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Nutritional analysis and wine production potentials of *Telfairia occidentalis* (fluted pumpkin) leaves and *Cucumis sativus* L. (cucumber) using Baker's and palm wine yeast strains

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ABSTRACT

Telfairia occidentalis leaves and *Cucumis sativus* (cucumber) are vegetables that grow best in Tropical countries like Nigeria and have good nutritional properties but are highly perishable. Both vegetables were evaluated for wine production singly and in composite forms using palm wine and Baker's yeast strains. In addition to wine production, the vegetables were screened for phytochemicals, anti-nutrients and nutrients (proximate composition, elements and vitamins) using standard methodologies. Proximate composition (g/100 g dry matter) revealed that *T. occidentalis* leaves had moisture content, ash, protein, fat, fibre and carbohydrate contents of 86.60±0.10, 5.72±0.02, 4.30±0.10, 0.97±0.02, 6.30±0.10 and 82.45±0.02, respectively. In contrast, *Cucumis sativus* had a moisture content, ash, protein, fat, fibre and carbohydrate contents of 96.75±0.01, 5.40±0.02, 13.50±0.02, 10.30±0.10, and 66.12±0.01, respectively. Both plants contained various phytochemicals, including alkaloids, glycosides, saponins, tannins, flavonoids, reducing compounds and polyphenol, but not anthraquinones and phlabotanins. However, on quantification, reducing compounds and polyphenol recorded the highest concentrations. Vitamins A and C were detected in both samples. *C. sativus* had high amounts of K, P, and Mg and moderate amounts of Ca, Na, Cu, Fe and Mg. *T. occidentalis* leaves had moderate amounts of Ca, Zn, Fe, Mg, Ca, and Na. Anti-nutrients levels were all below allowable regulatory limits for vegetables. Density, pH, and alcohol values ranged from 0.20 - 0.99, 0.30- 4.6, and 1.95 - 9.94%, respectively. Sensory evaluation of the wine samples showed that wine produced from 70% fluted pumpkin and 30% cucumber had the best scores in terms of acceptability, taste, aroma, and appearance. Given the findings in the study, wine production using tropical vegetables could double as a viable

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alternative to tropical fruits and also help to curb post-harvest losses, commonly experienced in the tropics.

***Keywords*:** Wine, Nutrients, Alcohol, Palm wine yeast, Tropical, Vegetables, *Telfairia occidentalis, Cucumis sativus*

1. INTRODUCTION

Tropical climate is well known for its unique environmental conditions and is home to diverse exotic fruits and vegetables with potentials for wine production [1]. Alcoholic beverages obtained via fermentation from the juice of fruits naturally or intentionally is generally known as wine [2]. They are divided into three categories, namely beers, wines, and spirits [3]. These fruits and vegetables are known to be very rich sources of vitamins, minerals, anti-oxidants and form a part of regular diets [1, 4-7]. As expected, fruit wines are well known for their beneficial effects, notably amongst these are positive effects on inflammation, cardiovascular health, antimicrobial activities, antioxidant properties. These beneficial effects have been attributed to phytochemicals, such as polyphenols and flavonoids that they individual fruits and vegetables contain [1, 8-9]. Yeasts play an important role in wine production where they ferment the carbohydrate present in substrates into alcohol under anaerobic conditions. *Saccharomyces cerevisiae* and *S. carribegenesis*, although commercially available as Baker's yeast, they can be isolated from a number of sources. Notably, it can be isolated from Palm wine, a natural alcoholic beverage that is widely consumed in the Southern part of Nigeria [9-10]. A number of studies have shown that palm wine yeasts have fermentative abilities that could be exploited commercially [12]. *Telfairia occidentalis*, commonly called fluted pumpkin is a tropical vegetable that is widely grown in Nigeria due to its nutritive properties, economic potential of its leaves and edible seeds. It is a member of the Cucurbitaceae family and is indigenous to Southern Nigeria, and they are well known for their medicinal properties [13]. The fruits of this plant can last for over 6 months when stored properly but not the leaves [14-15]. On the other hand, Cucumber commonly called cucurbitis or gourd is ranked as the fourth most important vegetable worldwide. It is widely cultivated and eaten in Southern Nigeria, very rich in nutrients and emerging as a model species in plant biology [16-17].

Although, the focus is now shifting gradually from grapes to fruits other than grapes for wine production [18]. Vegetables also have great potentials in wine production but this is not fully exploited as seen with fruits. Farmers and middlemen have to dispose of these vegetables fresh and preferable on the same day of harvest to avoid losses. Given the lack of technologies to preserve these fruits and vegetables so as to curb post-harvest losses, wine production from them is very promising. Thus, the primary aim of the study was to evaluate the wine production potentials of cucumber and fluted pumpkin leaves in addition to their nutritive properties.

2. MATERIALS AND METHODS

Collection of materials

Freshly harvested fluted pumpkin leaves and cucumber were purchased from Itam Market in Uyo Metropolis, Akwa Ibom State, South-South Nigeria. These were then transported in clean polyethene bags immediately to the microbiology laboratory of Obong University for identification and analysis. Freshly collected palm wine was obtained, a renowned palm wine tapper in Obong University community in clean plastic bottle (500 mL capacity). Baker's yeast was purchased from a commercial dealer in Uyo, Akwa Ibom State.

Sample preparation and phytochemical screening

The samples and the extracts (aqueous and ethanolic) were prepared using methods previously described [4-7]. The phytochemicals screened for were alkaloids, saponins, glycosides, tannins, flavonoids, reducing sugars, polyphenols, anthraquinones, phlobatannins and hydroxymethyl anthraquinones.

Quantification of phytochemicals

Tannin, saponin, alkaloid, and flavonoid, reducing sugar, glycosides and polyphenol were quantified using methods previous reported [4-7] [19].

Proximate composition analysis

The vegetable samples analyzed for food composition according to the methods of Association of Official Analytical Chemists (AOAC) (1995) [20]. These included moisture, crude fiber, ash, crude protein, crude fat, and carbohydrate.

Estimation of anti-nutrients and vitamins

Vitamins A and C were determined according to the methods previously described [4-7, 21-22].

Determination of elemental composition

Mineral elements were determined by the dry ash extraction method of AOAC (1995) [20] at the Central Laboratory of Faculty of Agriculture, Wildlife and Forestry, University of Calabar, Calabar. Some of the mineral elements include sodium, potassium, calcium, magnesium, iron, zinc, copper and phosphorus.

