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Research Article

Proximate, Chemical Compositions and Sensory Properties of Wine Produced from Beetroot (*Beta vulgaris*)

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Abstract

Table wine was produced from juice which had been extracted from washed and peeled beetroot. Fermentation of the juice lasted for 21days at room temperature and aging for 21days at below 10^{0}C. The wine sample produced under anaerobic and aerobic fermentation was coded BN and BA respectively. A commercial table wine (WBO) was used as reference sample. There were gradual changes in the physicochemical properties of the must as fermentation (aerobic and anaerobic) and ageing lasted. There was reduction in the pH from 4.7 to 3.9, Specific gravity from 1.092 to 1.021, ^{0}Brix from 21.84 to 6.22 and increase were recorded for alcohol from 0 to 8.4 %v/v and titratable acidity from 0.15 to 0.34%. The Proximate composition and the physicochemical analysis of the anaerobic and aerobic fermented wine samples were Moisture (86.53- 88.25%), Crude protein (0.28%), Ash content (0.50 0.81%), Crude fat (0.10%), Carbohydrate (3.25- 4.20%) and total solids (4.55-4.71%), total titratable acidity (0.31-0.34%), specific gravity (1.030-1.021), pH (3.9), Alcohol (7.2-8.4 %v/v) respectively. The vitamin and mineral contents of the anaerobic and aerobic fermented wine samples were Pro-vitamin A (24.16-25.83mg/100mL), Vitamin B_1, (0.523-0.433mg/100mL), Vitamin C (1.697-1.873mg/100mL), Vitamin E (0.315-0.374mg/100mL) and iron content (0.750-0.773mg/100mL), potassium (28.360-29.056 mg/100mL), Magnesium (0.780-0.803 mg/100mL). The commercial sample was the most preferred with highest score (7.70) in general acceptability. The anaerobic fermented wine sample was more preferred with higher score (7.13) in general acceptability. The formulated wines compared favourably with the control (commercial wine) in taste, tartness, mouthfeel and general acceptability.

Keywords: Beetroot, Fermentation, Aerobic, Anaerobic, Wine

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Introduction

Beetroot (*Beta vulgaris L.*) is a member of the *Chenopodiaceae* family which includes silver beet, sugar beet and fodder beet [1]. They are biennials although they are usually grown as annuals and believed to have originated from Germany [2]. Beetroot produces green tops and a swollen root during its first growing season. It is highly productive and usually free of pests and diseases [3]. Beetroot is a valuable vegetable, which is semi-hardy and biennial. It is grown year-round for its sweet, tender, succulent roots. Beets contain more sugar than any other vegetable, and its earthy taste and aroma comes from an organic compound called geosmin [4, 5]. Beets of different colors, sizes and shaped have been grown, ranging from red, yellow, white, multi-colored, round, long cylindrical and huge sugar and mangle beets. Beetroot has red color naturally and its color is mostly stable at pH of 4.5-5.5; it is rather unstable outside this range [5]. Beetroots can be processed into a table wine through the following unit operations and processes; Cleaning, Cutting, blending into juice, fermentation, filtration, pasteurization and blending. During fermentation, the yeast consumes the sugar in the fruits or fruit juice and convert them into alcohol. The biochemical conversion of juice to wine occurs when the sugar in the fruit, usually glucose and fructose is converted to acetaldyde and finally to alcohol.

This work deals with the processing of the beetroot into a wine. Wine from beetroot can be good for health as it has good antioxidant activity, and studies have reported that health from wine is due to the presence of antioxidants in them [6].

Experimental

Materials

Fresh ripe beetroot (Beta vulgaris) fruit was procured from Ikpa market in Nsukka, Enugu State. *The fruit was* *assembled for immediate processing in the food processing laboratory, Department of Food Science and Technology, University of Nigeria, Nsukka.*

Sample Preparation

The beetroot was prepared as shown in the flow chart below (**Figure 1**).

