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Production, Chemical Properties and Sensory evaluation of Wine from blends of Gaper(*Vitis vinifera*) fruit, Pawpaw(*Carica papaya*) fruit and Tiger nut (*Cyperus esculentus*)tuber

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Abstract : Production of wine from sources other than grapes encourages wine makers as much as availability of different styles of wine. Pawpaw (*Carica papaya*) is a tropical fruit commonly known for its nutritional and phytochemical values.Tiger nut (*Cyperus esculentus*) is a high-yielding, readily-available tuber which has lots of dietary and medicinal values. In this study, wine was produced from different blends of juice from grape (*Vitis vinifera*) fruit, pawpaw fruit and tiger nut tubers; and the quality of the wine evaluated. Healthy fruits and tiger nut obtained from a market in Ebonyi State, Nigeria were washed with clean water and ground with an electric blender until a homogenous pulp was obtained. Water ($100cm^3$) was added to equal amount of each pulp and the mixture was filtered using a muslin cloth to obtain the juice. A solution of sugar in water (200g in $70cm^3$), 0.90g of *Saccharomyces cerevisiae*, ammonium phosphate (0.60g) and potassium phosphate (0.60g) were added and the mixture was allowed to ferment for 6 days (primary fermentation). The temperature, pH, specific gravity, total titrable acidity, and sugar level of the sample were determined after every 12 h. The wine was racked and allowed to ferment for 14 days (secondary fermentation). It was then left to clarify for three months. The clarified wine was left to mature for 6 months before the final physico-chemical and sensory evaluation were carried out. The results of the analysis revealed that the temperature of all the wine samples was 28.0^oC. Grape and pawpaw wine had pH of 3.70, alcohol content of 17.00%, total acidity of 0.86% residual acidity of 0.32%, volatile acidity of 0.54% and specific gravity of 0.9776. Pawpaw and tiger nut wine had pH of 3.95 alcohol content of 16.06%, total acidity of 0.59%, residual acidity of 0.14%, volatile acidity of 0.255 and specific gravity of 0.9810. Grape, pawpaw and tiger nut wine had pH of 3.78, alcohol content of 17 81% total acidity of 0.72%, residual acidity of 0.30%, volatile acidity of 0.51% and specific gravity of 0.9760. Grape and tiger nut wine had pH of 3.90, alcohol content of 18.65% total acidity of 0.78%, residual acidity of 0.30%, volatile acidity of 0.48% and specific gravity of 0.9745.Although these values were comparable to those reported of good fruit wines, the highest alcohol content was obtained from a blend of grape and tiger nut juice. The sensory evaluation revealed that the attributes of the wines were acceptable to the majority of the respondents.

Key words : Pawpaw, Tiger nut, Grape, Fruit wines, Fermentation, Sensory evaluation.

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Introduction

Wine is commonly identified as alcoholic fruit beverage fermented by yeast. Although there are some brands of non-alcoholic wine [1], a greater number of winesare alcoholic.Natural wines may exhibit a broad range of alcohol content, from below 9% to above 16% [2].In wine making, grapes are usually preferred because of the natural chemical balance of the grape juice which aids their fermentation process without the addition of sugars, acids, enzymes, or other nutrients [3][4].Different varieties of grapes and strains of yeasts produce different styles of wine with variable levels of acceptability.Over the years, grape wine has dominated wine market, except in those areas where cultivation of grapes is limited by climatic conditions. To avoid monopoly and the consequent monotony, winemakers have moved beyond the vineyard to bottle fruit juice and every other thing that can ferment to give tasty products [5].

Fruits such as banana, cucumber, pineapple, mango, pawpaw and watermelon[3] [6]; stems such as sugar cane [1] and tubers such as potato and tiger nut[7] have been usedin wine production. Home-made wine has been produced with various fruits such as pineapple, strawberries, plums, watermelons, quince, apricot, apple, raspberries, bilberries, cherries blackberries [8], mango [9], banana, oranges, cucumber, watermelon, guava [3], mulberry [10], kiwifruits [11], peaches, gooseberries, boysenberries, grapefruits, pears and persimmons [12].

Making wine from fruits other than grapes needs adjustments especially in the sugar level and acidity of the juice. Most fruits naturally either lack a high amount of fermentable sugars; have relatively low acid value, low yeast nutrients needed to maintain fermentation, or a combination of these three characteristics. To obtain products of high phytochemical yield and sensory satisfaction, blends of fruits have been investigated. Wines made from blends of mango, jackfruit and pineapple [4];banana, pawpaw and watermelon [3]; apple and medicinal herbs [13] and pawpaw and pineapple [14] have been reported. Wines fermented from tuber extracts have also been reported[7][15]. Different blends of fruits and tubers do not only lower the cost of wine production but increases thephytochemicals contained in the wine and at the same time reduce the fruit wastages.