Isolation of palm wine yeast

The freshly collected palm wine was vigorously shaken for one minute and used to carry out a ten-fold serial dilution. Following serial dilution, all the dilutions were plated onto triplicate potato dextrose agar (PDA) plates supplemented with 0.05 mg/mL of chloramphenicol and gentamicin each to inhibit bacteria growth. Plates were incubated at room temperature (25 ± 2 °C) for a maximum of 48 hours.

Representative colonies (confirmed to be yeasts by microscopy) were purified by re-streaking on PDA plates and isolates stored on PDA slants. Yeast isolates were identified by standard morphological and biochemical methods [23]. The yeast isolate was then multiplied by inoculating the yeast onto Malt Extract Broth and incubated at 27 ºC for 72 hours. The broth was then centrifuged at 500 rpm for 5 minutes. The cell pellet was then used for must fermentation.

Preparation of must

This was done following the modified method reported by Ogobo *et al*. (2018) [24]. The freshly harvested cucumber and vegetables were first thoroughly washed with separate distilled water. After that they were disinfected by soaking them briefly in 70% ethanol. The cucumber was then peeled using a sterile (stainless steel) knife. After peeling, the cucumber was then reduced into smaller pieces, and then thoroughly blended using a clean Blender. After blending, the mixture was then transferred into a clean bowl where 1 g of sodium metabisulphate dissolved in 100 mL of distilled water was added to serve as sterilizer and also prevent fermentation before the addition of the starter culture. Similarly, this was also done for fluted pumpkin leaves. After the must preparation, the various compositions were also sorted out (100% pumpkin leaves, 100% cucumber, 50-50% cucumber and pumpkin, 70% cucumber and 30% pumpkin leaves and 30% cucumber and 70% pumpkin leaves) for wine production.

Preparation of starter culture

This was done, as reported by Ogobo *et al*. (2015) [24] and Ogobo *et al*. (2018) [25]. Briefly, 5.00 g of the Baker's yeast and palm wine yeasts each was weighed out and mixed with exactly 200 mL of various musts. In addition, 2 g of yeast nutrients dissolved in 100 mL of sterile distilled water and sugar (500 g) were also added. They were allowed to stand for 3 hours before being used for fermentation.

Fermentation

The fermentation was carried out as described previously [24-25] but with small modifications. Primary fermentation was carried out using the starter cultures prepared and was allowed to run for a total of 3 days (72 hours). At intervals of 24, 48, and 72 hours, aliquots were obtained, from which pH, density, and alcohol concentrations were determined as described below. After 72 hours, the wines were then racked into a secondary fermenter and allowed to stand for three weeks. Clarification was done using bentonite as a clarifier while filtration was done using a muslin cloth, sieve and syphon tubes that were sterilized by 70% ethanol. The wines were then placed in 50-mL sterile bottles and labelled accordingly before being subjected to sensory evaluations.

Physicochemical analysis of the wine

Following 24, 48, and 72 hours of fermentation, aliquots of the wines were taken and analysed for pH, density, and alcohol contents using appropriate meters obtained from Uyo Champion Breweries. Density was determined using a density meter and alcohol content determined using an alcolyzer. The pH values were determined using a pH meter (Model 3320, Jenway).

Sensory evaluation

A panel of 20 (students, lecturers, and laboratory staff) sourced from the Department of microbiology, Obong University, were engaged in the sensory evaluation assessment. The sensory parameters evaluated were general acceptability, appearance, aroma, and taste of wines. These were done under headings, such as strongly agree (SA), agree (A), neutral (N), disagree (D), and disagree strongly (DS), and each was given a 5% score for each panel member.

Statistical analysis

Replicate data obtained in the various analyses were first expressed as mean ± standard deviation. Paired student T-test was then used to compare the readings for both vegetables and this was done using Microsoft Excel 2016. Probability values less than 0.05 was considered significant.

3. RESULTS

The results of the study are presented in the **Figures 1** to **10** and **Tables 1** to **11**. Figures 1 to 10 show the various levels of pH, alcohol concentration, and density of the various single and composite wines fermented with either Baker's or palm wine yeasts. Tables 1, 2, 3, 4, 5, and 6 show the results for crude phytochemical screening, phytochemical quantification, proximate nutrient composition, anti-nutrient estimation, vitamin quantification, and mineral element composition in both samples, respectively.

From Figure 1, the levels of alcohol (%) rose from 3.62 in day 1 to 5.22 in day 3 (72 hours). Density (g/cm^3) rose from 0.58 at 24 hours, 0.77 on day 2 and 0.99 on day 3. Figure 2 shows the levels of alcohol, pH and density in wine made from 100% pumpkins fermented with palm wine yeast. From the figure, the alcohol rose from 4.20 % to 6.94 % on day 1 to day 3. On the other hand, pH and density rose from 2.42 and 3.26 and 0.56 to 0.70 g/cm^3, respectively.

Figures 3 and 4 show the levels of alcohol, pH and density in wine made from 100% cucumber fermented with Baker's and palm wine yeast, respectively. From Figure 3, the levels of alcohol and pH decrease after 48 hours to 2.4% from 2.7% and 1.7 to 1.3, respectively. On the contrary, density steadily increased with time from 0.2 to 0.7 g/cm^3. From Figure 4, the levels of alcohol, pH and density in wine made from 100% cucumber and palm wine yeast are increasing.

The level of alcohol at 72 hours was almost doubled the values at 48 hours. The pH value rose from 2.1 to 3.6 after 72 hours, and density rose slightly from 0.66 to 0.99 g/cm^3.

Figures 5 and 6 show the levels of alcohol, pH, and density in wine made from 50% Cucumber + 50% fluted pumpkin leaves fermented with Baker's and Palm wine yeast. When 50% each of cucumber and Fluted pumpkin leaves was used in wine production, density as observed previously was under 1.00 g/cm^3. Alcohol levels rose from 3.25% after 24 hours and peaked at 4.55% after 48 hours and then decreased to 3.81% at 72 hours. The pH of the wine value was 1.97 and 3.19, at 24 and 72 hours. When Palm wine yeast was used, pH and alcohol were lower than that of wine fermented with Baker's yeast, however, they increased with time from 1.70 to 3.48 and 4.85 to 7.20 %, respectively.

Figures 7 and 8 show the pH, density and alcohol concentration variations for wines produced using 70% fluted pumpkin leaves and 30% cucumber fermented with Baker's yeast and palm wine yeast. From both Figures, the final alcohol concentration after 72 hours was almost similar in both (6.7% and 6.6%, respectively) but pH level was slightly higher in the composite wine with palm wine yeast. Density was under 1.00 g/cm^3 in both wines.

