in all samples in week 1. The mean score values for pH ranging between 4.00 to 5.46. Sample TKP had the least value of pH, while sample TPK had the highest value. In week 2, no significant difference ($p \geq 0.05$) was observed for pH between sample HTK, and sample TKP. Significant difference ($p \geq 0.05$) was observed for pH in all samples in week 3. The mean score values for pH ranging between 2.78 to 4.40 Sample TPK had the least value of pH, while sample HTK had the highest value. Significant difference ($p \leq 0.05$) was observed for pH in all samples in week 4. The mean score values for pH ranging between 2.72 to 4.42. Sample TPK had the least value of pH, while sample HTK had the highest value. The results obtained in this study are similar to the findings of Famurewa *et al.* (2013) who reported a pH range 3.76 to 4.43 as well as to the findings of Anandsynal *et al.* (2018) who reported a pH range of 3.15 to 4.14, among the parameters analyzed for the assessment of ketchup stating the significance of pH as acidity influences the thermal processing conditions required for producing a safe product.

Proximate Compositions of the Ketchup Blends

The proximate composition of five various compositions of tomatoes and hog plum are represented in Table 5.

Table 5: Proximate properties of ketchup from tomatoes and hog plum

Samples	% Ash	% Fibre	% Protein	% Fat	% CHO	% M.C.
HPK	$9.16^{e}\pm0.01$	$1.84^{e}\pm0.02$	$6.17^{e}\pm0.02$	$4.30^{c}\pm0.27$	$28.79^{e}\pm0.25$	$49.75^{a}\pm0.00$
TPK	$6.95^{b}\pm0.02$	$1.34^{b}\pm0.02$	$4.66^{b}\pm0.01$	$6.63^{d}\pm0.46$	$25.81^{b}\pm0.44$	$54.60^{c}\pm0.01$
THK	$7.48^{d}\pm0.01$	$1.49^{d}\pm0.02$	$5.00^{d}\pm0.01$	$2.83^{a}\pm0.03$	$26.66^{c}\pm0.04$	$56.53^{d}\pm0.01$
HTK	$6.76^{a}\pm0.02$	$1.31^{a}\pm0.02$	$4.44^{a}\pm0.02$	$3.48^{b}\pm0.14$	$24.79^{a}\pm0.12$	$59.20^{e}\pm54.41$
TKP	$7.29^{c}\pm0.00$	$1.42^{c}\pm0.01$	$4.89^{c}\pm0.01$	$4.33^{c}\pm0.20$	$27.65^{d}\pm0.17$	$54.40^{b}\pm0.02$

Values are means of triplicate ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance.

The mean score values obtained for ash content of samples HPK, TPK, THK, HTK, TKP in this study are 9.16, 6.95, 7.48, 6.76, 7.29 respectively. Significant difference ($p\leq0.05$) was observed in all samples for ash content values, the values ranging from 6.76-9.16, sample HTK had the minimum mean score value for ash content while sample HPK had the maximum mean score value. The result obtained for ash content is not in correspondence with previous research findings such as that of Anandsynal *et al.* (2018) who reported ash content value less than 1.5 and Mohie *et al.* (2011) who reported ash content value which of 1.4 ± 0.01.

Presence of fiber in foods help to regulate blood lipids, also preventing cardiovascular diseases. The mean score values obtained for the crude fibre content of samples, HPK, TPK, THK, HTK, TKP in this study were 1.84,1.39,1.49, 1.31, 1.42 respectively. Significant difference ($p\leq0.05$) was observed in all samples for crude fibre values, the mean score values obtained ranged between 1.31-1.84. Sample HTK had the minimum mean score value for crude fibre while sample HPK had the maximum mean score value. The result obtained in this study is similar to the findings of Anandsynal *et al.* (2018) who reported a range of 0.36 – 2.71 for crude fiber content.

The mean score values obtained for the protein content of samples, HPK, TPK, THK, HTK, TKP in this study were 6.17, 4.66, 5.00, 4.44, 4.89 respectively. Significant difference ($p\leq0.05$) was observed between samples for protein content values, the values obtained ranging from 4.44-6.17. Sample HTK had the minimum mean score value for protein content while sample HPK had the maximum mean score value. High protein can be of nutritional importance in developing countries where many people cannot afford food with high protein because of cost (Adegunwa *et al*., 2014).

The mean score values for fat samples, HPK, TPK, THK, HTK, TKP in this study were 4.30, 6.63, 2.83, 3,48, 4.33 respectively. The mean score values for fat obtained ranged between 2.83 and 6.63 with the sample THK having the minimum mean score value and sample HPK having the maximum mean score value. No significant ($p\geq0.05$) difference was observed between samples HPK and TKP in this study.

Mean score values for carbohydrate obtained for samples, HPK, TPK, THK, HTK, TKP in this study were 28.79, 25.81, 26.66, 24.79, 27.65 respectively. The values obtained ranged between 24.79 and 28.79 with the sample HTK having the minimum mean score value and sample HPK having the maximum mean score value. No significant ($p\geq0.05$) difference was observed for carbohydrate between sample treatments for ketchup in this study. The result of carbohydrate obtained is slightly higher, but closely related to the findings obtained by Mohie *et al.* (2011) in who reported carbohydrate value of 22.7±0.3.