Grape *(Vitis vinifera L.)* is native to the Mediterranean region, central Europe, southwestern Asia, ranging from Morocco, Portugal, Germany to Iran [16].The fruitscontain water, proteins, lipids, carbohydrates (with roughly equal amounts of glucose and fructose and only a trace of sucrose), vitamins, minerals, and compounds with important biological properties such as fiber, vitamin C, and phenolic compounds (tannins, phenolic acids, anthocyanins, and resveratrol), depending on the climatic and cultivation conditions [17][18][19][20][21].Theyalso contain low concentration (around 0.5 mg/100g)of tartaric acid and malic acid[22]. Although grape is almost synonymous to wine, its production, like other fruits, is limited by climatic conditions; and as such, it is scarcely cultivated in the tropical region [16]. Winemaking from blends of grape,other fruits and tubers will not only encourage winemakers and availability of different styles of wine but will also increase the nutrients and phytochemicals in such wines.

Pawpaw (*Carica papaya*) is a tropical fruit commonly known for its food and nutritional values throughout the world.It is cultivated in countries like Mexico, Brazil, India, South Africa, Nigeria, Haiti and South East Asia [23]. Aside the nutritional value of the fruit, natural compounds (annonaceous acetogenins) produced in the leaf, bark and twig tissues of pawpaw plant possess both highly anti-tumour and pesticidal properties[3][23]. Pawpaw contains the protein digesting enzyme, papain, which has been reported to have remedy for dyspepsia and has also been utilized for the clarification of beer[24].The latex from both the ripe and unripe papaya fruits are used as meat softener, antibiotic for intestinal infections, antihelmentic, antimalarial, antifungal, antiamoebic, hepatoprotective, male and female antifertility, immunomodulatory and against histminergic[24].

It has been reported that sugarsare the major components of ripe pawpaw; comprising 48.3% saccharose, 29.8% glucose and 21.9% fructose [25]. Also contained in appreciable amounts are proteins, fat, vitamins and minerals [23]. These nutritional and phytochemical values underscore the reasons for making wine from pawpaw fruits[3].Therefore, blending pawpaw fruits and other sugar-rich fruits and tubers will raise the quality of wine produced and optimize the utility of pawpaw fruits in winemaking.

Tiger nut*(Cyperus esculentus*) is an annual or perennial plant, native to the tropics, subtropics and warm temperature regions [26]. One plant can produce several hundred to several thousand tubers during a single growing season. It is found wild, as weed, or cultivated as a crop [27] in Africa, South America, Europe and Asia (Spain). Tiger nut is cultivated in African countries such as Niger, Nigeria, Ghana, Togo and some others including the Ivory Coast where it is made into a sweet meat, used uncooked as a side dish or exported to Spain [26]. In Nigeria, it is a common crop in Kano, Zamfara, Gombe, Katsina States where it is called 'Aya' [27]. It is usually eaten either fresh, as snacks or dried for preservation, and rehydrated before eating.

Similar to pawpaw fruit, tiger nut has been reported to be a "health" food, since its consumption can help prevent heart diseases and thrombosis [27]; and it is said to activate blood circulation and reduce the risk of colon cancer [28]. Tiger nut is used in the treatment of flatulence, diarrhea, dysentery, debility and indigestion [29]. It is rich in energy food (starch, fat, sugar, and protein), minerals (mainly phosphorus and potassium), and vitamins E and C[30]. Tiger nut tubers contain almost twice the quantity of starch as potato or sweet potato tubers [27].

In Spain, tiger nut is used in making a beverage called horchata [27]. Flour of roasted tiger nut is sometimes added to biscuits and other bakery products as well as in making oil and soap [31]. It is also used for the production of nougat, jam, beer, and as a flavoring agent in ice cream and as nutrition supplement in the preparation of a local beverage called kunnu [32]. It is rich in high quality oil [30][31] which can be used naturally with salads or for deep frying. Tiger nut "milk" has been investigated as a replacement for milk in fermented products, such as yogurt production, and in the diet of people intolerant to lactose [27]. A recent report by the author[7] revealed that wine produced from tiger nut has good attributes. However, winemaking using blends of tiger nut juice and fruit juice such as grape and pawpaw has not been reported, hence the novelty of this work.

Materials and Methods

2.1 Materials

Materials used in this study: grape (Vitisvinifera), Pawpaw fruit, Tiger nut, Sugar, Distilled water, Ammonium phosphate, Potassium phosphate and Saccharomyces cerevisiae (baker's yeast), were sourced from Abakpa market in Abakaliki. White transparent bucket, Electric blender and Refractometer were sourced from Food Science Technology Department of Ebonyi State University, Abakaliki.

2.1 Wine Preparation

Healthy grape fruit, ripe pawpaw fruit and tiger nut tubers were selected and washed. The pawpaw fruit was peeled with clean knife to obtain the fruit flesh. Water (200cm^3) was added to each of the fruits and ground with electric blender.A muslin cloth was used to extract the juice by filtration. Four blends of juice were obtained by mixing grape and pawpaw (3150cm^3:3150cm^3), pawpaw and tiger nut (3150cm^3:3150cm^3), grape, pawpaw and tiger nut (2100cm^3:2100cm^3:2100cm^3) and grape and tiger nut (3150cm^3:3150cm^3); and were labeled sample A, B, C and D respectively.Each of A, B, C and D was poured into a clean transparent plastic bucket and allowed to stand for 3 h. A solution of sugar in water (200g in 70cm^3), 0.90g of Saccharomyces cerevisiae (baker's yeast), ammonium phosphate (0.60g) and potassium phosphate (0.60g) were added respectively [3][33].