Figures 9 and 10 show the levels of pH, alcohol and density in wine made from 70% cucumber fermented with Baker's and palm wine yeast strains. From both Figures, the density showed a slight increase but was under 1 g/cm^3. The highest alcohol concentration and pH of 7.5% and 4.6 was observed with 70% cucumber and 30% fluted pumpkin wine fermented with Baker's yeast.

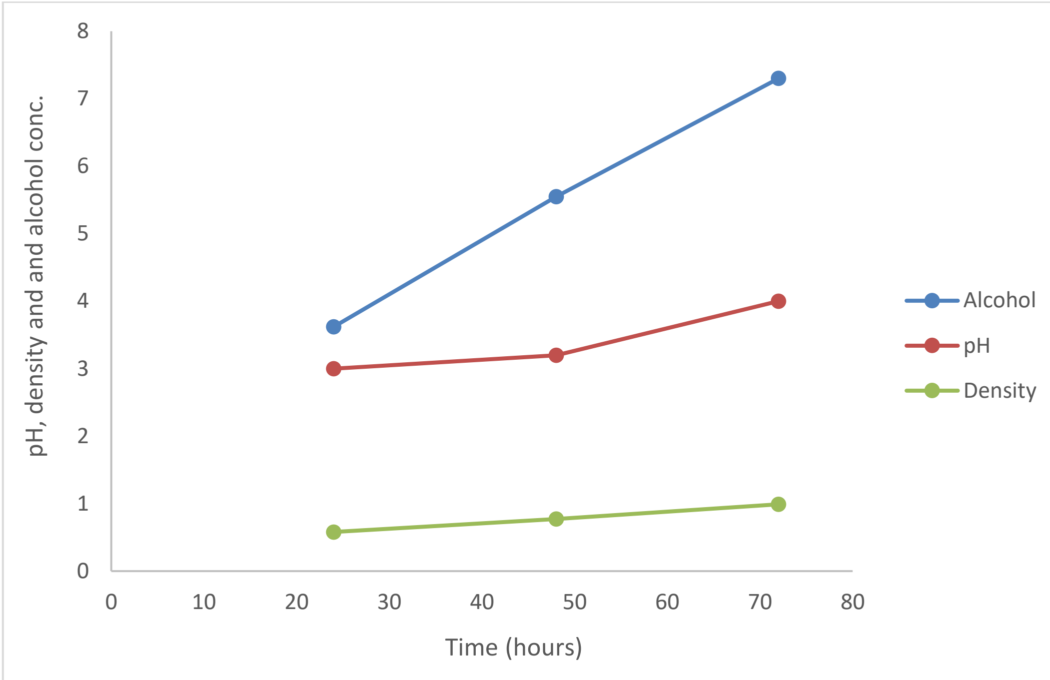

Figure 1. Levels of alcohol, pH and density in wine made from 100% fluted pumpkins leaves fermented with Baker's yeast.

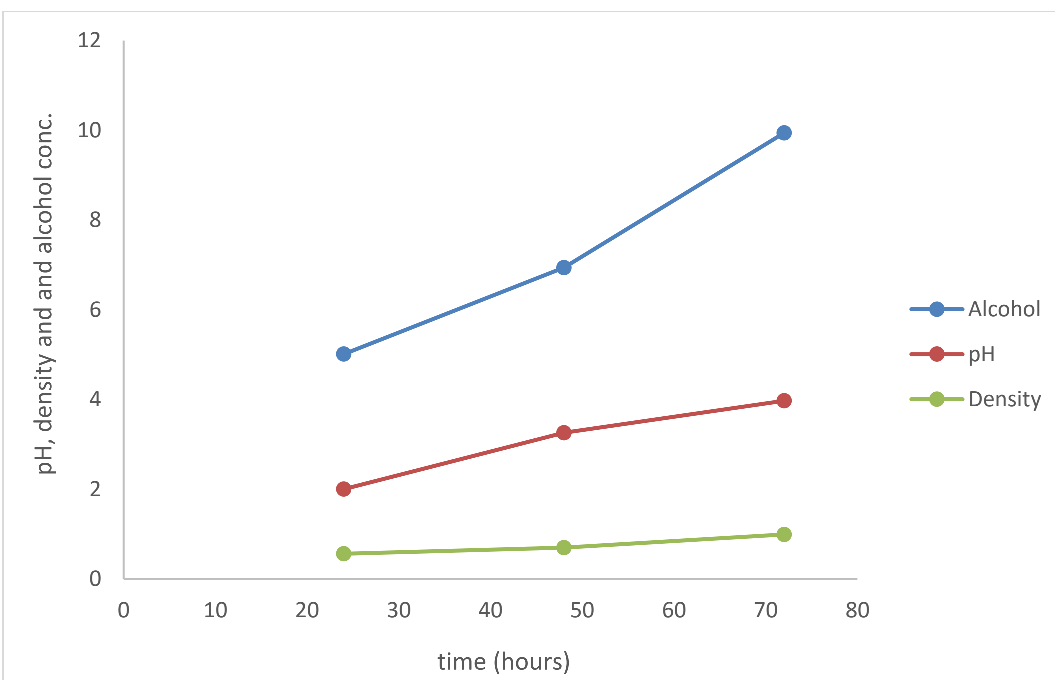

Figure 2. Levels of alcohol, pH and density in wine made from 100% fluted pumpkin leaves fermented with Palm wine yeast.