Beetroot
↓
Sorting/Washing
↓
Peeling/Cutting
↓
Blending (Extraction)
↓
Filtration
↓
Pasteurization (65-80^{o}c)
↓
Packaging
↓
Store Chilled

Figure 1 Flow chart for the production of beetroot juice

Processing of Beetroot into Wine

The extracted fruit juice was pasteurized, cooled to the room temperature, the brix□ raised and pitched using *Saccharomyces cerevisiae* for fermentation to wine for 2-3 weeks. The fermentation was done under aerobic and anaerobic conditions. The flow chart for the processing of the juice into wine is shown in the flow chart below (**Figure 2**).

Fruit Juices
↓
Brix adjustment
↓
Pitching (Addition of yeast)
↓
Fermentation for (21Days)
↓
Blending (into various proportions)
↓
Filtration (Clarification)
↓
Racking (4 times)
↓
Pasteurization (60^{0}C For 30 min)
↓
Aging (21Days)
↓
Packaging
↓
Table wine (Store chilled)

Figure 2 The flow chart for the production of beetroot wine

Determination of physicochemical changes in the fermenting medium

Physical and chemical changes were determined during fermentation. The parameters looked at were pH, titratable acidity, alcohol content, total solids and specific gravity. The pH; Total solids; TTA as% citric acid was determined as according to standard methods [7]. The pH was then determined using fisher science Education pH meter (model 90526 Singapore) by inserting the pH probe into the slurry. For TTA; Twenty milliliters of each sample was collected in a beaker; one 1mL of phenolphthalein indicator was added and was titrated with 0.1N NaOH to pink colour. The total titratable acidity was calculated as percentage citric acid as shown by the equation % TTA = volume at base × normality of base × millimeter equivalent × 100. For total solids Ten millitres (10mL) of the sample was pipetted into a washed, dried and weighed crucible. The dish and the contents (crucible containing 10mL of the sample) were put into an oven and dried at 70^0C for 3hours.It was cooled in a desiccator and the weight of the solid determined.

The alcohol content was determined using the standard distillation method.100mL of the wine was measured into a distillation flask and the apparatus set up. The alcohol was distilled at 78^0C and the volume was calculated.

The specific gravity of the wine was determined using the pycometer bottle as describe by [7].The pycometer bottle was thoroughly washed with detergent, water and petroleum ether, and it was dried and weighed. The bottle was filled with water and was weighed. After drying the bottle, the sample was filled in it and weighed.

Proximate composition

Crude protein, moisture content, total ash, fat of beetroot wines were determined using the method described by [7]. Carbohydrate was calculated by difference.

Vitamins Analysis

Pro-vitamin A, Thiamine content (B1), Vitamin C and Vitamin E were determined using the described by [7].

Mineral analyses

The determination of Fe, K and mg was carried out as described by [7]. The samples were digested with a mixture of nitric acid and perchloric acid in the ratio of 10:4 (v/v) on hot plates sand bath. After complete digestion; samples were cooled to room temperature and appropriately diluted and were analyzed by Atomic Absorption Spectrometry.

Sensory evaluation

Sensory evaluation was carried out on the wine samples. A nine-point Hedonic scale and Analysis of variance [8]. Thirty semi-trained panelists were recruited. They were served the juice samples in coded cups. The panelists assessed the taste, appearance, flavors and general acceptability of the samples using a nine-point Hedonic scale where 1 = like extremely and 9 = dislike extremely.

Results and Discussion

Changes in pH, Total Titratable Acidity, Specific Gravity, ^{O}Brix, and Alcohol Concentration during Fermentation

Fruits that contain sugar (fermentable sugar) can be used for the production of wine [9]. Although the specific gravity of the must was augmented with granulated sucrose. During fermentation changes were observed. The specific gravity of the samples gradually decreases in values as observed throughout the period of fermentation (21Days) and aging (21Days) from 1.092 to 1.021 for the beetroot must under anaerobic fermentation, and from 1.092 to 1.030 for the beetroot must under aerobic fermentation. The steady decrease in the specific gravity of the samples was due to the activities of the yeast which fed on the sugar to produce alcohol and carbon dioxide. The must fermented under anaerobic condition used up the available sugar more than the aerobic condition, therefore more potential alcohol. In the absence of oxygen, yeast converts the sugars of wine into alcohol and carbondioxide through the process of fermentation. A similar phenomenon was reported for sugar fermentation using *Saccharomceyces cerevisiae* isolated from fermented grape pomace [10].