The shelf stability of a product is a function of the moisture content (Khubber *et al.*, 2020). The mean score values obtained for moisture content of samples, HPK, TPK, THK, HTK, TKP in this study were 49.75, 54.60, 56.53, 59.20, 54.40 respectively. Significant difference ($p \leq 0.05$) was observed between samples for moisture content, the values obtained ranged between 49.75 and 59.20. Sample HPK had the least mean score value, while sample HTK had the maximum mean score value. The result obtained for moisture is similar to the findings of (Petrotos & Gerasopoulos, 2022).

Viscosity

Viscosity is the property of a fluid which opposes the motion between two surfaces of the fluid that are moving at different velocity. For week 1, significant difference ($p \leq 0.05$) was observed for viscosity between samples during storage. The mean score values for viscosity ranged between 6750.0 mPa and 17957.0 mPa. Sample TKP had the least mean score value of viscosity while sample HPK had the highest mean score value for viscosity. In the second week (week 2), significant ($p \leq 0.05$) difference was observed among all the samples for viscosity, the viscosity ranged from 6050.0mP to 14100.0mP. Sample HPK had the minimum mean score value of viscosity while sample HTK had the highest mean score value. No significant ($p \geq 0.05$) difference was observed in all samples for the mean score values of viscosity in week 4, the viscosity ranged between 7250.0mP and 11250.0mP. Sample HPK had the minimum mean score value of viscosity while sample HTK had the maximum mean score value. Also for week 4, no significant ($p \geq 0.05$) difference was observed in all samples for viscosity, the values ranged between 7,000.0mP and 11,500.0mP Sample HPK had the least mean score value of viscosity while sample THK had the highest mean score value for viscosity.

The viscosity level for sample TPK varied. While for sample HPK the results showed a drastic reduction in the level of viscosity after which a little increase was observed in week 3 then a slight rise in week 4. The trend for sample THK showed a gradual increase in viscosity during the storage period. Sample HTK showed a rise in viscosity level in week 2 then a reduction in week 3 and a slight increase in week 4 while sample TKP showed a fall and rise in the level of viscosity during the storage period. The viscosity of fluid food product is a physical property as well as a textural parameter which is relevant to the quality of food product such tomato paste and ketchup (El-Desouky, 2010). Some of the parameters that contributes to flow behavior of tomato ketchup are the raw materials used and its processing conditions (Bayoda *et al.*, 2008). The results of viscosity obtained is similar to the standard of viscosity of ketchup that ranged between 50,000 – 70,000cp (Divina *et al.*, 2017).

Sensory Evaluation

The sensory evaluation scientifically analyses and measures human responses and perceptions of food and drinks e.g. appearance, touch, odour, texture, temperature and taste. The colour for sample HPK was significantly ($p \geq 0.05$) different between the samples for colour. The colour mean score values ranged between 2.47.0 and 4.10.0. Sample THK had the least mean score value for colour while sample HPK had the highest mean score value. No significant ($p \geq 0.05$) difference among all samples for mean score value of aroma. No significant ($p \geq 0.05$) difference was for Texture, for mean score values of texture in all samples as well as that of taste. There was no significant ($p \geq 0.05$) difference observed between the samples for mean score values of overall acceptability, sample TPK, however had an intermediate mean score value for overall acceptability between sample HPK and sample THK.

Table 6: Sensory Evaluation of Ketchup produced from Tomato and Hogplum

Samples	Colour	Aroma	Texture	Taste	Acceptability
HPK	4.10^{b}±2.14	4.00^{a}±1.53	4.23^{b}±2.19	4.97^{b}±2.20	4.43^{b}±1.76
TPK	3.03^{a}±1.25	3.60^{a}±1.67	3.37^{ab}±1.67	4.03^{ab}±2.34	3.80^{ab}±1.88
THK	2.47^{a}±1.20	3.33^{a}±1.56	3.27^{a}±1.34	3.50^{a}±1.53	3.43^{a}±1.74
HTK	2.67^{a}±1.35	3.23^{a}±1.55	3.40^{ab}±1.48	3.43^{a}±1.85	3.47^{a}±1.43
TKP	2.50^{a}±1.66	3.60^{a}±1.94	3.20^{a}±1.88	3.47^{a}±2.13	3.20^{a}±1.99

Values are means of triplicate ± standard deviation, different superscripts within the same column are significantly different at 5% level of significance.

Energy Value Determination

There was no significant ($p \geq 0.05$) difference between samples THK, HTK and TKP. Sample HPK had the maximum mean score value of 12.90 and sample TPK having a minimum mean score value of 12.02. The determination of energy value is important for nutritional labelling. The growing trend of obesity is major concern of the government particularly in the young. The knowledge on general calorie intake and food labelling is seen as a method for combating obesity in many national strategies (Ledikwe *et al.*, 2005).