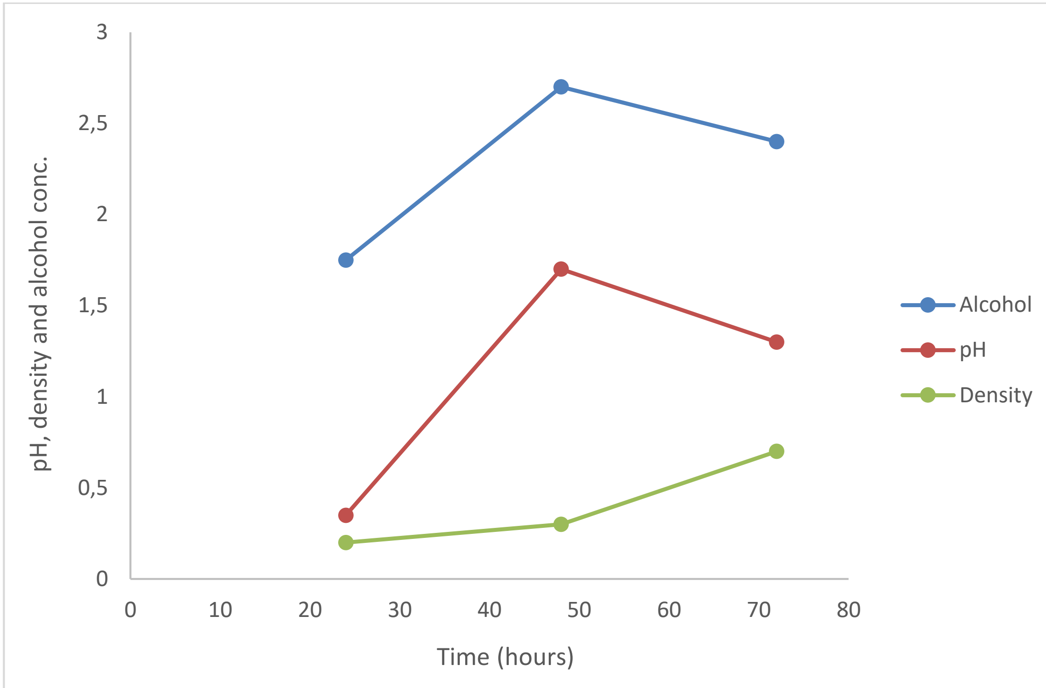

Figure 3. Levels of alcohol, pH and density in wine made from 100% cucumber fermented with Baker's yeast.

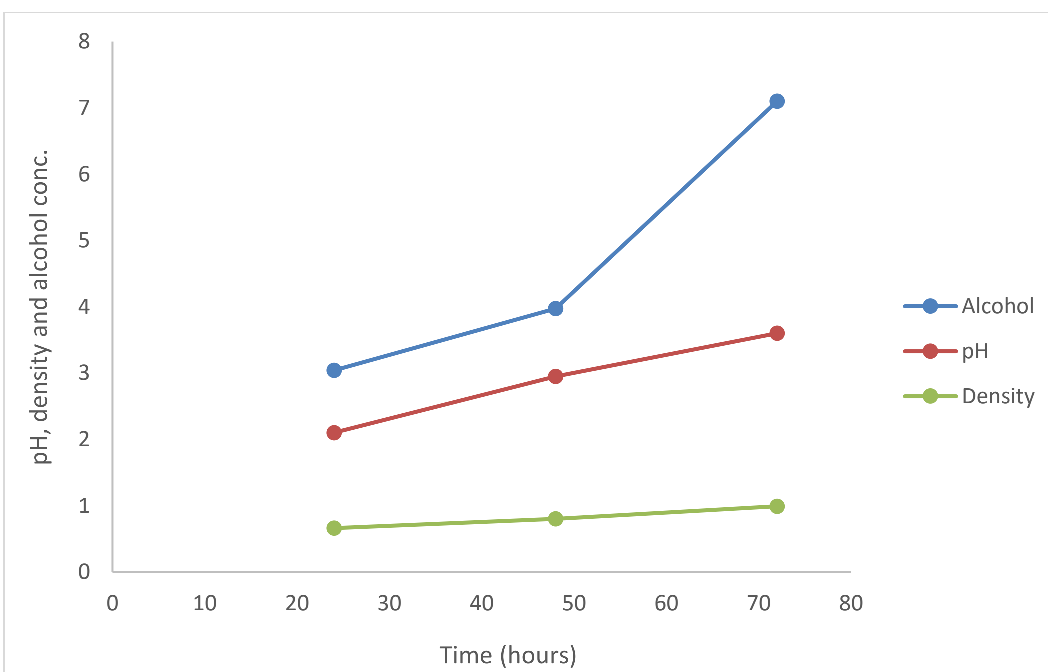

Figure 4. Levels of alcohol, pH and density in wine made from 100% cucumber fermented with palm wine yeast.

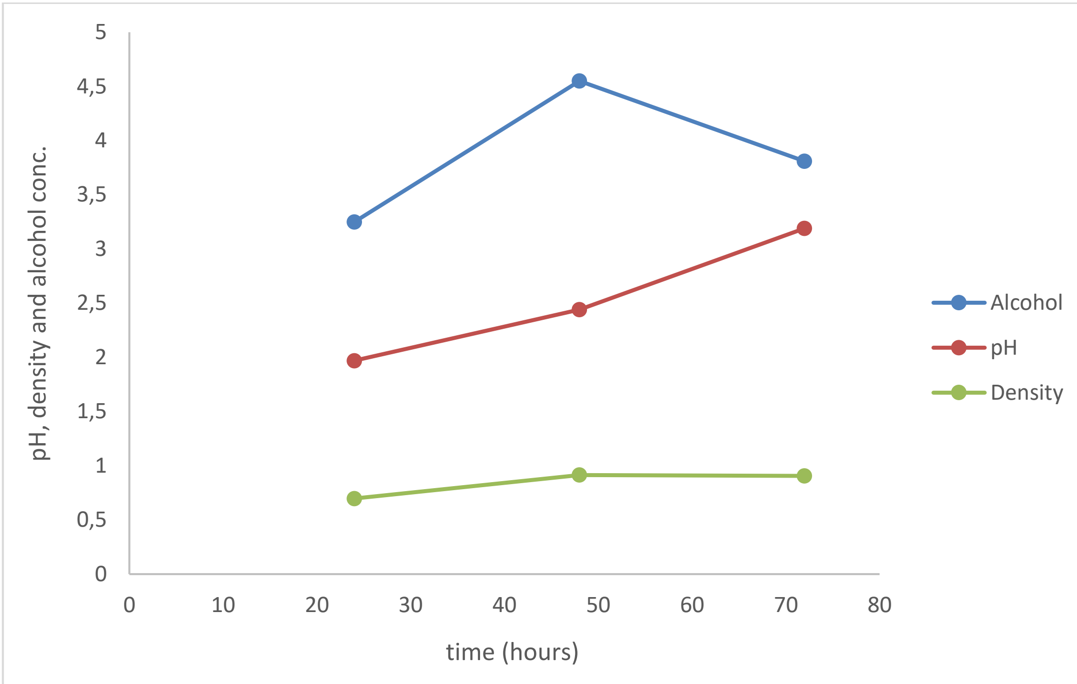

Figure 5. Levels of alcohol, pH and density in wine made from 50% cucumber + 50% fluted pumpkin leaves fermented with Baker's yeast.