The primary fermentation of the juice (must) lasted for 6 days in an air-tight transparent plastic container. The mixture was stirred vigorously, every 12 h, with subsequent reading of the temperature, pH, specific gravity, total titrable acidity, and sugar level (brix). After 6 days, the wine was racked into the secondary fermenter. The secondary fermentation was done in an air tight container from which a tube was passed into a transparent plastic bucket containing clean water. As fermentation progressed, air bubbles passed into the water through the tube and were used to monitor the course of fermentation. This was allowed for 14 days; when fermentation was assumed to have been completedwhich was evident from the absence of bubbles in the water container.

When fermentation stopped, the wine was promptly clarified, ensuring minimum exposure to oxygen. After secondary fermentation, the wine wasalso clarified. The clarification was done as described in a recent research report [3] using bentonite (a clarifying agent). Bentonite (125g) was dissolved in 500cm^3 of boiling water and stirred properly to a gel form. This was allowed to stand for 24 h. Then 40 g of the gel-like bentonite was transferred into the wine followed by stirring to dissolve properly. A small quantity of the mixture was collected in a clean bottle which was covered tightly and was used to monitor the process of clarification.After three months of clarification,the wine was filtered using muslin cloth, sieve and siphon tubes sterilized by 70 % alcohol. The wine was siphoned into the sieve containing four layers of muslin cloth. The residues were removed and the filtrates were allowed to mature for a period of 6 months before physico-chemical analysis was carried out.

Table1: Recipefor Wine Production from blends of fruit juice

Ingredient	Fruit juice	Sugar solution	Saccharomyces cerevisiae (baker's yeast)	$(NH_4)PO4$	K_3PO_4
Amount	$5300cm^3$	$70cm^3$	0.9g	0.6g	0.6g

2.3 Physico-chemical analysis

2.3.1 Total titrable acidity

The total titrable acidity of the wine was determined as described by Ogu [34]. Using phenolphthalein as indicator, $10cm^3$ of the wine sample was measured into a conical flask and titrated against 0.1N solution of sodium hydroxide. The total titrable acidity was calculated as follows:

$$\text{Total titrable acidity (TTA)} = \frac{V^1 \times N \times 75 \times 100}{1000 \times V}$$

Where

V^1 = Volume (cm^3) ofNaOH
V = Volume (cm^3) of sample used
N = Normality of NaOH

2.3.2 Alcohol content

The alcohol content of the wine was determined using psycnometer as described by Ogu [34], and calculated as follows:

Percentage alcohol = (OG – FG) x 0.575%

Where,

OG = Original Gravity of the sample
FG = Final Gravity of the sample

2.2.3 Total sugar content

The total sugar content (brix) was determined using a refractometer. This was done by placing about 3 drops of the must or wine sample on top of the prism assembly and then closed with the daylight plate. The sample was then allowed to stand for approximately 30 seconds for it to adjust to the temperature of the refractometer. Then the result was taken by reading the calibrations of the refractometer through the eyepiece.

2.3.4 Specific gravity, pH and Temperature

The specific gravities of the wine were determined using the hydrometer and the results were determined from the reading on the stem [3]. The pH and temperature were also determined using a calibrated digital (HANNA) pH meter and an analytical thermometer respectively.

2.4 Sensory evaluation

The wine was evaluated by panel tastings. Thirty judges,from Department of Food Science and Technology, Ebonyi State University, Abakaliki participated in the experiment. Their selection was based on interest as well as their experience in wine sensory analysis. The panelists were first trained to familiarise them with the triangle test or a duo-trio test[35] for wine tactile, taste and odour. Aqueous solutions of Sucrose (10 g/L), Tartaric acid (0.5 g/L), Sodium chloride (2 g/L), Quinine sulphate (6 mg/L),Monosodium L-glutamate (0,6 g/L) and tannic acid (1.0 g/L) were used to set five basic tastes for sweet, sour, salty, umami, bitter and astringency respectively[35]. Samples were assessed one after the other in comparison to a sample of potable water. Variations in taste intensity depend on the concentration of the stimulus in the test sample, and were detected based on already established suprathreshold level [7][35]. All the judges identified taste and odour of the wine sample and rated the intensities of the stimulus using a 0-5 point hedonic scale.

Results

The changes observed in the physico-chemical properties of the wine during primary fermentation are presented in Fig.1 Fig 2 and Fig 3. Properties of the wine after secondary fermentation and the finished product are presented in Table 3 and Table 4 respectively. The hedonistic grading of the finished product is presented in Fig.4.

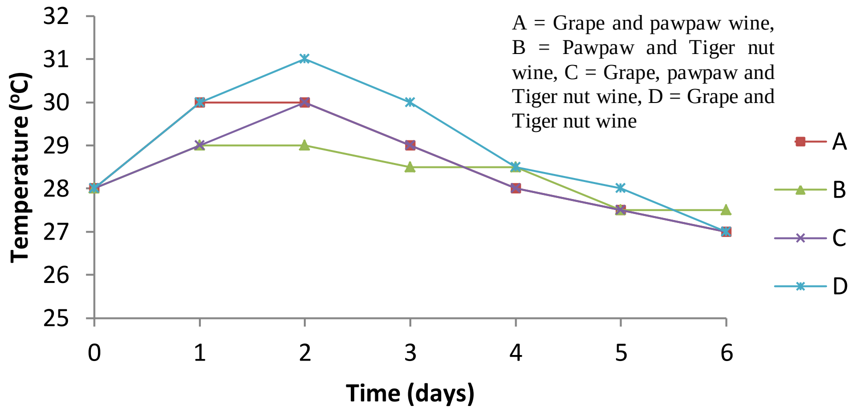

Fig. 1 Temperature variations of the wines during primary fermentation.

