Production of Wine from Banana

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ABSTRACT

Juice was extracted from banana (Musa sapientum) pulp with the addition of lemon juice and was inoculated with Baker's yeast (Saccharomyces cerevisiae) and held at 30 ± 2^{o}c for seven days. The result of the yeast count increases at 48hr, and at 96hr the yeast count decreased gradually. It ranges from $4.9x10^{7}$cfu/ml at 0hr, $5.1x10^{7}$ at the 48hr and $4.8x10^{7}$cfu/ml at 168hr. The pH of the Banana wine produced at the end of fermentation decreased (2.85) while the testable acidity of the Banana wine produced increased. The total dissolved solids, total suspended solids decreased with increasing length of the fermentation time of juice. The alcohol content of the wine increased with 14%.

1. Introduction

Wine is a product of alcoholic fermentation by yeast of the juice of ripe grapes or any fruit with a good proportion of sugar (Brook and Madigan, 2003; Okafor, 2007) [1]. Wine is one of the most recognizable high value added products from fruits. It can also be used as a substrate for the manufacture of vinegar, a by-product of wine manufacture.

Bananas *(Musa sapientum)* are an important staple starchy food in Nigeria. It is a seasonal and highly perishable fruit, which can be available all year round. The large quantity of bananas and plantains provides the potential for industrial use (FAO 2003). [2] In addition, any application to produce a marketable, value-added product will improve banana farming economies and eliminate the large environmental problem presented by banana waste. Banana could then compete in the market, either as banana juice or as mixtures with other juices because of its flavor and aroma (Lee *et al*. 2006). [3]

Bananas has a lot of nutritional benefits, thus demands in the market are high. They are highly recommended by doctors for patients whose potassium is low, because of its impressive potassium content. Potassium is an important component of cell and body fluids that helps control heart beat and blood pressure, countering bad effects of sodium. Banana is considered as an important food to boost the health of malnourished children, it contains good amount of soluble dietary fiber that helps normal bowel movements; thereby reducing constipation problems. Medicinal uses of banana have positive contribution towards successful treatment of anemia, heartburn, temperature control, ulcer, overweight

Banana juice can also be applied to wine production; however, banana juice is turbid, gray in color, very viscous, tends to settle during storage and, therefore must be clarified prior to commercialization (Lee *et al.*2006) [3] The turbidity and viscosity of banana wine are caused mainly by the polysaccharides in banana juice such as pectin and starch and therefore make the clarification process harder. Application of pectinase and α-amylases that affect the quality of wine is important for improving the process of banana wine production.

1.1 Background

Wine manufacture is challenging in which marketable product can be obtained, but the processes involved in its production are relatively straight forward (Obisanya, M. O *al.*1987) [4]

Highly acceptable wines can be made from practically all fruits. Wine can be fermented with yeast that occurs naturally in grape and in other countries where grape is not produced, emphasis is usually placed on other fruits for wine making. There are some soft fruits from both temperate and tropical regions whose pigment stability and flavor profiles match those of any wine from grapes, but suffer from the lack of intensive research and development given to grape wine.
Reports on tropical fruit wines have been mainly on exotic species such as banana, pineapple, citrus, mango, pawpaw, apple, strawberries e.t.c (Maldonado *et al*. 1975). [5] Wine represents a safe and healthful beverage; it also provides calories and vitamins. During period when life was often strenuous, it offered relaxation and relief from pains.

1.2 Statement of the problem

The problem statement indicates the production / manufacture of wine from banana through specific processes that includes the Juice (must) preparation, fermentation of the juice, Aging of wine, clarification, Packaging/ bottling of wine, quality evaluation of wine in terms of clarity / appearance, odour/ smell, taste and color.

1.3 Objective of the study

The general objective is to produce wine from banana and the specific objectives is to evaluate the qualities of the wineand to carry out or monitor yeast count during fermentation.