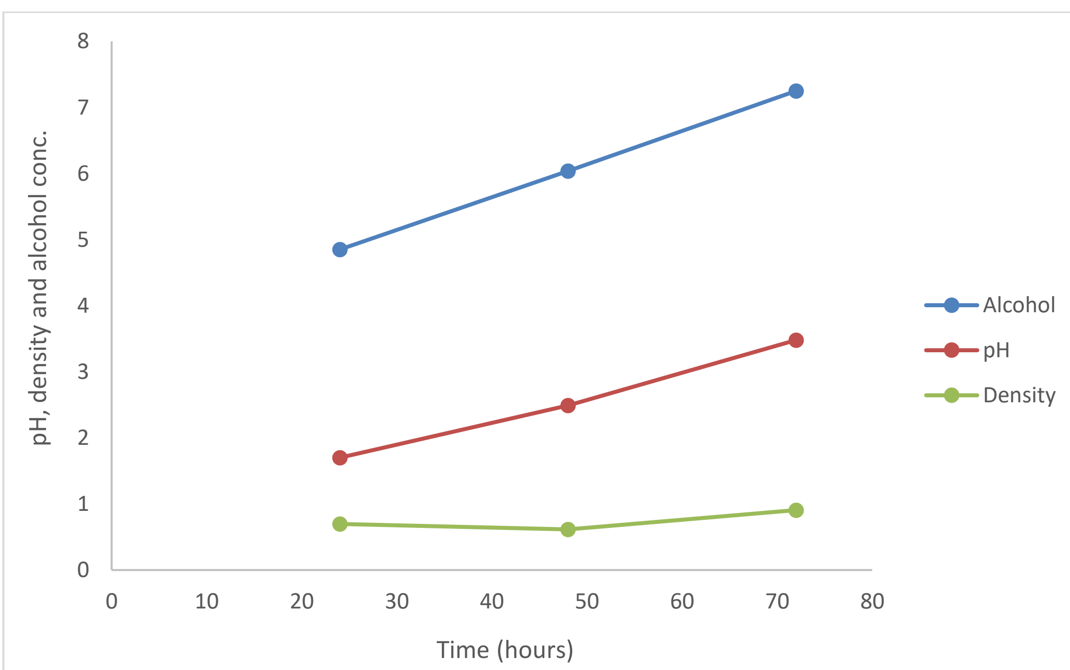

Figure 6. Levels of alcohol, pH and density in wine made from 50% cucumber + 50% fluted pumpkin leaves fermented with Palm wine yeast.

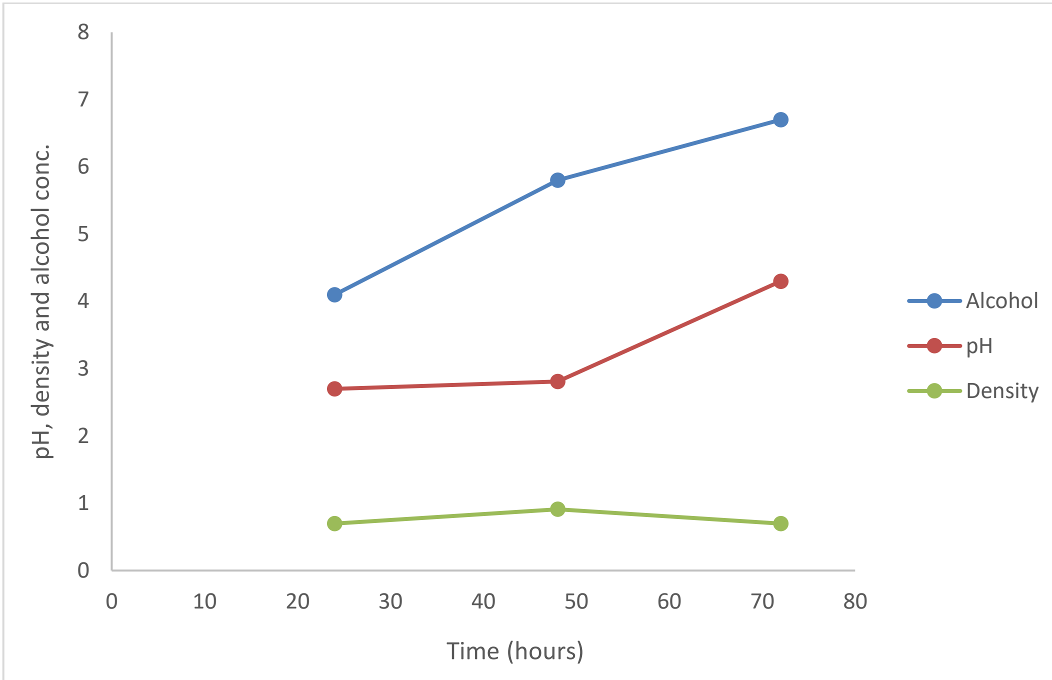

Figure 7. Levels of alcohol, pH and density in wine made from 30% cucumber + 70% fluted pumpkin leaves fermented with Baker's yeast.