The reduction in Brix content from 21.84 to 6.22 and the resultant increase in the alcohol concentration from 0 to 8.4 (%v/v) for the beetroot must under anaerobic fermentation, shows the efficiency of the *Saccharomceyes cerevisae* (brewer yeast) in utilizing the sugar as source of carbon and energy. Similar decrease was reported by [11], who stated that blends of paw-paw and roselle wine decreased in brix from 22.1 to 7.1 after 14 days of fermentation and 30days of aging. The conversion of reducing sugar in to ethanol and carbon dioxide is due to the activity of microbes.

The pH reading 4.7 to 3.9 decreased gradually during fermentation for beetroot must. Similar observation was reported by [12], who stated that the lowering of pH from the initial 4.5 to 3.5 of the samples may probably be due to the formation of acetic acid as the pH was below 4. The attained pH (3.8) falls within the pH range of 3.5 to 4.0 that was reported to be optimal for yeast activity [13]. These results were in agreement with that of Ifie *et al*. (2012) who reported the decrease in total solids and pH, and increase in the yield of alcohol during the fermentation of roselle wine [14]. Studies have shown that during fermentation of fruits, low pH is inhibitory to the growth of spoilage organisms but create conducive environment for the growth of desirable organisms.

The total titratable acidity increased from 0.15 to 0.34 for the beetroot must. This may be as a result of increase in the production of organic acids. Anuna *et al*. (1990) observed that during fermentation of must, organic acids such as acetic acid and pyruvic acids were produced [9]. Acidity plays a vital role in wine quality by aiding the fermentation process and enhancing the overall characteristics and balance of the wine. A similar study conducted by [15], revealed that there is a corresponding reduction in pH as the acidity increased in sour-sop juice. This is reported in the studies by [16]. Acidity plays a vital role in determining wine quality by aiding the fermentation process and enhancing the overall characteristics and balance of the wine as stated by [17].

The high yield of alcohol is attributed to the ability of the yeast to breakdown the fermented sugar in the must. Reports have shown that alcoholic fermentation leads to a series of by-products in addition to ethanol. Some of the by-products include carbonyl compounds, alcohols, esters, acids and acetals, all of them influencing the quality of the finished product. The results for the changes in pH, Titratable acidity, Specific Gravity, ^{O}BRIX, and Alcohol concentration during beetroot wine fermentation are shown in **Figures 3-6**.

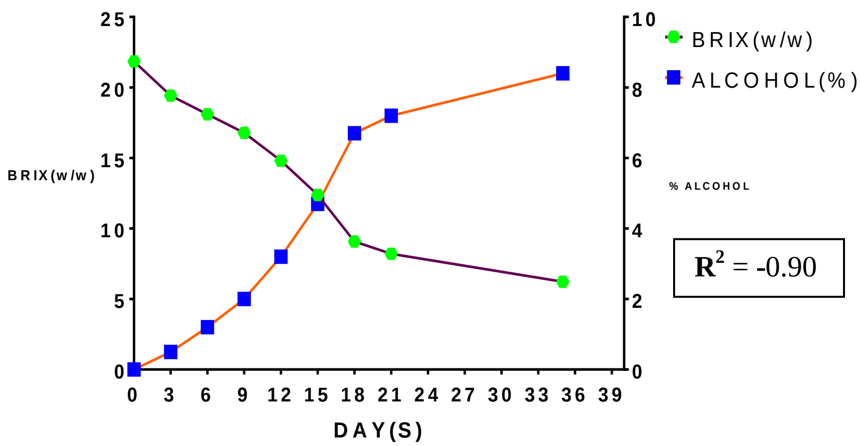

Figure 3 Changes in ^{O}BRIX, and Alcohol concentration during Beetroot wine anaerobic fermentation (BN)