2. **Literature review**

2.1 History of wine making

The practice of wine making is as old as our most ancient civilization and wine has played a central role in human culture for more than 8000 thousand years. In contrast to food and beverages that spoil quickly or that can spread disease; wine doesn't spoil if stored properly; the alcohol in wine called ethanol is present in sufficient concentrations to kill disease causing microorganism, and throughout history, wine was often safer to drink than water or milk.(Bisson and Butzke, 2009) [6] This properly was so significant that before the connection between microorganism, poor sanitation and disease was understood, ancient civilization regarded wine as a gift from the gods because it protected against diseases. (Bisson and Butzke, 2009) [7]

A 2003 report by archaeologists indicates a possibility that grapes were used together with rice to produce mixed fermented beverages in China in the early years of 7000BC. Pottery jars were found to contain traces of tartaric acid and organic compounds commonly found in wine. (McGregor, *et al*. 2003) [8]

2.2 Origin of African Wines

The traditional alcoholic beverage of tropical Africa includes palm wines which are produced from saps of palms. Faparusi, (1973) and Okafor, (1972) [9] studied the micro flora of Nigeria palm saps and reported that it is a good source of yeast as well as bacteria and moulds. Recent investigations have shown that yeast strain *(Saccharomyces cerevisiae)* from fresh palm wine can be us in the production of acceptable wines from tropical fruits. (Aina and Soetan, 1986, Obisanya*et al.*, 1986) [10]. Palm wine is usually a whitish and effervescent liquid both of which properties derive from the fact that the fermented organisms are numerous and alive when the beverage is consumed. It differs from grape wines in that, it is opaque. (Okafor, 1978) [11]. Palm wines are produced in southern Nigeria, southern Ghana, Gabon, Congo and Zaire.

Agadagidi wines are made from bananas and plantains and have the opaque effervescent sweet-sour nature typical of African traditional alcoholic beverages and it is common in south-western part of Nigeria. (Okafor, 1978) [11]. Tej is another traditional alcoholic beverage also known as mead (that is a wine made by fermenting honey) of Ethiopian origin. (Okafor, 1978) [11].

Few tropical fruits already used for wine are citrus, pineapple, mango, apple, banana, e.t.c and the resultant wines are normally named after the fruit from which they are produced (for example, banana wine) and generally known as fruit wine. Others such as barley wine and rice wine(that is, sake), are made from starch-based materials and resemble beer and spirit more than wine while ginger wine is fortified with brandy (Okafor, 1972) [12]

The techniques used in production of wines from these tropical fruits are similar to those of grape wine production which includes; pressing out the juice, fermenting, maturing and bottling (Okafor, 1972) [12]

2.3 Classification of wines

According to Agrawal and Pradeep, (2006) [13] in their book titled Industrial Microbiology: Fundamental and Application, it was reported that wine is classified in three major categories;

1. Table wines, also called still or natural wines, are consumed primarily as complements to food.
2. Sparkling wines, for example champagne distinguishable by their effervescence, and are drunk for most part on festive occasions.
3. Fortified wines, such as sherry or vermouth, are most commonly drunk before or after meals and are also frequently used in cooking. These are termed fortified because their alcoholic and sugar content are increased and fermentation arrested by the controlled addition of a more

potent liquor; usually a grape brandy, during the wine making process; this results in an alcoholic content of 15-22% by volume as against 9-14% for most table wines.

Pearson, 1970 [14] reported in his studies that there are different types of wines and they include fruit wines, fortified wines, table wines and sparkling wines.Wine has also played an important role in medicine. Epidemiological studies have consistently demonstrated that moderate consumption of alcohol and wine is statistically associated with a decrease in death due to cardiovascular events such as heart failure, although excessive alcohol consumption has adverse health effects. (Lindberg and Amsterdam 2008) [15]. A 2007 study found that both red and white wines are effective anti-bacterial agents against strains of *Streptococcus.*(Daglia, *et al.* 2007) [16]. Also, a report in the October 2008 issue of *Cancer Epidemiology, Biomakers and prevention*, posits that moderate consumption of red wine may decrease the risk of lung cancer in men. Red Wine May Lower Lung Cancer Risk [17].

2.4 Properties of Banana fruit

Banana is a general term embracing a number of species or hybrid in the genus *Musa* of the family *Musaceae.* Banana is one of the most important food crops of the world which is consume extensively throughout the tropics which it is grown and also valued in the temperate zone for its flavor, nutritional value, and availability throughout the year. (Holmase*et al.*1990) [18]. Bananas (*Musa sapientum*) are an important staple starchy food of many tropical populations. Depending upon cultivar and ripeness, the flesh can vary in taste from starchy to sweet, and texture from firm to mushy. Both skin and inner part can be eaten raw or cooked. The fully ripe fruit is elongated and red or yellow in color. The skin is thick and soft and covers a firm edible tissue.