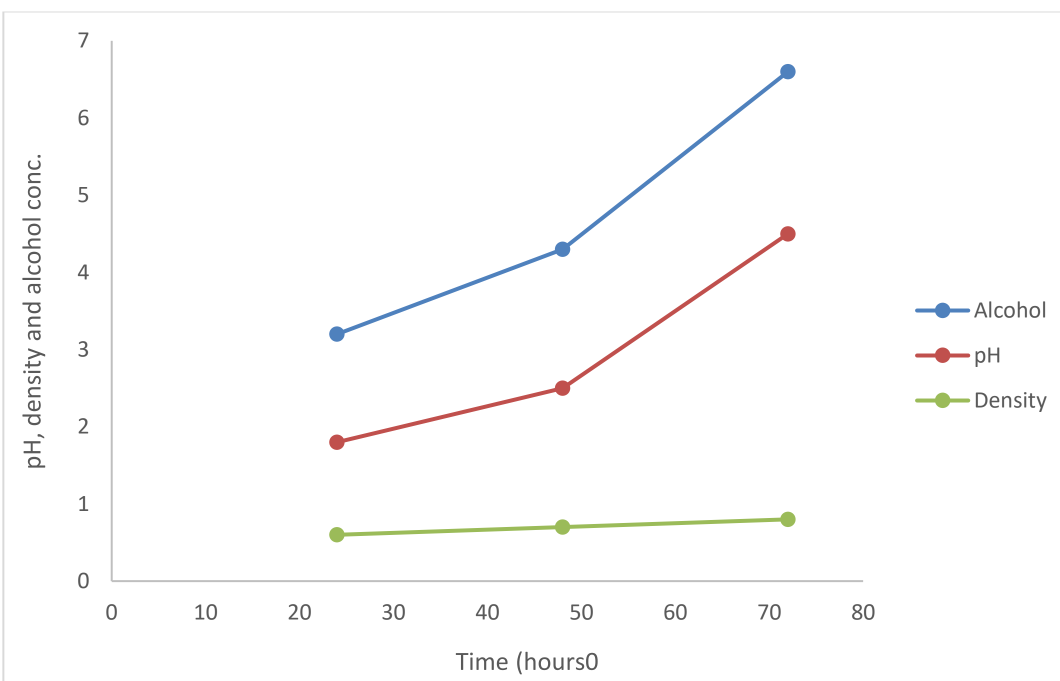

Figure 8. Levels of alcohol, pH and density in wine made from 30% cucumber + 70% fluted pumpkin leaves fermented with palm wine yeast.

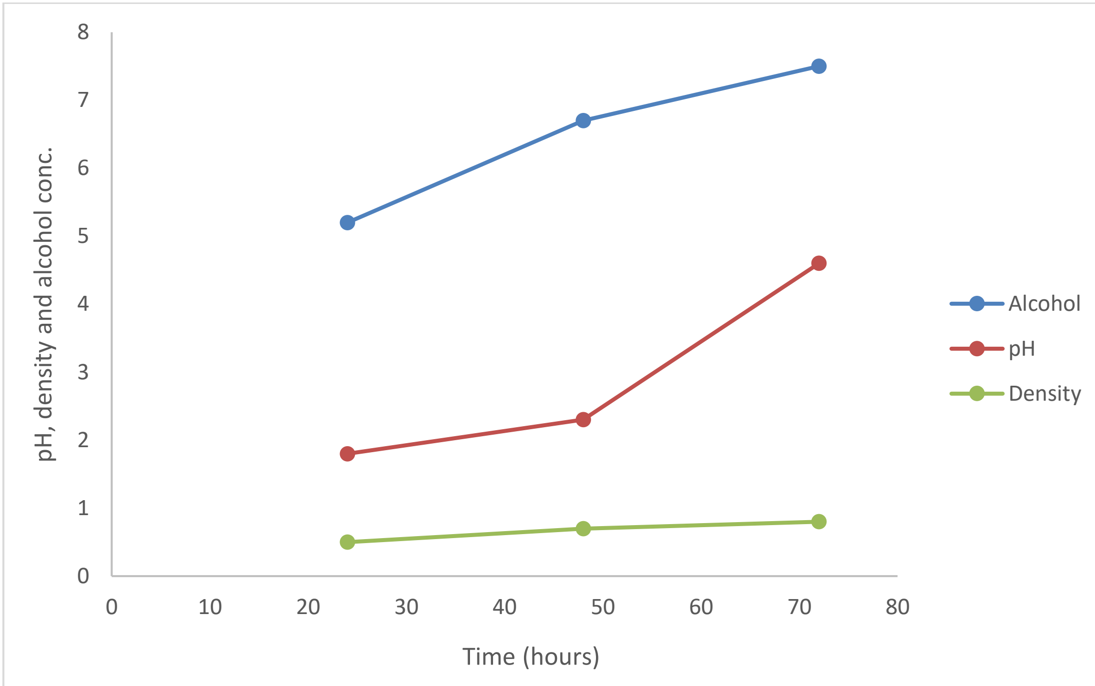

Figure 9. Levels of alcohol, pH and density in wine made from 70% cucumber + 30% fluted pumpkin leaves fermented with Baker's yeast.

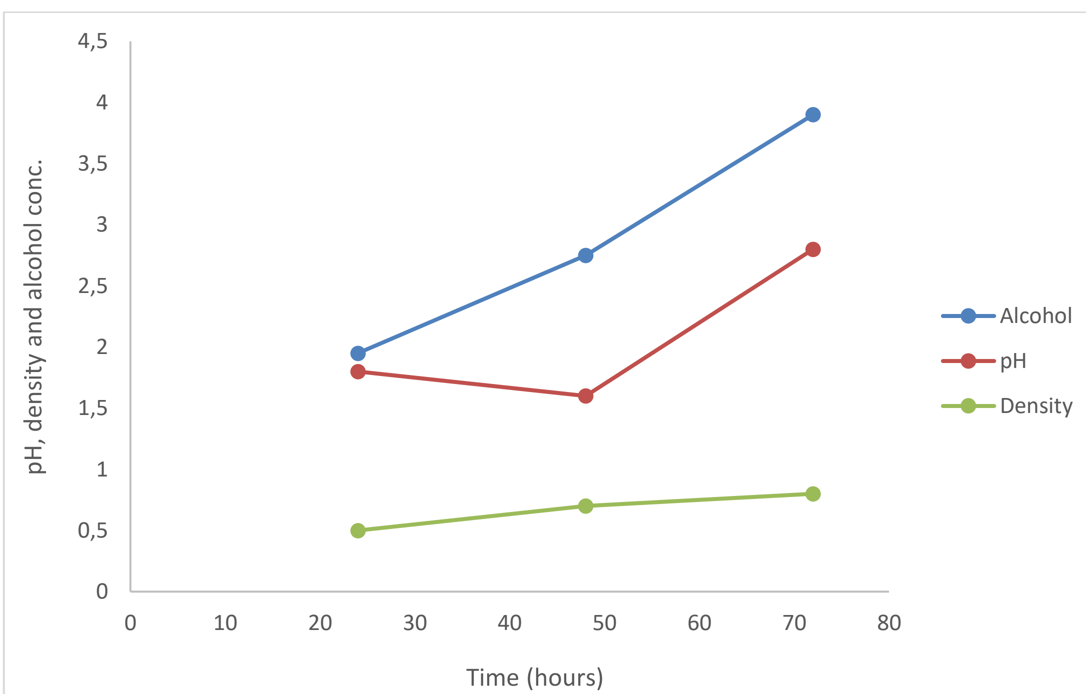

Figure 10. Levels of alcohol, pH and density in wine made from 70% cucumber + 30% fluted pumpkin leaves fermented with palm wine yeast.