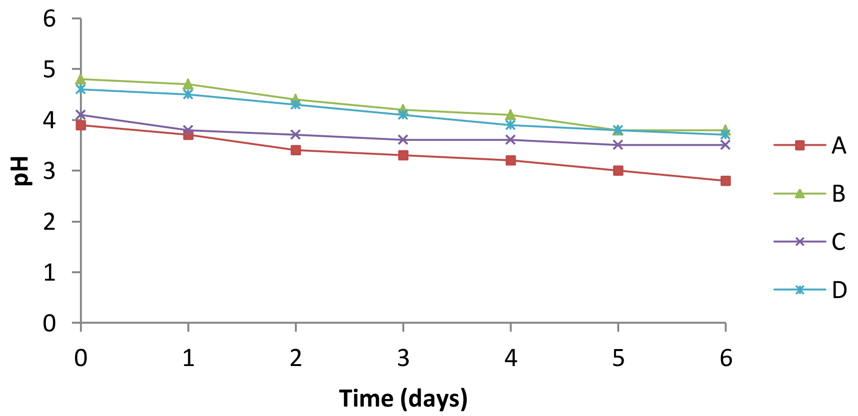

Fig. 2: pH variations of the wines during primary fermentation.

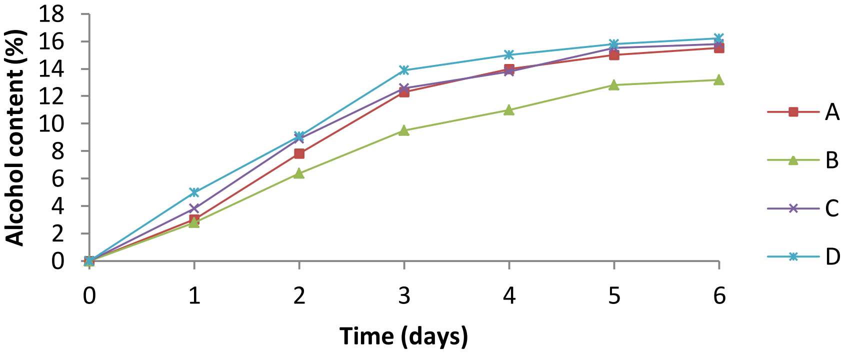

Fig. 3:Alcohol content variations of the wines during primary fermentation.

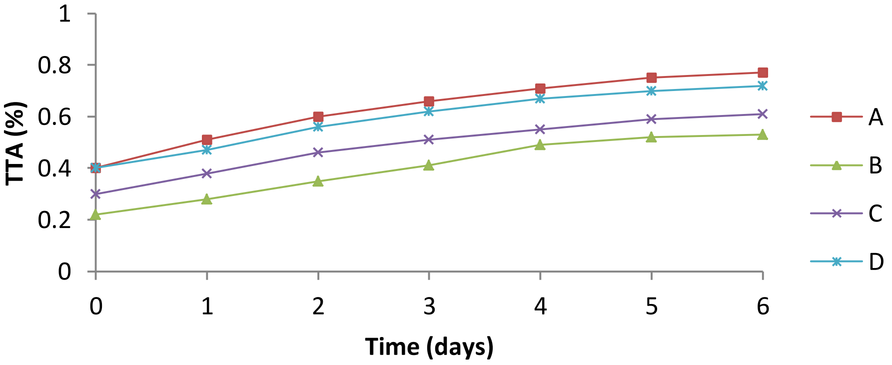

Fig. 4: Total titrable acidity variations of the wines during primary fermentation.

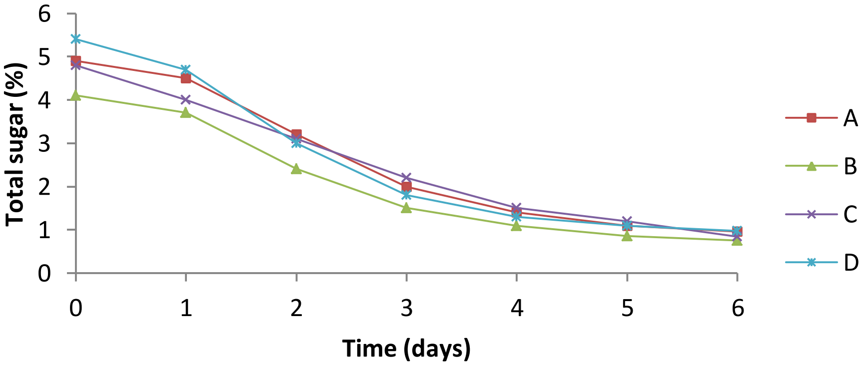

Fig. 5: Variations total sugar of the wines during primary fermentation.