During the ripening process, bananas produce a plant hormone called ethylene, which indirectly affects the flavor. Among other things, ethylene stimulates the formation of amylase, an enzyme that breaks down starch into sugar, influencing the taste of bananas. The greener, less ripe bananas contain higher levels of starch and, consequently, have a starchier taste. On the other hand, yellow bananas taste sweeter due to higher sugar concentrations. Furthermore, ethylene signals the production of pectinase, an enzyme which breaks down the pectin between the cells of the banana, causing the banana to soften as it ripens. (Kunkee, 1967) [19].

2.5 Composition of Banana

The edible pulp of ripe bananas contains 70% water, 1.0% protein, 20% carbohydrate, traces of fat, micronutrients per 100g: iron 0.4mg, niacin 0.6mg and ascorbic acid 10mg.(Ihekoronye and Ngoddy,1985) [20] Normally, green fruit contains 1-2% sugars, mainly sucrose, glucose and fructose, and these increases to about 20% when the fruit is fully ripe. During the ripening phase, the flesh becomes softer owing to inter-conversion of pectic substances, pectin methyl esterase being the enzyme system involved. The banana fruit contains at least 200 individual volatile compounds, the most important being isoamyl acetate, amyl acetate, amyl propionate and amyl butyrate. Bananas' flavor is due, amongst other compounds, to isoamyl acetate which is one the main constituents of banana oil.

Banana has a lot of health benefits. The fruit contains good amount of health benefiting anti-oxidants, minerals and vitamins and are rich in calories but very low in fats. Banana pulp is composed of soft, easily digestible with simple sugars like fructose and sucrose that when eaten replenishes energy and revitalizes the body instantly; thus, for these qualities, banana are being used by athletes to get instant energy and as supplement food in the treatment plan for underweight children. The fruit contains good amount of soluble dietary fiber that helps the normal bowel movements; thereby reducing constipation problems and it is a very rich source of potassium. Potassium is an important component of cell and body fluids that helps control heart rate and blood pressure, countering bad effects of sodium. Banana fruits are sometimes known to cause skin and systemic allergic reaction, in "oral allergy syndrome" which causes itching and smelling in the mouth or throat within hours after digestion.

Bananas are eaten raw as dessert fruit and are eaten deep fried, baked in their skin in a split bamboo, or steamed in glutinous rice wrapped in a banana leaf. Bananas can be made into jam, pancakes and chips produced from sliced dehydrated or fried banana. (Akubor, *et al.* 2005) [21]

2.6 Raw Materials This section of the paper deals with the raw materials

2.6.1 Raw materials for wine Production

The various raw materials and chemicals that are required for the wine production are given as

- Banana fruit
- Sulfur dioxide (SO_2- 70 to 200 ppm)
- Pectinase
- Yeast (*Saccharomyces cerevisiae*)
- Water, sugar, ethanol, CO_2
- Flavouring agents: Alchohol, Esters, Fatty acids, carbon compounds
- Carbon sources: Fructose, Glucose
- pH maintaining agents: Tartaric acid, Malic acid, Citric acid
- Wood extractives
- Fining agents: gelatin, casern, isinglass, pectinase, albumin
- Metal Ion removal agents: potassium ferrocyanide (removes copper, iron, manganese, and zinc from wines).

3. Methodology

The main steps involves Viticulture, Harvesting, Stemming/Crushing, Fermentation, Draining , Pressing, Mixing, Clarification, Aging, Bottling.