From **Table 1**, the phytochemicals obtained in both samples were alkaloids, glycosides, saponins, tannins, flavonoids, reducing compounds, polyphenols, anthraquinones, and hydromethyl anthraquinones in varying amounts. However, phlobatannins were absent while polyphenol and reducing compounds were the most abundant phytochemicals. The quantitative estimation of both samples, as presented in **Table 2**, confirmed the high abundance of polyphenol and reducing compounds observed in the crude phytochemical screening. Reducing compounds was the highest in fluted pumpkin leaves with 20.70% compared to 18.34 % in cucumber. It was however, the reverse for polyphenol, which was the highest in fluted pumpkin leaves.

As expected, the moisture content and carbohydrate were the most abundant parameters in both samples with the values of 86.60 and 96.75 and 82.45 and 66.12 (g/100 g), respectively. Protein and fat content were higher in cucumber than in fluted pumpkins. Anti-nutrient analysis (Table 4) revealed that all the analysed anti-nutrients were higher in fluted pumpkin than in cucumber. These were hydrocyanic acid, total oxalate, soluble oxalate, phytate and tannin (% mg) and their respective values were 4.86, 32.42, 18.30, 21.72, and 0.48 (mg/100 g).

Vitamin analysis (Table 5) showed the presence of itamins A, soluble and total vitamin C in both samples. However, total vitamin C and soluble vitamin C levels were the highest (57.63 and 23.44 mg/100 g) in cucumber. Vitamin A levels were higher in fluted pumpkin leaves (278.79 µg /dL) compared to 5.95 µg /dL. The result of mineral analysis shows that both samples had the following minerals: Na, K, Ca, Mg, Fe, Zn, Cu, and P. Apart from Fe, which was higher in the fluted pumpkin leaves, cucumber had the highest abundance of the minerals samples in this study. K, Mg, and P were the 3 most abundant minerals in cucumber (585.10, 456.43 and 183.56, mg/100 g dry matter, respectively).

Table 1. Preliminary phytochemical screening of fluted pumpkin leaves and cucumber

Phytochemicals	Fluted pumpkins		Cucumber	
	Ethanolic extract	Aqueous extract	Ethanolic extract	Aqueous extract
Alkaloids	++	+	+	++
Glycosides	+	++	+	+
Saponins	++	+	+	+
Tannins	+	+	+	+
Flavonoids	+	+	+	+
Reducing compounds	++	++	++	+
Polyphenols	+++	++	+++	++
Phlobatannins	-	-	+	+
Anthraquinones	+	+	-	-
Hydromethyl anthraquinones	+	+	+	-

Key: - = Absent; + = present, ++ = present in excess; +++ = present in much excess.

Table 2. Quantitative estimation of phytochemicals in fluted pumpkin and cucumber

Phytochemicals	Fluted pumpkin leaves	Cucumber
Alkaloids	2.20±0.10[a]	2.30±0.10 [a]
Glycosides	2.54±0.01	1.52±0.01
Saponins	1.35±0.01	1.70±0.02
Tannins	0.22±0.01	1.58±0.02
Flavonoids	1.70±0.10	7.18±0.02
Reducing compounds	20.70±0.10	18.34±0.02
Polyphenol	8.43±0.20	7.10±0.10

[a]Represents non-significant student t-test ($p > 0.05$).

Table 3. Proximate composition fluted pumpkin leaves and cucumber (g/100 g dry matter)

Proximate component	Fluted pumpkin leaves	Cucumber
Moisture	86.60±0.10	96.75±0.01
Ash	5.72±0.02	5.40±0.02
Protein	4.30±0.10	13.50±0.02
Fat	0.97±0.02	10.30±0.10
Fibre	6.30±0.10	4.52±0.01
Carbohydrate	82.45±0.02	66.12±0.01

Table 4. Estimation of anti-nutrients in fluted pumpkin leaves and cucumber

Anti-nutrient	Fluted pumpkin leaves	Cucumber
HCN (mg/100 g)	4.86±0.10	1.10±0.10
Total oxalate (mg/100 g)	32.42±0.02	3.50±0.10

Soluble oxalate (mg/100 g)	18.30±0.10	0.56±0.02
Phytate (mg/100 g)	21.72±0.02	2.05±0.01
Tannins (mg %)	0.48±0.02	0.20±0.10

Table 5. Estimation of vitamins in fluted pumpkin leaves and cucumber

Vitamins	Fluted pumpkin leaves	Cucumber
A (mg/dL)	278.79±0.01	5.98±0.02
Total C	45.14±0.02	57.63±0.01
Soluble C	21.28±0.02	23.44±0.02

Note: mg/dL is equivalent to mg / 100 mL and 1 mg /dL = 0.001 mg/ 100 mL

Table 6. Estimation of vitamins in fluted pumpkin leaves and cucumber (mg/100 g dry matter)

Element	Fluted pumpkin leaves	Cucumber
Na	1.84	7.0
K	2.45	585.10
Ca	8.40	17.50
Mg	7.14	183.56
Fe	6.03	1.55
Zn	4.37	7.50
Cu	0.95	3.90
P	1.71	456.43

The results for the sensory evaluation tests are presented in Tables 7 to 11. From Table 7, it can be observed that 100% cucumber wine fermented with palm wine yeast scored higher in terms of taste, aroma, and appearance even though the panelists failed to agree strongly to both wines. Table 8 shows the sensory evaluation of the composite wines made from 50% fluted pumpkin and 50% cucumber fermented with Baker's and palm wine yeast strains.

Acceptability, taste, aroma, and appearance received strongly agreed scores of 100, 60, 50 and 60%, respectively. However, that of Baker's yeast received strongly agreed scores of 80, 40, 20 and 70%, respectively. The best sensory evaluation scores were obtained for composite wine (70% fluted pumpkin and 30% cucumber) fermented by palm wine yeast. This composite wine received agree strongly scores for acceptability, taste, aroma, and appearance of 100, 70, 80, and 100%, respectively. The worst wine was the composite wine obtained using 70% cucumber and 30% pumpkin with Baker's yeast followed by that obtained by palm wine yeast (Table 11).

Table 7. Sensory evaluation of 100% cucumber wine fermented with Baker's and palm yeast strains

Sensory parameters	Baker's yeast					Palm wine yeast				
	AS	AG	N	D	DS	AS	AG	N	D	DS
Acceptability	0	3	6	1	0	0	5	3	2	0
Taste	3	0	5	1	1	5	3	2	0	0
Aroma	0	0	2	3	5	8	1	1	0	0
Appearance	5	3	2	0	0	6	1	2	1	0

Keys: AS = Agree strongly; AG = Agree; N = Neutral, D = Disagree, DS = Disagree strongly.