Table 2: Temperature, pH, specific gravity, alcohol content and total acidity of the wines after secondary fermentation

Wine sample	Temp (^oC)	pH	Specific gravity	Alcohol content(%)	Total acidity (%)	Total sugar
A	28.00	3.80	0.9800	16.45	0.82	0.93
B	27.50	3.70	0.9890	15.22	0.55	0.74
C	27.50	3.30	0.9790	17.15	0.62	0.81
D	28.00	3.60	0.9780	17.95	0.78	0.92

Table 3: Chemical parameters of the final wines

Chemical parameters		**Wines**		
	A	**B**	**C**	**D**
Temperature (^{o}C)	28.00	28.00	28.00	28.00
pH	3.70	3.95	3.78	3.90
Alcohol content (%)	17.00	16.06	17.81	18.65
Total acidity (%)	0.86	0.59	0.72	0.78
Residual acidity (%)	0.32	0.14	0.30	0.30
Volatile acidity (%)	0.54	0.25	0.51	0.48
Specific gravity (g/cm^3)	0.9776	0.9810	0.9760	0.9745
Total sugar (%)	0.83	0.74	0.81	0.93

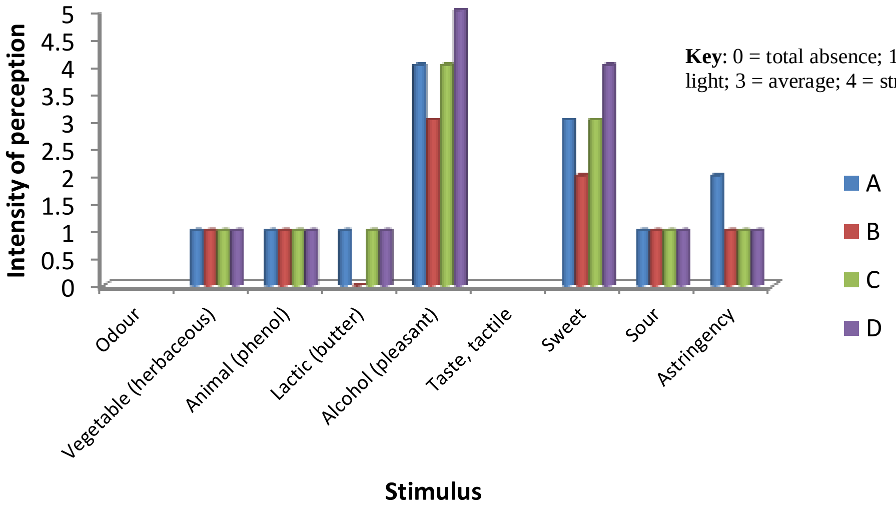

Fig. 6: Olfactory, tactile and taste characteristics of tiger nut wine

Table 4: Summary of sensory evaluation

Grade	**Excellent**	**Very good**	**Good**	**Fair**	**Neutral**	**Poor**	**Percentage of acceptance**
sample	**Number of respondents**						
A	7	10	8	6	-	-	80%
B	6	9	8	5	2	-	76%
C	8	11	6	5	1	-	80%
D	9	12	5	4	1	-	83.33%

Discussion

The process of converting sugars into wine follows complex biochemical pathways involving yeast strains, carbohydrates, other nutrients and phytochemicals[36]. Temperature and level of acidity also determine the ability of the yeast to convert the sugars into alcohol and esters.Since different fruits have different composition, variations of yeast strains performance in different environments, such as sugar composition, concentration of acetic acid [6][36][37] and temperature equally determine the quality of the end product.The fluctuations in temperature of the wine samples (Fig 1and Table 2), observed during the period of fermentation, could be as a result of biochemical changes occurring during the metabolism of the substrates by the fermenting organism. The temperature of the wines, during the primary fermentation, fluctuated through 28, 30 to 27 °C for both grape and pawpaw wine and grape, pawpaw and tiger nut wine; through 28,29 to 27.5^{o}C for pawpaw and tiger nut wine and through 28, 31 to 27 ^{o}C for grape and tiger nut wine (Fig 1).After secondary fermentation, the temperature increased from 27^{o}C to 28^{o}C for grape and pawpaw wine and grape and tiger nut wine; increased from 27 to 27.5 ^{o}C for grape, pawpaw and tiger nut wine but remained at 27.5 ^{o}C for pawpaw and tiger nut wine.The differences influctuation pattern was a function of the alcohol content and the acidity of the wine which influenced the activity of the yeast as well as the heat generated in the process [38][39].

In the case of pH, there was a general decrease, though at varied levels, in values for all the wine samples during primary fermentation(Fig 2). The pH value decreased from 3.9 to 2.8 for grape and pawpaw wine, 4.8 to 3.8 for pawpaw and tiger nut wine, 4.1 to 3.5 for grape, pawpaw and tiger nut wine, and 4.6 to 3.7 for grape and tiger nut wine. Apart from grape and pawpaw wine, other wine samples in this study recorded slight decrease in pH values after secondary fermentation. This could be ascribed to increase in the production of organic acids as the fermentation progressed[34][40]. Similar observations have been reported for sweet potato wine [14], banana, watermelon and pawpaw wine [3] and tiger nut wine[7]. Low pH, as observed in this study is beneficial in winemaking sinceit provides a competitive advantage to fermenting yeasts, inhibits the growth of spoilage organisms [6][41] and perhaps increases the shelf life of wines.