3.1 Wine Production

In manufacturing wine, the major steps include the 'must' (juice) preparation (crushing and extracting the juice), fermentation, aging and storage, clarification and packaging. (Pederson, C.S, 1979) [22]

3.1.1 Juice ('Must') preparation

The raw material (fruit) can be peeled, and crushed if one desired to have a white wine or the peel and pulp are crushed together to get red or colored wine. It is then treated with sulfur dioxide (75 to 200ppm) to inhibit the growth of unwanted bacteria, and wild yeasts. (Frazier and Westhoff 1995)

[23]. Pectinase can be added to degrade the fiber content that is in the 'must' and make clarification easier and faster. (Amerine*et al.* 1980) [24]. After the juice extraction and sulfiting, the 'must' is then inoculated with a starter culture generally yeast (strains of *Saccharomyces cerevisiae*) interest, inoculation is usually 2-5% of wine yeast; a process known as pitching. The addition of water, sugar is required before pitching if there is any need if their levels are compared to the standards. (Amerine and kunkee, 1980) [25].

3.1.2 Fermentation

The fermentation process is the critical unit operation in the making of any wine and it can be done in two stages; the primary and secondary fermentations.In the primary stage, the contents of the fermenter are mixed twice daily and aerated. This encourages the growth of yeast and aid in the extraction of color for red wine. (Frazier and Westhoff 1995) [23] During the primary fermentation, must is fermented to ethanol, carbon dioxide, and flavor compound by the yeast added (Kunkee and Amerine, 1980) [25]

Later the mixing is discontinued to encourage anaerobic conditions that are most favorable to alcoholic fermentation (secondary fermentation). It is very important that the temperature is maintained within an optimal range that is between 24 and 27^{o}C for red wines during the active fermentation which takes about 3 to 5 days, and at 10 to 21^{o}C for white wine and (active fermentation take 7 to 14 days). This temperatures mentioned above must be maintained to produce the best aroma because excessively high temperature inhibits the wine yeast and permits competing organisms, for example, *Lactobacillus*, to grow and cause defects, too low a temperature slows action of wine yeasts and permit wild yeasts, lactic acid bacteria, and other organisms to grow. (Frazier and Westoff 1995) [23]. Flavor development of the wine is due to some flavours that come from the fruit and mostly comes from the yeast action.The flavor is due to alcohol, esters, fatty acid and carbonyl compounds but especially esters. (Nmema, 2010) [26]. During fermentation, there are a lot of sources and factors that affect the process which requires adequate attention and must therefore be taken into consideration to improve the quality of the wine that will be produced- the factors include:

a) The Yeast Strain:

Selection of the starter culture of yeast (*Saccharomyces cerevisiae*) to be used in the production of wine is very important and must be carried out or done with all accuracy required. Pure culture of wine yeast (*Saccharomyces cerevisiae*) in the form of packaged dry yeast or tube agar culture is now available for wine maker (McGregor*et al,* 1970) [7] listed twelve desirable characteristics of wine yeast

a) Efficient conversion of the fruit sugar to alcohol
b) Rapid initiation of fermentation (48 hours)
c) Sulfur dioxide ($S0_2$) tolerance
d) Ability to cause even fermentations
e) Ability to ferment at low temperature
f) Ability to ferment to dryness (alcohol tolerant)
g) Good flocculation after fermentation to aid in removal.
h) Production of a desirable bought
i) Low foaming
j) Low H_2S or marcaptan fermentation
k) For sensory quality of the wine, a relatively high glycerol production
l) Production of a relatively low amount of higher alcohol

b) Carbon Sources:

The sugar in must is mainly 15-25% fructose and glucose. These are excellent carbon source for yeast growth, sugar content of the must above 25% solids retards fermentation due to osmotic effect (Johnson and Peterson, 1974). Higher sugar content has been reported to prolong the fermentation time with less alcoholic production (Amerine*et al* 1980) [28] Yeast can also grow on a variety of other carbon sources especially aerobically.

1. Alcohol:

The yield of alcohol varies with the yeast strain, composition of must, fermentation temperature, amount of mixing through stirring and the design of the fermenter particularly the surface area to volume ratio (Kunkee and Amerine, 1972) [25]

2. pH Maintaing agents (Acids):

The pH of the must is very important in the fermentation process but little attention has been paid to the effects of fixed organics acid on the alcoholic fermentation of the must. The juice (must) have a pH of 3-4 due to tartaric acid, malic acid and small amount of citric acid (Nmema, 2010) [26]

If the pH of the must is lower than the 3, fermentation is somehow reduced; yeasts however, are not quite sensitive to the amount of fixed organic acids present in normal musts. These acids appear to inhibit the growth of many undesirable bacteria in the finished wine. The fatty acids that have inhibitory effects are fortunately very negligible in normal fermentation.