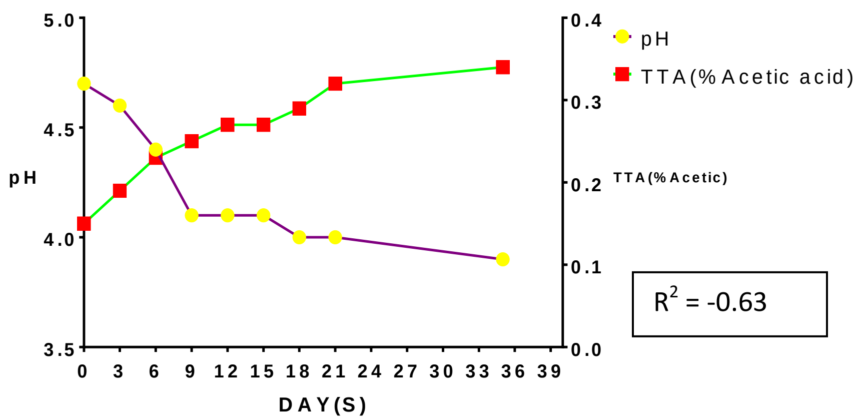

Figure 4 Changes in pH and Titratable acidity during Beetroot wine anaerobic fermentation (BN)

Proximate Composition of Wine from Beetroot

The proximate composition of fruit wines produced reflected the composition of the fruit substrate used in producing them. It has been reported by [18], that proximate compositions of fruits vary with location where the fruits are grown. The moisture content of a sample determines how shelf stable a product a product will be and the overall nutritional value of the sample. The moisture of the wine samples ranged from 86.53 to 88.25%. The wine samples had moisture content similar to that of the commercial sample which had moisture (87.18%). This is similar to the report given by [19], for watermelon wine. High moisture content makes beverage suitable as a refreshing and quench-thirsting product which is characteristic of good beverage.

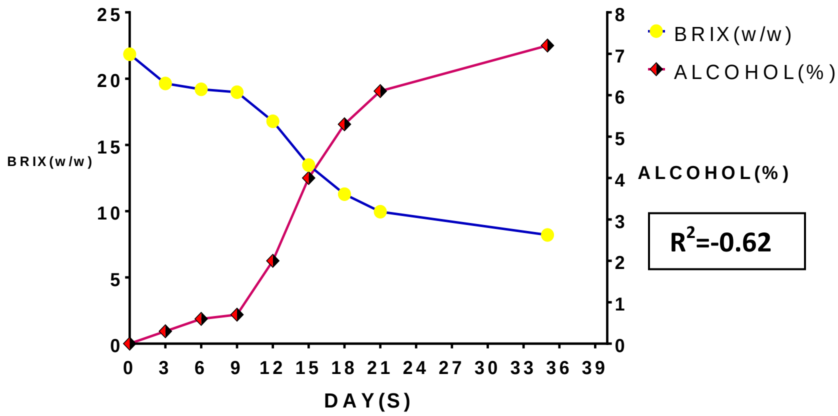

Figure 4 Changes in ^{O}BRIX, and Alcohol concentration during Beetroot wine aerobic fermentation (BA)