Colour

Table 7 shows the result of the colour analysis of the tomato and Hogplum composites blends. No significant difference was recorded between the "L" values (23.88) of sample THK (90-10) and (23.90) of sample TKP (70-30). Degree of lightness is represented by 'L' values, sample HTK (80-20) was observed to be the lightest ('L' = 25.67). The result obtained above is similar to the findings of Mohie, *et al.* (2011) who reported a value of 25.26 ± 0.0552 for "L" value in his study.

The degree of redness was represented by "a" values. A significant difference ($p \leq 0.05$) was observed for all the "a" values of the samples. Sample TPK (100% tomato ketchup) recorded the highest "a" value (27.57), while sample HPK (Tomatoes Hogplum 0:100% ketchup) recorded the least "a" value (19.66). The result obtained for "a" is similar to the findings of Mohie *et al.*, (2011) who reported a value of 36.11±0.23 in his research work "Fourier Transformation Infrared Spectroscopy for Quality Assurance of Tomato products"

The "b" value represented the degree of yellowness. A significant difference ($p \leq 0.05$) was observed among all sample. The "b" value was observed to increase with corresponding increase in hog plum substitution level in tomato. A decline (30.27) was observed in "b" value for THK (90-10 Hog plum, tomato ketchup). Sample HTK (80-20 hog plum, tomato ketchup) had the highest "b" mean score value of degree of yellowness.

ΔC refers to Chroma and it represented the perceived strength of a surface colour. It also implies the colourfulness of an object relative the brightness of a white object similarly illuminated. The Chroma value range between 38.2 and 42.89. The Chroma value was observed to increase with corresponding increase in hog plum substitution level in tomato. A decrease (41.65) was however observed for sample TKP (70 – 30 Tomato, Hog plum ketchup). Sample HTK 80 – 20 has the highest Chroma value (42.89)

The total colour intensity was represented by ΔE. Colour intensity value was observed to increase with corresponding increase in hog plum substitution level. There was an increase and decrease in colour intensity value for all sample and this ranged between (45.06-49.99) with sample HTK 80-20

(Tomato, Hog plum ketchup) recording the highest mean score value of colour intensity

Hue Angle

Hue angle refers to the degree to which a stimulus can be described as similar to or different to stimuli that are described as red, green, blue and yellow.

The hue value range between 49.04 – 60.55. Hue value was observed to increase in corresponding increase in substitution level with sample TKP 70 – 30 (hogplum, tomato ketchup) having the highest mean score value of substitution for hue angle 55.24.

TABLE 7: Results colours of tomato and hog plum ketchup

CODE/ PARAMETERS	HPK	TPK	THK	HTK	TKP
L	23.48	23.79	23.88	25.67	23.90
a	19.66	27.57	23.33	24.85	23.75
b	34.81	31.75	30.27	34.96	34.22
a^2	386.52	760.10	544.29	617.52	564.06
b^2	1211.74	1008.06	916.27	1222.20	1171.0
Chroma (ΔC)	39.98	42.05	38.22	42.89	41.65
Colour intensity (ΔE)	46.36	48.31	45.06	49.99	48.02
Hue angle	60.55	49.04	52.37	54.60	55.24

Legend: "L" value represented the degree of Lightness**;** "a" value represented the degree of redness**;** "b" value represented the degree of yellowness

Microbial Population of Samples

As shown in Table 8, The total plate count for the samples immediately after pasteurization yielded no colonies. However, at week four, the total plate counts ranged between 10 – 250 colonies.

All the products except TPK fell below the maximum acceptable viable count limit of 10 colonies (DMS, 2018). It was noted that the lower the tomato proportion in the blend, the higher the level of contaminants recorded. The yeast count ranged between 0 – 500 colonies, mould count ranged between 200 – 900 and coliform count ranged below 0 – 330 count. All these fell below the acceptable level permissible in tomato sauce and ketchup (DMS, 2018).

Table 8: Microbial Analysis of Ketchup from Tomato and Hog plum

Sample	Total count 10^{-2} cfu/g	Yeast 10^{-2} cfu/g	Mould 10^{-2} cfu/g	Test for coliform 10^{-2} cfu/g
TPK	**0.1**	**0**	**2**	**1.3**
THK	**1.2**	**2**	**6**	**0.1**
TKP	**2.5**	**5**	**9**	**3.3**
HPK	**0.2**	**1**	**4**	**0.3**
HTK	**1.7**	**3**	**3**	**0**

Legend: cfu/g = colony forming unit/g

4.0 CONCLUSION

The result of this study revealed that hog plum is a good source of essential nutrient and antioxidant. It also proved that hog plum can be utilized and developed into a variety of product like ketchup. This study revealed that, ketchup made from hog plum is a rich source of vitamin C, protein, and energy but poor in taste in terms of sensory attribute. The proximate composition, sample HPK (100 % hog plum: 0 % tomato) had the least moisture content (inferring a better shelf stability), highest protein content, crude fibre (good aid for digestion) as well as highest carbohydrate (good source of energy) and ash content. The microbial shelf life study at week four showed that the tomato: hog plum blend products did not meet up with permissible limit indicating a short shelf life.

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