

Research Article

Production and Comprehensive Characterization of Banana Fruit Wine Using *Saccharomyces Cerevisiae*

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Abstract

Bananas (*Musa* spp.) are a globally cultivated fruit valued for their flavor and rich nutritional content (high in sugars, potassium and B-vitamins). Because ripe bananas are highly perishable, converting excess or overripe bananas into wine can reduce waste and add value. Fruit wines are produced by fermenting fruit juices with yeast, turning sugars into ethanol, carbon dioxide and minor by-products that give wine its aroma and preserve it. In particular, the high sugar/carbohydrate content of banana makes it an excellent substrate for fermentation. Thus banana wine production has emerged as an attractive alternative to grape wine in regions where grapes are scarce: it harnesses surplus fruit, yields a vitamin-rich beverage, and extends shelf life through fermentation. In this study, ripe banana pulp was cleaned, mashed and blended with water, sugar and lemon juice, then inoculated with baker's yeast (*Saccharomyces cerevisiae*) and fermented anaerobically for about six days. Fermentation progress was monitored by measuring pH, titratable acidity, specific gravity, total dissolved solids (TDS) and ethanol content at regular intervals. These analytical assays are standard for fruit wine characterization. The yeast consumes banana sugars to produce ethanol and CO₂; as fermentation proceeded we observed vigorous bubbling (CO₂ release) and viscosity reduction, as expected for *Saccharomyces* fermentation. The fermenting banana must showed the typical trends of wine fermentation. The pH fell markedly (from about 5.0 initially to ~2.0 by the end), reflecting increased organic acid production, while titratable acidity rose to ~1.6 g/100 mL (as lactic/acetic acid equivalents). Specific gravity declined (from ~0.983 to ~0.982), indicating sugar depletion and ethanol formation. Correspondingly, ethanol content increased steadily and reached about 14% v/v by day six. Observed ethanol rising to ~15% as pH dropped into the low-3 range during fruit fermentation. A clear, amber banana wine was obtained after racking; it exhibited the characteristic aroma and flavor of banana and acceptable clarity.

Keywords

Banana Wine, Fermentation, *Saccharomyces Cerevisiae*, Fruit Wine, Ethanol Content, Titratable Acidity

1. Introduction

Wine is an alcoholic beverage made by fermentation of fruit juice of ripe grape using *Saccharomyces cerevisiae*; other sugar rich fruits can also be used. It has been produced for thousands of years since ancient civilization to modern times, and is enjoyed by people: from peasants to kings [1]. Ripe

bananas are consumed raw as a desert fruit. Banana serves as good nutritional sources of carbohydrates, minerals such as potassium and vitamins such as B1, B2, B3, B12, C and E. Following the high nutritional content of banana, it is consumed in large quantity in a variety of ways in Africa. The

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banana fruit can be eaten raw or cooked (e.g., deep fried, dehydrated, baked in its skin or steamed), processed into flour or fermented for the production of beverages such as banana juice, beer, vinegar, wine [2]. Wine are healthful beverages that has been seen as a natural remedy for man's illness from early days and are said to aid recovery during convalescent period. Fermentation processes are usually done by species of the yeast *Saccharomyces*, whereby the sugars in the fruit juice are converted into alcohol and organic acid, that later react to form aldehydes, esters and other chemical components [3]. Banana is one of the major fruits produced and consumed domestically in the country. It is produced by both large-scale commercial farms and small-scale producers. Currently, one can get banana in small shops to large supermarkets, which shows the growing of the market. Retailers also sell by roadsides; while moving from place to place [4]. Various fruits have been used for the production of wine since the dawn of humancivilization. The fermentation with yeast is used for the production of wine that is considered as one of the oldest alcoholic beverages. Usually, grapes were taken as the substrate for winemaking but in recent years preferences have been given to other fruits such as apricot, banana, citrus fruits, and so on. Banana (*Musa spp*) is a valued fruit across the world due to its flavor, high nutritional value, and availability throughout the year. Fermentation has made it possible to obtain wine from the fruits with the application of a variety of microorganisms, especially yeasts. Themicrobial cell utilizes the nutrition present in the fruits to produce alcohol through fermentation. The alcoholic content in the wine is mainly due to ethanol production [5].