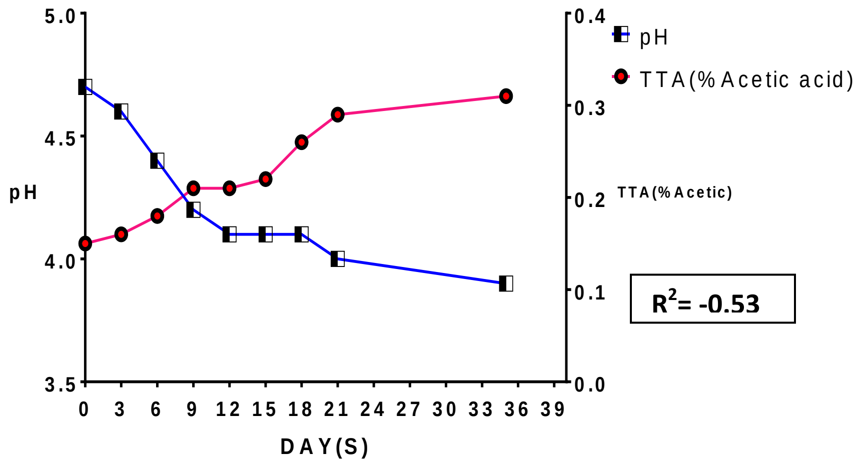

Figure 5 Changes in pH and Titratable acidity during Beetroot wine aerobic fermentation (BA)

Figure 6 Anaerobic and Aerobic Fermentation Set-up

The crude protein content of the samples was 0.28%. The commercial sample had a low protein content of (0.54%).This is comparably lower than the result (1.05-1.14) % reported by [20], who formulated wine from blends of watermelon and pawpaw. The ash content of the sample ranged from 0.50 to 0.81%. However, the commercial sample had the least ash content of 0.3%. This indicates the presence of mineral component in the wine. This is similar with the reports by [21] who reported 0.5% of ash content. The crude fat content of the wine sample was 0.10%. The samples fat content agrees with the 0.1% reported by [22]. This low fat content is in line with that from formulated watermelon-pawpaw wine (0.015-0.030) % [20]. The carbohydrate content was determined by the difference method and ranged from 3.25 to 4.20%. The commercial sample had a low carbohydrate content of 1.52%. This might be due to decline in the sugar content as a result of rapid and effective utilization of the sugar available in the must by the yeast cells leading to the fermentation of the must. A similar observation was reported by [23].

The factors that affect the chemical composition of wine include production area, viticulture practices, grape variety, soil type, climate, yeasts and wine-making techniques. These factors play significant roles in the characterization and differentiation of wines. The proximate compositions of the table wines from blends of watermelon and beetroot wine are shown in **Table 1**.

Table 1 Proximate composition of table wine from blends of watermelon and beetroot

Sample Code	Moisture (%)	Crude Protein (%)	Ash (%)	Crude Fat (%)	Carbohydrate (%)
WBO	87.18± 0.02	0.54 ± 0.06	0.30 ± 0.081	0.00 ±0.00	1.52 ± 0.15
BN	86.53±0.26	0.28 ± 0.04	0.50 ± 0.055	0.10 ±0.006	4.20 ± 0.26
BA	88.25±0.18	0.28 ± 0.04	0.81 ± 0.29	0.10 ±0.006	3.25 ± 0.26

Values are means ± standard deviation of triplicate determinations. Means with different superscripts in the same column are significantly different ($p < 0.05$).
KEY: **BN**= Beetroot wine (**anaerobic**) fermentation, **BA**= Beetroot wine (**aerobic**) fermentation, **WBO**= Commercial wine.

Physicochemical Analysis of the Wine from Beetroot

The total solids and specific gravity of the wine samples ranged 4.55 to 4.71% and 1.009 to 1.014 respectively. This was supported by [24]. This values for specific gravity fall within EC Wine Regulations reported by [25]. The total solid and specific gravity is an index of the dissolved solids in the wine samples. In order to supplement the sugar content of the musts granulated sugar which is sucrose was part of the additives. Reports have shown that the major problem associated with the use of tropical fruits in wine production is their low sugar content [26]. The commercial sample had the total solids (2.32%) and specific gravity (0.999), the low specific gravity could be attributed to its low dissolved sugar and high alcohol content.