3. Carbon dioxide:

Carbon dioxide content of 7.2 atmospheres essentially stops yeast growth and a higher CO_2 pressure up to 30 atmospheres is necessary to prevent alcoholic fermentation from occurring (Amerine*et al*, 1972).

3.1.3 Aging

This is the period of maturation of wines and could last from few months to several years, (Johnson and Pederson, 1974). The taste quality of wine is improved during aging, wines with high acidity takes larger time to mature than those with less acidity but will eventually be superior since the acidity value ensures against deterioration (Amerine*et al* 1980) [27]

After fermentation, wine are transferred to wooden casks (100-1000gallons), barrels (50 gallons) or tanks (several thousand gallons) for aging, temperature of 11-16^{o}C is best for aging wines and aging lasts for 2-5 years depending on the type of wine.

During aging, desirable changes occur in the wine

a. Alcohol reacts with acids to form esters and tannins are oxidized.
b. Wood extractives add flavor to wine
c. Formation of lactic acid adds a rich flavor to the wine. (Nmema. 2010) [26]

The entire products, of maturation go a long way in contributing to the tastes of wine hence it becomes clear. Wines aged longer give better tastes and are even priced higher, for instance champagne (Pederson, 1971) [28]

3.1.4 Clarification

At the end of the aging period, some wine must have clear naturally, for others artificial clarification may be necessarily, this is done by adding fining agent, which will react with tannin, acid, proteins, etc to give coagulum’s which settles (Nmema. 2010). Fining is used to affect a rapid clearing of wines which will not clear naturally, to remove substance which would render the wine unstable after bottling, and to effect changes in the sensory properties (Amerine*et al*, 1980). [27]

Fining agents used in wine making include gelatin, casern, isinglass, pectinase, albumin etc. removal of metal ions is accomplished with potassium ferrocyanide known as “blue fining”. This removes excess copper, iron, manganese, and zinc from wines.

3.1.5 Packaging/Bottling

Wines may be bottled before or after aging depending on the producer. Most wines which are bottled before aging are the sparkling wines and the generally require filtration before the final bottling. Generally, wines are packaged in sterilized bottles of various shapes and sizes and then aged at about 12^{o}C (Amerine*et al.* 1980) [27]

3.1.6 Block Flowdiagram for banana wine production

BANANA

↓

WASHING

↓

WEIGHING, SLICING AND BLENDING

↓

ADDITION OF OTHER SUBSTRATES

↓

PITCHING

↓

FERMENTATION

↓

BOTTLING

Figure 1: Flow chart for Banana wine production.