Fermentation is a viable technique in the development of new products with modified physicochemical and sensory qualities, especially flavor and nutritional components. Alcohol and acetic and lactic acid fermentation are important for qualityin production. Of these, alcoholic fermentation is widely employed for the preparation of beverages in which alcohol is major constituent. Alcoholic fermentation leads to a series of by-products in addition to ethanol. They include carbonyl compounds, alcohols, esters, acids, and acetals, all of them influencing the quality of the finished product. Thecomposition and concentration levels of the by-products can vary widely [6]. Banana, a wonderfully sweet fruit with firm and creamy flesh that come prepackaged in a yellow jacket, available for harvest throughout the year consists mainly of sugars and fibers which make it a source of immediate and slightly prolonged energy. When consumed, reduces depression, anemia, blood pressure, stroke risk, heartburns, ulcers, stress, constipation and diarrhea. It confers protection for eyesight, healthy bones, kidney malfunctions, morning sickness, itching and swelling, improves nerve functions as well as help people trying to give up smoking. Any fruit with a good proportion of sugar may be used for wine production and the resulting wines are normally named after the fruit hence banana, apple, orange, pineapple, strawberries and coconut may be used to produce wine. The type of fruit wine to be

produced dictates the fruit and strain of yeast to be involved [7].

Wine is produced on the basic principle of conversion sugars by yeast into ethanol and carbondi-oxide. Banana is a staple starchy food consumed all over the world. Bananas are rich in potassium and fiber. They may help to prevent asthma, cancer, high blood pressure, diabetes, cardiovascular disease, and digestive problems. Potassium is important as it helps maintain fluid levels in the body and regulates the movement of nutrients and waste products in and out of cells. Potassium also helps muscles to contract and nerve cells to respond. It keeps the heart beating regularly and can reduce the effect of sodium on blood pressure. Potassium may reduce the risk of kidney stones forming as people age. In turn, healthy kidneys make sure that the right amount of potassium is kept in the body. The wastage of the banana can be minimized by utilizing the ripe bananas for production of wine. The main reason for the utilization of banana for the wine production is because of their sugar content, presence of anti-oxidants and widely consumable drink which is richer in health benefits. Also, winemaking from banana is considered as an alternative of utilizing surplus and over- ripe fruits without wastage for generating additional revenues for the fruit growers. The banana wine production can also be done in smaller scale levels also. By the production of wine, the growers would get benefit and also the wastage of the bananas can be decreased [8].

Currently in Ethiopia wine is produced from grapes but the grape is insufficient to produce wine because of the grape is grown in limited area or agro-ecological zone. Also it is not cultivated in large amounts and difficulty to store. Because of this there is a lack of wine for the matter of insufficient availability of raw materials and its high cost. Therefore, the shortage of wine occurred due to the interruption of wine production. Not only this but also the cost of the wine produced industry is very expensive and the society is suffering by this problem. Therefore, additional feed stock for production of wine at local level is vital. Since, Ethiopia is capable with rich ago-ecological zone for production of large range of fruits including banana, so banana is the one which can block this gap. One crucial Problems of Ethiopian farmers are they cannot store the ripe cultivated banana for long period of time they become sell raw banana in small price beside it get ripe need at their hand they sell it even at low price to the brokers, or selling agents or it get perished as result, farmers face great challenge in competitive market. For this reason we are happy to solve this problem through making wine production from banana. Accordingly, banana is an alternative raw material for the production of wine.

This study is used to find and fill the problem of producing wines other than grapefruits and altering with banana fruits. Bananas are extremely healthy and delicious. They contain several essential nutrients and provide benefits for digestion, heart health and weight loss. Aside from being very nutritious, they are also a highly convenient snack food. In some coun-

tries, bananas used for cooking may be called "plantains", distinguishing them from dessert bananas. The fruit is variable in size, color, and firmness, but usually elongated and curved, with soft flesh rich in starch covered with a rind, which may be green, yellow, red, purple, or brown when rip. However, different sizes of bananas contain varying amounts of calories so, such importance and energy content would be included in banana based wine productions and the banana fruit wine product conducted in this study usually with such health and nitrous composition with in modern life system.

2. Research Methodology

2.1. Sampling and Experimental Site

This study was conducted in Bule Hora University. Bule Hora is located southern part of the capital city of Ethiopia on the distance of 467km from Addis Ababa. Bule Hora University found in Oromia regional state of West Gujii zone. The altitude of the study area range from 500 m to 2500 m. The climate condition of area study highlands 34%, middle land 55% and lowland 11%. The annual temperature range is 15 °C land rainfall range from 500 mm to 1250. The study samples were collected from located at Bule Hora. Then the samples were transported into laboratory of Department of Chemistry, College of Natural Sciences, Bule Hora University This study was done in different laboratories based on the available resources. Accordingly, moisture and sucrose content of raw banana fruits were done in the research laboratory, Department of Chemistry, College of Natural Sciences, Bule Hora University.