Table 8. Sensory evaluation of 100% fluted pumpkin leaves wine fermented with Baker's and palm yeast strains

Sensory parameters	Baker's yeast					Palm wine yeast				
	AS	AG	N	D	DS	AS	AG	N	D	DS
Acceptability	4	1	2	1	2	5	3	1	1	0
Taste	8	1	1	0	0	6	2	2	0	0
Aroma	4	2	2	0	2	10	0	0	0	0
Appearance	7	2	1	0	0	10	0	0	0	0

Keys: AS = Agree strongly; AG = Agree; N = Neutral, D = Disagree, DS = Disagree strongly.

Table 9. Sensory evaluation of 50% fluted pumpkin leaves and 50% cucumber wine fermented with Baker's and palm yeast strains

Sensory parameters	Baker's yeast					Palm wine yeast				
	AS	AG	N	D	DS	AS	AG	N	D	DS
Acceptability	8	2	0	0	0	10	0	0	0	0
Taste	4	4	2	0	0	6	3	1	0	0
Aroma	2	2	0	1	5	5	3	1	1	0
Appearance	7	3	0	1	0	6	2	2	0	0

Keys: AS = Agree strongly; AG = Agree; N = Neutral, D = Disagree, DS = Disagree strongly.

Table 10. Sensory evaluation of 70% fluted pumpkin leaves and 30% cucumber wine fermented with Baker's and palm yeast strains

Sensory Parameters	Baker's yeast					Palm wine yeast				
	AS	AG	N	D	DS	AS	AG	N	D	DS
Acceptability	8	2	0	0	0	10	0	0	0	0
Taste	4	4	2	0	0	6	3	1	0	0
Aroma	2	2	0	1	5	5	3	1	1	0
Appearance	7	3	0	1	0	6	2	2	0	0

Keys: AS = Agree strongly; AG = Agree; N = Neutral, D = Disagree, DS = Disagree strongly.

Table 11. Sensory evaluation of 30% fluted pumpkin leaves and 70% cucumber wines fermented with Baker's and palm yeast strains

Sensory parameters	Baker's yeast					Palm wine yeast				
	AS	AG	N	D	DS	AS	AG	N	D	DS
Acceptability	0	5	3	2	0	2	5	2	0	0
Taste	0	0	3	2	5	0	0	0	4	6
Aroma	0	0	0	0	10	0	0	1	1	8
Appearance	4	4	1	1	0	2	4	1	1	0

Keys: AS = Agree strongly; AG = Agree; N = Neutral, D = Disagree, DS = Disagree strongly.

4. DISCUSSION

For ages, people from tropical countries have had wines made from grapes [10]. However, in the tropics, this trend is changing due to a number of reasons [1]. Both vegetables used in this study are consumed widely in Nigeria and beyond. As edible vegetables, they are usually consumed fresh and contain amount of high moisture which makes it highly perishable. The results of the nutrient analysis revealed that both vegetables were rich in proximate nutrients. In an earlier study, fluted pumpkin was shown to have moisture content of 8.54±0.07%, ash content of 3.48±0.02%, crude fiber of 15.85±0.03%, crude protein of 29.15±0.04%, crude lipid of 27.83±0.07%, and carbohydrates of 15.15±0.01% [14]. These confirms our finding of these nutrients in our sampled fluted pumpkin leaves. Compared to other edible vegetables (*Lasianthera africana* and *Dennettia tripetala*), our findings were within the range [6].

In another study that compared the nutritional value of harvested cucumber from three states with Nigeria (Rivers, Imo, and Plateau), it was discovered that nutrients (proximate composition and minerals) differed significantly with location. Furthermore, when compared with our findings, their proximate nutrients were far lower than our reported findings for cucumber and pumpkin leaves. Similar trend was also observed with potassium, calcium, copper, magnesium, sodium, and zinc which were again lower than our reported values for both vegetables [26]. Although vitamin A content of fluted pumpkin was higher than that of cucumber, vitamin C levels were more similar. Compared to those of mushroom in an earlier study, the vitamin C levels in our samples were higher [19]. Anti-nutrient levels in our study were all below regulatory limits and also within the range of other edible vegetables [6, 27].

The medicinal and health benefits of plants are attributed to the presence of phytochemicals in these plants [1, 4-9, 12]. The phytochemicals present in our samples include alkaloids, glycosides, saponins, tannins, flavonoids, reducing compounds, polyphenols, anthraquinones and hydromethyl anthraquinones in varying amounts.

More and more tropical fruits, other than grapes, are gaining popularity and acceptability in wine production [1]. A number of factors affect wine production and these include, amongst others, temperature, pH, and fermentative capacity of employed yeast strains [1, 24, 25]. During fermentation and at the end, wines are known to have low pH values [24]. In an earlier study, wines made from *Mangifera indica* (Mango) were acidic (3.4 – 3.50). At pH below 3.5, most microbes are eliminated but not those with fermentation abilities [3]. As a general rule, all the wines (single and composite) increased gradually from ≥ 1.5 to up to > 3.0 in almost all the wine samples. The density of the wines after 24, 48, and 72 hours showed a gradual increase in density, but in all cases, the density was lower than 1.00 g/cm^3. This finding is in line with less than 1.00 g/cm^3 reported previously [24-25]. Wine made from fruits have been shown to have an alcoholic content of 5 to 13%.

Most of alcohol contents of our wines were within this range, however, some were lower than the lower range. In another study, 0.00 – 7.50% alcohol was reported for wines made from a tropical fruit and it was more agreeable with our findings [24-25]. The nutritive value of wine is usually enhanced by released amino acids and other nutrients during the fermentation process [3]. Sensory evaluation of the various wines made from our tropical vegetables showed that the single and composite wines (50-50% and 30-70% and 100% pumpkin fermented wine) were widely agreeable in terms of taste, aroma, appearance, and acceptability. However, composite wine made from 70% pumpkin and 30% cucumber was the best based on the evaluation of the panelist.

5. CONCLUSIONS

Tropical fruits and vegetables have well known as nutritive and health benefits. The findings in this study have shown that agreeable wines (single and composite) can be made using tropical vegetables (cucumber and fluted pumpkin leaves) fermented with strains of palm wine and Baker's yeasts. However, the best wine was the composite wine made from 70% fluted pumpkin and 30% cucumber with palm wine yeast strains. Given the perishable nature of these vegetables, large-scale production of composite wines from cucumber and fluted pumpkin leaves should be used deployed where possible to help reduce post-harvest losses of these vegetables.

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