Conversion of sugar to alcohol is the hub of wine making. It is evident from Fig 3 that all the wine samples recorded steady increase in alcohol content throughout the period of primary fermentation. The marginal difference in alcohol content decreased toward the end of the process. Alcohol content of 15.5%, 13.2%, 15.8% and 16.2% was respectively observed for grape and pawpaw wine, pawpaw and tiger nut wine, grape, pawpaw and tiger nut wine after primary fermentation.However, after secondary fermentation, there was appreciable increase in alcohol content of all the wine samples. Grape and tiger nut wine had the highest concentration (17.95%) which was followed by grape, pawpaw and tiger nut wine (17.15%), grape and pawpaw wine (16.45%) and pawpaw and tiger nut wine (15.22%); each of which is a mark of good quality wine. These values are appreciably higher than 10.45% reported [6] for potato wine and in the same range with 18.5% reported for banana, pawpaw and watermelon wine [3]

It is not surprising since documented evidencehas shown that each of the juice extract has a high concentration of fermentable sugar [16][27][pawpaw]and the yeast (S. cerevisiae) is a known high performance species. High alcohol content has been reported as a factor of good quality wine since alcohols are important precursors for the formation of esters and other carbonyl compounds necessary in wine making [3][37]. This implies that the concentration of ethanol affects the whole characteristic quality and flavour of the finished product.

In consonance with pH values observed above, all the wine samples recorded consistent increase in the total titrable acidity throughout the period of primary fermentation. The increase in total titrable acidity during primary fermentation is, undoubtedly, as a result of increase in the production of organic acids. At the end of primary fermentation, grape and pawpaw wine, pawpaw and tiger nut wine, grape, pawpaw and tiger nut wine and grape and tiger nut wine had total titrable acid value of 0.77%, 0.53%, 0.61% and 0.72% respectively (Fig 4). An earlier investigation [37][5] has reported that the total acidity of final wine should fall within the range of 0.5 and 1.0 %. The result of this study reveals that thevalues for total acidity of the final wine samples (0.59 – 0.86%) were within this range. This value is consistent with the reports of 0.35 - 0.88% for mixed banana, pawpaw and watermelon fruit wine [3] and 0.15g/100cm^{3}for bael wine [41]. However, it is lower than the report 1.34g/100cm^3 for sweet potato wine [14], 0.97% for tiger nut wine [7]. Higher values of volatile acidity than the residual acidity, as observed in the final product (Table 3) is a good phenomenon. Volatile acids can easily be removed from the body system through perspiration [3] and consequently have less harmful effect than the residual acids.

Inadequate sugar content and low level of acidity have been reported as the major problems associated with making non-grape wine[3][14][42]. In order to supplement the sugar content of the mixed juice samples, a sugar solution was added before fermentation. The total sugar content of each of the wine samples decreased in the course of fermentation (Fig 5). Upon completion of fermentation, grape and pawpaw wine, pawpaw and tiger nut wine, grape, pawpaw and tiger nut wine and grape and tiger nut wine recorded total sugar content of 0.93%, 0.74%, 0.81% and 0.92% respectively (Table 3). These valuesare in the same range with 0.54 – 0.94% reported [3] for banana, pawpaw and water melon wine. They are however lower than the reports for tiger nut wine (1.25%)[], sapota fruit wine (3.28g/100cm^3) [43], potato wine (1.35g/100cm^3) [14], andbael wine (2.05g/100 cm^3)[41]. Since the total sugar content of all the wine samples were not more than 9%, they can comfortably be regarded as dry table wines [44][45].

Wines from all the blends of juice investigated were observed to have light pinkcolour. The olfactory characteristics of the wines (Fig. 6) indicate that the highest level of pleasant aroma was emitted by grape and tiger nut wine.This was followed in a decreasing order by grape, pawpaw and tiger nut wine and pawpaw and tiger nut wine. This could be attributed to theirrespective alcohol content which serves as a starter for esters and other carbonyl compounds [3]. These qualities compared favourably with the reports forother tropical fruit wines [3][14][41][43][46] and tubers [7]. In the same vein, sweet taste was strongly observed for all the wines in the decreasing order of grape and tiger nut, grape, pawpaw and tiger nut wine, grape and pawpaw wine and pawpaw and tiger nut wine (Fig. 6).Grape and pawpaw recorded, relatively, the highest level of astringency. It is evident from Table 7 that 80% accepted grape and pawpaw wine, 76% accepted pawpaw and tiger nut wine, 80% accepted grape, pawpaw and tiger nut wine while 83.33% accepted grape and tiger nut wine. In summary, sensory evaluation rated the wines acceptability in a decreasing order as grape and tiger nut wine > grape and pawpaw wine > pawpaw and tiger nut wine>grape, pawpaw and tiger nutwine.