2.2. Experimental Procedure

The required raw material are Raw Materials Ripped banana, Sugar, *Saccharomyces cerevisiae* (baker yeast) and Ripe lemons were collected and cleaned well then, All glassware's used in wine preparation and proximate analysis were washed with dilute nitric acid and rinsed in distilled water, dried in hot oven prior to use to avoid unwanted contamination during the preparation of feed stock sample and for the analyses, cutting knife grinder for size reduction of samples and mechanical mixer used for preparation of wine. Such as Beaker, pH paper, Oven, Balance, Thermometer, Burette, Nylon cloth, Firm wooded stirrer, Alcohol meter, Measuring Cylinder, Tongs, Evaporating dish, Aluminum Foil, Conical flask, Condenser, Heating Mantle, Iron Stand, Funnel, Dropper, Pipette, Hot Plate, Stainless Still Knives, Round-bottom flask.

2.3. Sample Preparation of Juice ('Must')

First the ripe bananas were washed with distilled water. Secondly the bananas were thoroughly disinfected with cotton wool soaked in ethanol. Next to this weighing of the banana

fruit, sugar, lemon juice, yeast cells, distilled water with the following specification; 500g of banana pulps, 5.00g yeast cells, 255g of sugar, 375g lemon juice and 750ml water was carried out. Each banana fruit were hand peeled and the edible portion was sliced with a stainless-steel knife. After this the slices were blended with 100 °C hot water in 1000ml of glass beaker. Finally, the slurry was filtered through a double folded nylon cloth to obtain the juice (must) and pH of the banana must was taken.

2.4. Banana Wine Fermentation

Sugar, lemon juice (to enhance distinct aroma/flavor), and distilled sterile water was added to the banana must, and 5g of dried yeast cells was inoculated into the banana must contain in a ferment-er, a process known as pitching. Finally, the experiment was observed for seven days. The nature of ferment er used is an anaerobic ferment er. With this period, bubbles of CO₂ were observed. The fermenting tube which was passed into a clear bottle containing clean portable water allowing the CO₂ produced during fermentation to escape while preventing entrance of O₂. This stage began when yeast was vigorously converting sugar to alcohol. The contents of the fermenter were stirred thoroughly during the first 7 days of primary fermentations. This was to facilitate temperature equilibrium and encourage aeration which was necessary for initial yeast growth [9].

2.5. Analytical Assay

Analytical Assay carried out the sample every 72 hrs to 144hrs for, total dissolved solids, titrable acidity, pH determination, specific gravity, and alcohol content.

2.5.1. pH Determination

The sample was poured into the beaker. The pH paper was dipped in to the test tube that containing of the sample and finally compared the color obtained on the pH paper with the shades on the pH scale.

2.5.2. Determination of Total Dissolved Solids

The evaporating dish was washed and dried. Then the evaporating dish was weighted and that containing of sample was weighted and dried in oven at 100 °C. Finally, the evaporating dish that containing of the sample was cooled and weighted. Mill gram of Dissolved Solids/L=AB*1000/ ml sample Where: - A = weight of dried residue + dish, mg B = weight of dish, mg.

2.5.3. Specific Gravity Determination

Fifty ml specific gravity bottle was thoroughly cleaned with distilled water, dried in an oven for 50 °C and allowed to cool. The weight of the cooled dried bottle (W1) was recorded. The dried bottle was filled with deionized water and surface of the

bottle was cleaned with a cotton wool and weighed as (W2). The bottle was empty and cleaned twice with 10ml of the “must” thereafter the bottle was filled to the brim with the “must” and the bottle cleaned with cotton wool and weighed as (W3). The specific gravity (S.G) was calculated.

$$S.G = W3 - W1 = SW2 - W1 W$$

Where: S= weight of volume of must (W3 - W1)

W= weight of volume of water (W2 - W1)

2.5.4. Titrable Acidity

1% of aqueous alcoholic phenolphthalein as indicator was added to 200ml of distilled water. It was titrated with 0.1M of NaOH. Titration was stopped when a faint but definite pink color appeared. The titre was taken, this served as the initial titre. 5ml of the must was added to the neutralized solution. The same 0.1M NaOH was used to titrate it. The titration was stopped at the appearance of faint, but definite pink color. The titre was taken. This served as the final titre. The titratable acidity was calculated as gram of lactic acid per 100ml of sample.

$$\% \text{Acid (Wt./ml)} = N * V1 * \text{Eq. wt.} / V2 * 10$$

Where: N = Normality of titrant (m. Eq. /ml), V1 = Volume of titrant (ml)

Eq. wt. = Equivalent weight of Lactic acid (mg/m. Eq.), V2 = Volume of Sample (ml) is about 10ml

2.5.5. Alcohol-content

Alcohol content was determined only by getting the specific gravity of the wines each day. Using the alcohol determination chart/specific gravity, individual alcohol content for the wines was determined [9].

$$\%v/v \text{ alcohol} = (SG2 - SG1) / 0.0074$$

Where: SG1= is the initial specific gravity measurement, SG2= is the final specific gravity

3. Results and Discussions

3.1. Test for pH

During the study, the analytical assays carried out comprise pH determination, titrable acidity, specific gravity, total dissolved solid and alcohol content.