The alcohol content of the wine samples ranged from 7.30 to 8.37%v/v. The commercial sample had the highest alcohol content (10.5%v/v). Alcohol contributes to taste, mouthfeel and sweetness, but at a very high alcohol content the taste will be suppressed, it causes a burning sensation in the nostril and creates a sense of bitterness. The wine samples fermented under anaerobic condition had more alcohol content. In the absence of oxygen, yeast converts the sugars of wine into alcohol and carbondioxide through the process of fermentation. The alcohol content of the fermenting must increased during fermentation. The increase in the alcohol content can be attributed to yeast metabolism by continuous utilization of the sugar content, ethanol is produced and thus there is an increase in the alcohol content of the fermenting must, this continued until all the available sugar in the fermenting must has been utilized. This result is in consistent with the work of [23]. The final alcohol content of the wine samples 7.30 to 8.37%v/v ranks it among table wines. This agrees with the findings of [27] who reported that wines that has 7 -14% of alcohol are considered as table wine. The alcohol content in wine is influenced by method of wine preparation, type of yeast used and initial total soluble solids in must as reported by [27].

The pH of the wine samples fall within the range 3.6 to 3.8. The commercial sample had the lowest pH (3.4). The pH is acidic; this confers stability on the wine sample [28]. The pH of wine determines the microbial and physicochemical stability of wines. Also, low pH and high acidity are known to give fermenting yeasts competitive advantage in natural environments [29]. Total titratable acidity of the wine samples ranged from 0.15 to 0.19% tartric acid equivalent of the wine. There exists a correlation between pH and acidity of the sample. The higher the acidity, the lower the pH of the wine. This is because as the organic acids in the wine increased the pH lowers and total titratable acidity increased. This agrees with [30]. The pH of wine, a direct reflection of the total titratable acidity, is low and consequently, the wine will maintain good shelf stability. The study revealed an increase in total titrable acidity of the fruit wine throughout the period of fermentation. A similar study revealed that there is a corresponding reduction in pH as the acidity increased in sour sop must, the pH of the wine was below 4.00. This was supported by [31]. Lowering of pH from the initial 4.5 to 3.5-3.7 of the samples may probably be due to the formation of acetic acid as the pH was below 4 [12]. Lack of acidity might result to the production of a poor fermentation process. This corroborates [17]. The physicochemical analyses of the table wines are shown in **Table 2**.

Table 2 Physicochemical Analysis of the wine from beetroot

Sample Code	Total Solid (%)	TTA (% Acetic Acid)	SG (%Brix)	pH	ALCOHOL (Ethanol%v/v)	Methanol ($^0/_0$)
WBO	2.32 ± 0.02	0.54 ± 0.003	0.999 ± 0.001	3.4	10.50 ± 0.00	ND
BN	4.71 ± 0.66	0.34± 0.019	1.009± 0.001	3.6	8.37 ± 0.023	0.023±0.00
BA	4.55 ± 0.22	0.31 ± 0.02	1.014 ± 0.016	3.8	7.30 ± 0.17	0.019±0.0

Vitamin Composition of the Table Wine from Beetroot

The pro-vitamin A of the wine samples ranged from 24.16 to 25.83 mg/100mL. The commercial sample had the lowest pro-vitamin A content (9.51mg/100mL) while the pure beetroot wine (anaerobic) sample had the highest pro-vitamin A content (25.83 mg/100mL). There was no significant difference in pro-vitamin A between the aerobic and anaerobic fermented wine samples. The vitamin B_1 of the wine samples ranged from 0.433 to 0.523 mg/100mL. However the commercial sample had the highest vitamin B_1 of 0.80 mg/100mL, this could be as a result of nutrient enrichment in the food industries or the legal statutory requirements.

Vitamin C content of the samples ranged from 1.697 to 1.873mg/100mL. The decrease in vitamin C with fermentation period could be attributed to the oxidation of vitamin C by yeast during fermentation [26]. The reduction in vitamin C content may be due to the effect of heat during pasteurization. The ascorbic also acts as an antioxidant to help prevent molecular bioreactions caused by oxidation and as a promoter of iron absorption [32]. Vitamin E content of the wine samples ranged from 0.315 to 0.374mg/100mL. The commercial sample had the least vitamin E. Vitamin E is a strong antioxidant, and performs a preservative function on the wine. The vitamin compositions of the table wines are shown in **Table 3**.