Conclusion

Considering the determined parameters for wine produced from blends of juice, it may be inferred that mixed grape and tiger nut has the best quality. However,in the absence of grape, mixed pawpaw and tiger nut juice can be used to produce wine that has acceptable quality. The physcochemical and sensory attributes of all the wines were acceptable to the consumers and comparable to already published studies. Apart from high nutritional phytochemical values obtainable in mixed juice, there is the advantage of availability and sustainability. By understanding a few basic wine making principals, blends of readily available fruits and tuberscan easily be turned into value-added wine that can stand the test of time. Wine making using pawpaw, tiger nut and other fast perishable tropical fruits can open new doors to producers of wine who have limited access to grape. With good choice of yeast species and improved technology, the quality of such wines can compare favourably with grape wine.

References

1. Balogu T. V., Abdulkadir A., Ikegwu M. T., Akpadolu B. and Akpadolu K. (2016). Production and Sensory Evaluation of Non-Alcoholic Wine from Sugarcane and Tiger Nut Blend Using Saccharomyces cerevisiae. International Journal of BioSciences, Agriculture and Technology 7(2):7-14.
2. Jancis, R. (2006). The oxford companion to wine (3rd ed.)oxford university press.
3. Ogodo, A. C., Ugbogu, O. C., Ugbogu, A. E. and Ezeonu, C. S. (2015). Production of mixed fruit (pawpaw, banana and watermelon) wine using Saccharomyces cerevisiae isolated from palm wine. SpringerPlus, 4:683
4. Baidya, D., Chakraborty, I. and Saha, J. (2016) Table wine from tropical fruits utilizing natural yeast issolates. J Food SciTechnol, 53: 1663.
5. Jarvis B. Cider, perry, fruit wines and other alcoholic fruit beverages. <u>Fruit Processing</u> –ebook, 97-134.
6. Chilaka CA, Uchechukwu N, Obidiegwu JE, Akpor OB (2010) Evaluation of the efficiency of yeast isolates from palm wine in diverse fruit wine production. Afr J Food Sci 4(12):764–774
7. Ohoke F. O. and Igwebike-Ossi C. D. (2017)Physico-Chemical Properties and Sensory Evaluation of Wine Produced from Tiger Nut (Cyperusesculentus). International Journal of ChemTech Research, 10 (12):155-164.
8. Yildirim, H. K. (2006). Evaluation of colour parameters and antioxidant activities of fruit wines International Journal of Food Sciences and Nutrition, 57(1-2): 47-63.
9. Reddy, L.V.A. and Reddy, O.V.S.(2005).Production and Characterization of Wine from Mango Fruit (Mangiferaindica L) World J Microbiol Biotechnol, 21: 1345.
10. Butkhup, L., Jeenphakdee, M., Jorjong, S.,Sujitar Jorjong, Samappito S., Samappito W., and Chowtivannakul S.(2011) Food SciBiotechnol 20: 1021. doi:10.1007/s10068-011-0140-4. HS-SPME-GC-MS analysis of volatile aromatic compounds in alcohol related beverages made with mulberry fruits
11. Towantakavanit K., Park Y. S, Gorinstein S. (2011).Bioactivity of wine prepared from ripened and over-ripened kiwifruit. Cent.eur.j.biol. 6: 205. doi:10.2478/s11535-010-0118-x
12. Kraus E. C. (2002). How to Make Fruit Wine.http://eckraus.com/fruit-wine-making/ (accessed on 8/8/2017)