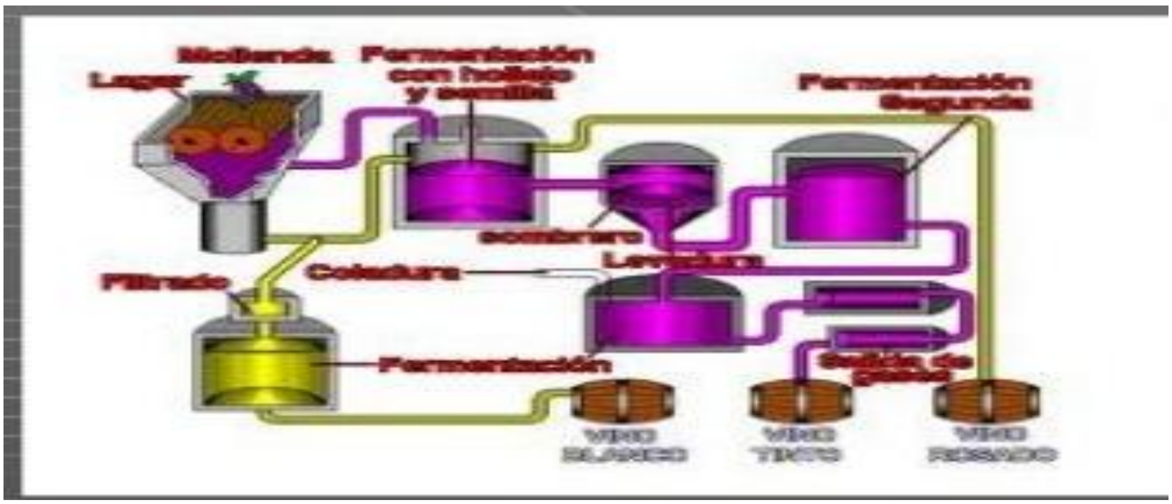

Fig 2 Block Flow diagram for wine production

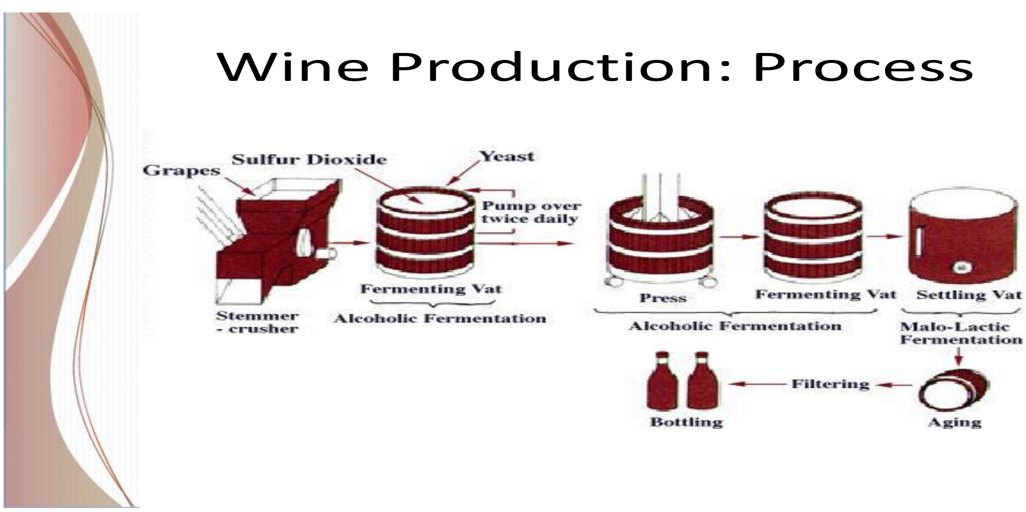

Fig 3 Wine Production process

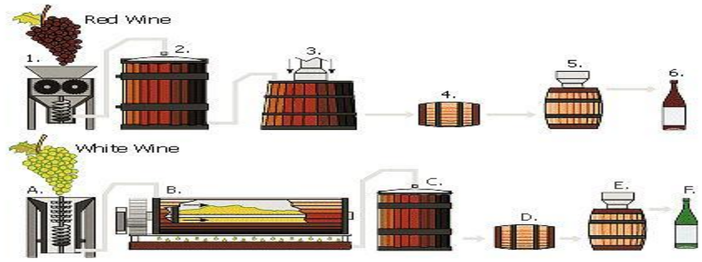

Fig 4 Red wine and white wine preparations

4.1 Materials &Detailed methodology of wine production

The above materials were purchased at the Chandigarh market, in the month of Augustand therefore brought to the biochemistry laboratory for analysis.

- Ripe bananas
- Ripe lemons
- Sugar
- *Saccharomyces cerevisiae*(baker's yeast)

4.2 Detailed methodology

4.2.1 Preparation of Juice ('Must)

- The ripe bananas were washed with distilled water.
- The bananas were thoroughly disinfected with cotton wool soaked in ethanol.
- Weighing of the banana fruit, sugar, lemon juice, yeast cells, distilled water with the following specification; 2.00kg of banana pulps, 5.00g yeast cells, 1.02kg sugar, 1.5kg lemon juice and 3L sterile distilled water was carried out.
- Each banana fruit were hand peeled.

- The edible portion was sliced with a stainless steel knife.
- The slices were blended with 100^{o}C hot water in a Super Mark blender.
- The slurry was filtered through a double folded cheese cloth to obtain the juice (must).
- The pH of the banana must was taken.