Table 3 Vitamin Composition of the table wine from beetroot (mg/100mL)

Sample Code	Pro-vitamin A	Vitamin B_1	Vitamin C	Vitamin E
WBO	9.51 ± 0.02	0.800 ± 0.00	1.233 ± 0.225	0.204 ± 0.006
BN	25.83 ± 0.05	0.433 ± 0.15	1.873 ± 0.125	0.374 ± 0.016
BA	24.16 ± 0.04	0.523 ± 0.006	1.697 ± 0.055	0.315 ± 0.025

Mineral Composition of the Table Wine from Beetroot

The iron content of the wine samples ranged from 0.750 to 0.773mg/100mL. There was no significant difference in the iron content between the aerobic and anaerobic fermented wine samples. Iron is said to be important element in the diet to prevent anaemia [33]. The potassium content of the wine samples ranged from 28.360 to 29.056 mg/100mL. The beetroot wine (anaerobic) had the highest potassium content. Beetroot is a rich source of potassium. Abby (2011), stated that beet juice is high in potassium which can help to regulate the body fluid levels and maintain the electrolytes [34]. There was no significant difference in the potassium content between the aerobic and anaerobic fermented wine samples. The magnesium content of the wine samples ranged from 0.780 to 0.803mg/100mL. The mineral compositions of the table wines are shown in **Table 4**.

Table 4 Mineral Composition of the table wine from beetroot (mg/100mL)

Sample Code	Iron	Potassium	Magnesium
WBO	0.071 ± 0.002	0.989 ± 0.008	0.035 ± 0.006
BN	0.773 ± 0.021	29.056 ± 1.060	0.780 ± 0.010
BA	0.750 ± 0.050	28.360 ± 1.519	0.803 ± 0.116

Sensory Evaluation scores of Wine from Beetroot

Table 5 shows the mean sensory scores of the wines for colour, flavor, taste, mouthfeel, tartness and general acceptability. There was a comparable rating in colour, this is because the sparkling red colour of beetroot. The flavor was quite below that for the commercial sample, flavour is a major contributor to the general acceptability of a wine product; it is the difference between the most expensive and the cheapest wine in the market. The beetroot wine samples had the least taste. The tartness of the wine samples is affected by the alcohol content of the wine sample. The commercial sample had the highest tartness, this relates to its highest alcohol content (10.50%v/v). The commercial sample was the most acceptable among the samples (7.70). The sample fermented under anaerobic condition had the best acceptability, after the commercial wine. The sensory evaluation scores of the table wines from blends of watermelon and beetroot wine are shown in Table 5.

Table 5 Sensory Evaluation Scores of the table wine from beetroot

Sample Code	Colour	Flavour	Taste	Mouthfeel	Tartness	G. Acceptability
WBO	8.63 ± 0.67	7.03± 1.45	6.87± 1.87	7.47 ± 1.25	7.40±1.07	7.70 ± 1.12
BN	6.73 ± 1.68	6.63±1.03	6.00±1.44	6.87±1.11	6.30± 1.15	7.13 ± 0.82
BA	6.90 ± 1.71	6.40±1.81	5.90± 2.02	5.90 ± 1.54	6.07± 1.57	6.60 ± 1.43

Conclusion

Wine was produced from the must prepared from beetroot fruit with brewers yeast (*Saccharomyces cerevisae*) as the fermenting organism. The wine was found to compare favourably with the commercial red wine from grape in most of the nutritional, chemical, physicochemical parameters (pH, titratable acidity, alcohol total solids). From the data obtained, the wine sample fermented under anaerobic condition was the best in terms of general sensory acceptability. The wine samples fermented under anaerobic condition gave a better quality more than those fermented under aerobic condition.

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