13. Lee, J. H., Kang, T. H., Um, B. H., Soln, E. H., Han, W. C., Ji, S. H. and Jang, K. H. (2013) Evaluation of physicochemical properties and fermenting qualities of apple wines added with medicinal herbs Food Science and Biotechnology, 22(4):1039–1046
14. Ezeronye, O.U. (2004). Nutrient utilization profile of Saccharomyces Cerevisiae from palm wine in tropical fruit fermentation. Antonie Van Leeuwenhoek 86: 235. doi:10.1023/B:ANTO.0000047927.59792.d4
15. Ray R. C., Panda S. K., Swain M. R. and Sivakumar S. P (2011) Proximate composition and sensory evaluation of anthocyanin-rich purple sweet potato (Ipomoea batatas L.) wine. Int J Food Sci Technol. doi:10.1111/j.1365-2621.2011.02861.x
16. Wikipedia
17. Sousa E. C., Uchôa-Thomaz A. M. A., Carioca J. O. B., de Morais S. M., de Lima A., Martins C. G., Alexandrino C. D., Ferreira P. A. T., Rodrigues A. L. M., Rodrigues S. P., Silva J. N. and Rodrigues L. L. (2014).Chemical composition and bioactive compounds of grape pomace (Vitis vinifera L.), Benitaka variety, grown in the semiarid region of Northeast Brazil. Food Sci. Technol, Campinas, 34(1): 135-142.
18. Ahmad, S. M., & Ali Siahsar, B. (2011). Analogy of physicochemical attributes of two grape seeds cultivar. Ciencia e InvestigaciónAgraria, 38(2), 291-301.
19. Rockenbach, I. I., Silva, G. L., Rodrigues, E., Gonzaga, L. V. &Fett, R. (2007).Atividadeantioxidante de extratos de bagaço de uva das variedades Regente e Pinot Noir (Vitis vinifera).Revista do Instituto Adolfo Lutz, 66(2), 158-163.
20. Pontes, P. R. B., Santiago, S. S., Szabo, T. N., Toledo, L. P., &Gollücke, A. P. B. (2010). Atributossensoriais e aceitação de sucos de uvacomerciais. Ciência e Tecnologia de Alimentos, 30(2), 313-318.
21. Burin, V. M., Falcão, L. D., Gonzaga, L. V., Fett, R., Rosier, J. P., & Bordignon-Luiz, M. T. (2010). Colour, phenolic content and antioxidant activity of grape juice. Ciência e Tecnologia de Alimentos, 30(4), 1027-1032.
22. Encyclopedia of life
23. Benny M., Benny., Jose J. K., Reshma M. (2015). Comparison of Phytochemical Chemical Constituents of Papaya Fruit and Leaves. Journal of Medical and Pharmaceutical Innovation; 2 (12); 9-14
24. AyoolaP. B. and Adeyeye A. (2010). Phytochemical and Nutrient Evaluation of Carica papaya (pawpaw) leaves. IJRRAS 5 (3); 325 - 327
25. Desai U. T and Wagh A.N. (1995). Papaya In Handbook of Fruit Science and Technology. Production, Composition, Storage, and Processing. New York: Marcel Dekker, Inc., 39-65.
26. Ndubuisi L. C. (2009). evaluation of food potentials of tigernut tubers (Cyperus esculentus) and its products (milk, coffee and wine). Dissertation.Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka.
27. Sánchez-Zapata, E; Fernández-López, J; Angel Pérez-Alvarez, J (2012). "Tiger Nut (Cyperus esculentus) Commercialization: Health Aspects, Composition, Properties, and Food Applications". Comprehensive Reviews in Food Science and Food Safety, **11**: p.366.
28. Arafat S., Gaafar A., Basuny A. and Nassef L (2009). "Chufa Tubers (Cyperus esculentus L.): As a New Source of Food". World Applied Sciences Journal, **7**:151.
29. Abano, E.E.; Amoah, K.K. (2011). Effect of moisture content on the physical properties of tiger
30. Bilali (2011). Exploring Serbian consumers' attitude toward ethical values of organic, fair-trade and typical/traditional products. The Fifth International Scientific Conference, Rural Development, Proceedings, Volume 5, Book 1, 337.
31. Makareviciene, (2013) "Opportunities for the use of chufa sedge in biodiesel production", Industrial Crops and Products, 50: 635
32. Belewu, M. A. and Abodunrin, O. A. (2008). "Preparation of Kunnu from Unexploited Rich Food Source: Tiger Nut (Cyperus esculentus)". Pakistan Journal of Nutrition.**7**:109.
33. Tedesco L. (2013). 6 Weird Fruit Wines You Must Try. Rodale Inchttp://www.prevention.com/food/healthy-eating-tips/6-fruit-wines-you-must-try (accessed on 7/8/2017)
34. Ogu, E O, Mgbebu, P O. (2011). Foundation for African development trough international biotechnology (FADIB), 19: 49-53

35. OIV.INT © (2015). Review document on sensory analysis of wine. http://www.oiv.int/public/medias/3307/review-on-sensory-analysis-of-wine.pdf (accessed on 2/8/2017)
36. Fleet G. H. (2003) Yeast interaction and wine flavour. Int J Food Microbiol, 86:11–22
37. Duarte W. F., Dias D. R., Oliveira M. J., Teixeira J. A., Silva J. D. and Schwan R. F. (2010) Characterization of different fruit wines made from cocoa, Cupuassu, gabiroba, jaboticaba and Umbu. Food SciTechnol 30:1–9
38. Oddbins Dictionary of Wine.(2012) "fermentation." London: Bloomsbury Publishing Ltd,.Credo Reference.Web. 17 September 2012.
39. Jackson, R. S. (2008). Wine Science Principles and Applications. San Diego, California: Academic Press, 276
40. Falola, A.O., Adesola, S.O. and Agwimah, J.O., (2009). Effect of storage on heat and chemically processed juice, Nigeria Food Journal.A publication of the Nigeria institute of food science and technology.Vol. 27 (21). (www.ajol.info/journal.nifoj) ISSN 0189-7241.
41. Panda S. K., Sahu U. C., Behera S. K. and Ray R. C. (2014b) Bio-processing of bael [Aeglemarmelos L.] fruits into wine with antioxidants. Food Biosci, 5:34–41
42. Alobo A. P. and Offonry S. U. (2009) Characteristics of coloured wine produced from roselle (Hibiscus sabolaritts) calyx extract. J Inst Brew 115(2):91–94
43. Panda S. K., Sahu U. C., Behera S. K.and Ray R. C. (2014a) Fermentation of sapota (Achrassapotalinn.) fruits to functional wine. Nutrafoods.doi:10.1007/ s13749-014-0034-1
44. Wine Folly (2016). Wines from Dry to Sweet.http://winefolly.com/tutorial/wines-from-dry-to-sweet-chart/
45. Davis B. (2017). Wines Considered Dry. http://wine.lovetoknow.com/wiki/Which_Wines_Are_Considered_Dry
46. Sahu U.C., Panda S. K., Mohapatra U. B. and Ray R. C (2012) Preparation and evaluation of wine from tendu (Diospyros melanoxylon L) fruits with antioxidants. Int J Food Fermentation Technol 2(2):167–178

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