4.2.2 Banana Wine Fermentation

- Sugar, lemon juice (to enhance distinct aroma/flavor), and distilled sterile water was added to the banana must.
- 5g of dried yeast cells was inoculated into the banana must contain in a fermenter, a process known as pitching.
- The experiment was observed for seven days at 30 (+ -) 2^{o}C.

4.2.3 Analytical Assay

Sampling was carried out every 48 hrs for yeast count, total suspended solids, total dissolved solids, titrable acidity, pH determination, specific gravity and alcohol content.

4.2.3.1pH determination

- The pH meter was standardized with buffer solution.
- The buffer solution was prepared with pH buffer powder of pH 4.00 at 25^{o}C dissolved in 250ml distilled water.
- The electrode of the pH meter was immersed in a glass beaker containing the sample.
- Readings were obtained from the photo-detector of the pH meter.

4.2.3.2 Determination of Total DissolvedSolids

- A crucible was dried in the oven at 105^{o}C for 1 hour.
- It was placed in a desiccator after one hour and allowed to cool. The crucible was weighed.
- 20ml of the sample was filtered using 0.45 membrane filter paper.
- The filtrate was measured and poured into a weighed crucible.
- The crucible containing the filtrate was dried in the oven for 1 hour.
- After one hour, the crucible was placed in desiccator and allowed to cool for 1 hour.

- The crucible containing the dried sample was re-weighed.
- The total dissolved solids were calculated.

4.2.3.3 Determination of Total Suspended Solids

- A membrane filter paper was faintly marked on the edge with alphabets.
- The filter paper was dried in the oven at 105oC for hour and placed in a clean desiccator for one hour.
- The filter paper was weighed and the Millipore filtration apparatus was connected and flushed for five minutes to get rid of debris.
- Membrane filter paper was placed in the membrane filter holder and soaked with clean distilled water free of solids. This was tightening with the Millipore spanners. Five liters of water sample was flowed through the membrane filter and pressure was maintained at 40 pounds per square inch (psi).
- The set was uncoupled at the end of filtration and the membrane filter paper placed inside clean watch glass and sealed.
- The used membrane filter paper was dried in the drying oven at 105^{o}C for one hour placed in clean desiccator for one hour and re-weighed.
- Total suspended solids were estimated.

4.2.3.4 Specific Gravity Determination

- Using a 50ml density bottle, the sample was poured into the bottle and weighed thereby giving the mass.
- The mass was divided by the volume of the density bottle yo obtain the density.
- The specific gravity was estimated.

4.2.3.5 Titrable Acidity

- To 200mls of boiling distilled water in a 500ml Erlenmeyer flask was added 1ml of a 1% phenolphthalein indicator.
- The solution was titrated with 0.1M sodium hydroxide solution to a faint but definite pink colour; 5mls of the sample was titrated to a pink color with the 0.1M NaOH, using 3 drops of 1% phenolphthalein as indicator.

- The total acidity is expressed interms of lactic acid

4.2.3.6 Alcohol Content

- The refractometer method was used in determining the alcohol content.
- A clean dry applicator was used to place 2drops of the sample (must i.e., before fermentation) on the prism of the refractometer and the value (original gravity) of the refractive index taken.
- Also, after fermentation, 2drops of the sample was applied on the prism of the refractometer and the value (total gravity) was taken.
- The refractive index of the sample was taken on two days interval of time.

  $$\%\text{Alcohol by volume} = \frac{(1.05 \times O.G - T.G) \times 0.79}{T.G}$$

  Where O.G= Refractometryvalue before fermentation

T.G= Refractometervalue during and after fermentation.

4.2.3.7 Yeast Count

- Yeast load or counts was determined using sterile Malt Extract Agar.
- The medium was prepared according to specification and sterilized in the autoclave at 121^{0}c for 15 min before use.
- The medium was allowed to cool to 45^{0}C.
- 1ml of fermenting wine was inoculated into labeled Petri dishes.
- The ready to pour medium was aseptically poured into appropriate labeled Petri dishes after adding streptomycin antibiotics which acts by inhibiting the growth of Bacteria.
- Plates were allowed to set then inverted and incubated at room temperature for 48 hours after which the microbial count was done and recorded accordingly.