Table 1. pH of the Fermenting Banana Wine.

Sample	Time				
	0hr	72hr	96hr	120hr	144hr
Fermenting banana wine	5	4	3	3	2

The pH was on the decrease as expected from 5-3. This should be a result of its inverse proportionally with acidity. The decreasing of pH is very important for microbial stabilization of wine, aroma and taste developments and shows that the wine become more acidic with the period of fermentation.

The drop in pH also records the utilization of the sugar present in must for growth. This observation is similar to that reported by Amerine et al., [10] and that of Obisanya et al., [11] during the fermentation of mango juice by *Saccharomyces cerevisiae*.

3.2. Tests for Titrable Acidity

Table 2. Titrable Acidity of the Fermenting Banana Wine (g/100ml).

Sample	Day		
	Day 3	day 5	day 6
Fermenting banana wine	1.56	1.58	1.6

The acidity of the fermenting must was increased from 1.56g/100ml in the three days to 1.6g/100ml at the 7th day as lactic acid. This result is found to conform to that of Sanni [12] who observed gradual increase in the titrable acidity and alcohol in fermentation of plantain. This increase in acidity is probably as a result of certain organic acids produced during fermentation [13].

3.3. Tests for Alcohol Content

Table 3. Alcohol Content of Fermenting Banana wine (%).

Sample	Day		
	day 3	day 5	day 6
fermented Banana wine	12	13.5	14

The result of alcohol content of 12% at three days to 14% at six days was recorded. The reason is that most of the fermentable sugars have been converted to alcohol. Also, toxicity of increased alcohol content produced made the yeast

inactive for more production [14]. Its final alcohol content was 14% mostly due to further conversion of residual sugars to alcohol is in agreement with normal alcoholic content of table wines which ranges from 10-14% [15, 16].

3.4. Tests for Specific Gravity

Table 4. Specific Gravity of Fermented Banana Wine.

Sample	Day		
	day 3	day 5	day 6
fermented Banana wine	0.98328	0.98263	0.98217

Specific gravity decreased due to conversion of sugar to alcohols since alcohols have less Specific gravity than sugar. The decrease was from 0.98328 on the 3 day to 0.98217 on the 6th day. This corroborates with P. I. Akubor, et al.[17] observations when he produced wine using banana (*Musa sapientum*) pulp.

3.5. Tests for Total Dissolved Solid

Table 5. Total Dissolved Solid of Fermented Banana Wine (mg/l).

Sample	Day		
	day 3	day 5	day 6
fermented Banana wine	2.7×10^4	1.3×10^4	5.5×10^3

The total dissolved solids decreased as the fermentation period increase. In the fermenter, the result is recorded for total dissolved solids as 2.7×10^4 at 3 days to 5.5×10^3 at 6 days. This observation is similar to that of Amerine et al., [18], they attributed this to the fact that a large percentage of the total dissolved colloids (soluble materials) were irreversible precipitated by fermentation and fed upon by fermenting yeast cells [19].

4. Conclusions

The results demonstrate that ripe banana can be effectively fermented into a stable wine with about 13–15% alcohol, low pH and moderate acidity, matching the typical physicochemical profile of table wines indicates that banana is a viable alternative feedstock for local wine production (especially in

regions like Ethiopia where grapes are limited). Using bananas for wine adds value to surplus or overripe fruit and can help alleviate raw-material shortages in the wine industry. In summary, the study confirms the feasibility of banana wine preparation and provides characterization data (pH, acidity, specific gravity, alcohol yield) that can guide its production and quality control in a scientific and practical manner as well as acceptable clarity.

Abbreviations

Musa spp.	Species Under the Genus Musa (Bananas)
CO ₂	Carbon Dioxide
TDS	Total Dissolved Solids
SG	Specific Gravity

v/v	Volume per Volume (Concentration Unit)
pH	Potential of Hydrogen
NaOH	Sodium Hydroxide
<i>S. cerevisiae</i>	<i>Saccharomyces Cerevisiae</i> (Yeast)
EtOH	Ethanol
Rpm	Revolutions per Minute
TTA	Titrateable Acidity

Author Contributions

Wabi Reggassa Boggale is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares that they have no conflicts of interest regarding the publication of this research work. No financial, personal, or institutional relationships influenced the study design, data collection, analysis, interpretation, or reporting of the findings.

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