5. CONCLUSION AND RECOMMENDATIONS

As this project is a theoretical based project, during the course of this study, the project outcomes involves the analytical assays carried out which comprises of pH determination, titrable acidity, specific gravity, total dissolved solids, total suspended solids, alcohol content. The yeast count was also evaluated.

The result of the yeast count increases at 48hr, and at 96hr the yeast count decreased gradually. It ranges from $4.9x10^7$cfu/ml at 0hr, $5.1x10^7$ at the 48hr and $4.8x10^7$cfu/ml at 168hr, this observation is in contrast with that recorded who reported increase in the total yeast count throughout the fermentation of Kunutsamia' due to the fact that the fermentation is not an alcoholic one.

Appearance of *Saccharomyces cerevisiae* at 96hr and above during fermentation period agrees with the result of who observed that *S. cerevisiae* could strive under low pH. The result of the pH values in the experiment shows progressive decrease, this is recorded as 2.85 at 168hr for the wines produced. This shows that the wine became more acidic with the period of fermentation. The drop in pH also records the utilization of the sugar present in the must for growth. This observation is similar to that reported by Amerine*et al.,* (1980) [27] and that of Obisanya*et al.*, (1987) [29] during the fermentation of mango juice by *Saccharomyces cerevisiae.*

Results obtain in the study records that the alcohol content and titratable acidity increases with the period of fermentation. The result of the titratable acidity is recorded as 1.33g/100ml at 0hr to 1.60g/100ml at 168hr. The result of alcohol content of 11% at 0hr to 14% at 168hr was recorded. This result is found to conform and observed gradual increase in the titratable acidity and the alcohol content in the fermentation of plantain.

The total dissolved solids and total suspended solids decrease as the fermentation period increase. In the fermenter, the result is recorded for total dissolved solids as $2.5x10^4$ at 0hr to $5.0x10^3$ at 168hr and for total suspended solids as $1.33x10^5$ at 0hr to $2.2x10^4$ at 168hr. This observation is similar to that of Amerine*et al.,* (1980) [27] they attributed this to the fact that a large percentage of the total colloids (soluble materials) were irreversibly precipitated by fermentation and fed upon by the fermenting yeast cells.

The result of the sensory evaluation of the wine sample produced show that the wine produced is clear with slightly creamy color. The wine sample produced has a sharp sour taste with strong alcoholic odor/aroma. In texture, the wine produced was completely watery at the end of fermentation. This result is similar to that recorded by Amerine*et al.,* (1980) [27] that as fermentation rate proceeded, gas was formed and this rose through the liquid then during active fermentation, forth or foam is formed on the surface. The gas carries the cells through the fermenting must cause it to be cloudy and as a result, a strong odor of alcoholic fermentation developed.

The result of the banana wine produced by the fermenting with dried yeast strains (*Saccharomyces cerevisiae*) shows high rate of alcoholic production at the end of 168hr. This result is similar to the observation reported by Mestre and Mostre (1980) who recorded that pure culture of *Saccharomycescerevisiae*produces more ethanol and give a faster fermentation than the native yeast.

5.1 CONCLUSION

In conclusion, banana wine is very easy to produce and could then compete in the market with other wines because of its flavor and aroma. It has a lot of nutritional benefits, thus demands in the market are high and therefore help create job opportunities.

5.2 RECOMMENDATION

From the result of the work carried out, I recommend that producing wine from banana will generally satisfy medical needs of people especially elders because fresh Banana fruit has a lot of nutritional and medicinal qualities and, banana wine and all other wines should be drunk moderately.

5.3 SUGGESTIONS FOR FUTURE WORK

1. In this work, there was no blending of banana juice and wine with other fruit cultivars or different fruit juices. This may be done under enzymatic processing in future work to monitor if there may be better quality properties in banana juice and wine.
2. Amelioration may be one of the means to improve quality of banana wine further. This may include chaptalization (addition of sugar) to must to improve the alcohol content in wine, if so desired by the wine consumers.
3. Future work investigations may necessitate further studies to find out the most appropriate enzyme mixtures for viscosity reduction, the temperature and enzyme-mash contact time for maximum juice yields in various banana cultivars.
4. More research may be designed to investigate and establish when (after how long) the protease enzymes would actually cease to effect any further haze stabilization (clarification) in banana wine.

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