



WOLKITE UNIVERSTY
COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING
FINAL THESIS :PRODUCTION OF WINE FROM BANANA
FRUIT

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A final project submitted to college of engineering and technology, chemical engineering department, in partial fulfillment of requirement for bachelors degree in chemical engineering

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May, 2023
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DECLARATION

We declare that this project entitled “production of wine from banana fruit” is the result of our own project except cited as in the references.

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ACKNOWLEDGEMENT

Above all, we would like to thank the almighty God, the lord of the universe, for he provided us health, guidance, strength, patience and made all things possible for us to complete our project study successfully. This project came to reality with the strength he gave us and without whom all our successes could not have been practically possible. We would like to express our deepest gratitude to our head department Dr. Gebre for his continuous follow up, constructive comments, guidance, support and concern from the beginning in selecting title, project writing and up to the completion of this project work. Secondly, We would like to offer our sincere gratitude to our advisor Mr. Teshager for his valuable support continues follow up, crucial remarks, priceless suggestion and comments throughout the thesis work accomplish. Thirdly, our thanks also go to laboratory assistance helping and assist us in all direction during parameters analysis in laboratory of Food Process Engineering department. And finally, we are very grateful to our family for their encouragement, moral support, cost and patience.

TABLE OF CONTENTS

DECLARATION	I
ACKNOWLEDGEMENT	II
TABLE OF CONTENTS	III
LIST OF TABLES	VI
LIST OF FIGURES	VII
ABSTRACT	VIII
CHAPTER ONE	1
1. INTRODUCTION	1
1.1. Background	1
1.2. Statement of the Problem	2
1.3. Objectives	3
1.3.1. General objective	3
1.3.2. Specific objectives	3
1.4. Significance of the study	3
1.5. The Scope of Study	3
CHAPTER TWO	4
2. LITERATURE REVIEW	4
2.1. General over view of wine	4
2.2. Classification of Wine	6
2.2.1. Red wine	7
2.2.2. White wine	7
2.2.3. Rose wine	7
2.3. Uses of wine	8
2.4. Banana wine	9
2.5. Nutritional Value of Banana	10
2.6. Properties of Banana	10
2.7. Wine Manufacturing Technology	12
2.7.1. Harvesting and Preparing Grapes for Wine Making	12
2.7.2. Crushing and Maceration	13
2.7.3. Microbial Ecology and Spontaneous Wine Fermentations	14
2.7.4. Separation and Pressing	15
2.7.5. Fermentation	15

2.7.6. Adjustments, Blending, and Clarification	16
2.7.7. Aging	16
2.8. Banana wine making technology	18
2.8.1. Selecting the right/suitable banana varieties	18
2.8.2. Harvesting and ripening the banana fruit	18
2.8.3. Peeling and boiling the ripe banana	18
2.8.4. Filtering	19
2.8.5. Addition of other ingredients	19
2.8.6. Fermenting and maturing	19
2.8.7. Packaging and Preservation	19
CHAPTER THREE	21
3. MATERIALS AND METHODS	21
3.1. Procurement's and raw material preparations	21
3.2. Chemicals and Equipment	21
3.3. Experimental procedure	21
3.4. Characterization of Banana Wine	23
3.4.1. Determining PH	23
3.4.2. Density determination	23
3.4.3. Specific gravity	23
3.4.4. The Alcohol content	24
3.4.5. The Determination of sugar content (°Brix)	24
CHAPTER 4	25
4. RESULTS AND DISCUSSION	25
4.1. Result	25
4.2. Discussion	28
4.2.1. Discussion on the characterization of the produced wine	28
CHAPTER FIVE	30
5. MATERIAL AND ENERGY BALANCE	30
5.1. Material balance	30
5.2. Energy balance	32
CHAPTER SIX	34
6. CONCLUSION AND RECOMMENDATION	34
6.1. Conclusion	34
6.2. Recommendation	35

REFERENCES.....	36
APPENDIX.....	37

LIST OF TABLES

Table 1 : Average composition of banana	11
Table 2 : Procedure for acquiring data and wine characterization	22
Table 3 : Result of fermentation time	25
Table 4 : Result of PH	25
Table 5 : Result of density	26
Table 6 : Result of specific gravity	27
Table 7 : Result of alcohol content	28

LIST OF FIGURES

Figure 1 : wine production block diagram	17
Figure 2 : Relationship between time versus PH	26
Figure 3 : Relationship between time versus density	27
Figure 4 : Relationship between time and specific gravity	27
Figure 5 : Relationship between time and alcohol content	28

ABSTRACT

Ethiopia banana, also common as desert banana, is one of the mainstays of the economy. The crop occupies nearly 60% of all fruit production area in the country. Its total production level is 68 percent of all fruits. Fruits are processed to different products (juice, beer, figs, powder, flour, chips, flakes, jams, wine, gin, baking soda etc.). This production process was help to maximize the utilization of banana in different terms of product. As a result setting or developing alternative means for banana usage can alleviate or reduce the deformation of a banana and add value for the banana fruit through wine production. The ripened banana was peeled and immersed to be boiled in boiling water under a controlled temperature of 100°C for 10 minute then after banana juice and pulp separated by means of nylon cloth which serve as filtering media. In order to increase the juice °Brix sugar was added. Next to this, yeast preparation was done by taking a sample of concentrated banana juice into a baker for 10 minute under water bath system for fast propagation. Finally the propagated yeast was added into the banana juice to ferment according to the designed experiment. The experiment was planned to be done as follow based on the *Saccaromyces cerevisiae* working principle conditions: the Working temperature were at room temperature and Fermentation time from 7-13 days. Based on those two basic conditions, the experiment was done for 3 different times at room temperatures and fermentation time. (i.e the experiment was done at room temperatures and 7, 10, and 13 fermentation days). The produced wine was characterized by PH of 4.8 for 7 day fermentation, PH of 4.32 for 10 day fermentation, PH of 4.06 for 13 day fermentation, alcohol content of 3.6 for 7 day fermentation, 5.4 for 10 day fermentation, 6.3 for 13 day fermentation, and °Brix of 31.2 for 7 day fermentation, 22.7 for 10 day fermentation, 18.8 for 13 day fermentation was obtained.

Key words: *Banana, Wine, °Brix, Alcohol content.*

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Wine is by common usage defined as a product of the “normal alcoholic fermentation of the juice of sound ripe grapes”(Yabaya et al. (2016). Nevertheless any fruit with a good proportion of sugar may be used for wine production. Thus, citrus, bananas, apples, pineapples, strawberries etc., may all be used to produce wine. Such wines are always qualified as fruit wines(Joshi et al, 2017). If the term is not qualified then it is regarded as being derived from grapes. The production of wine is simpler than that of beer inthat no need exists for malting since sugars are already present in the fruit juice being used. Mostpeople think that wine can be prepared from only grape, but the reality is it can be produced fromany fruits. The development of wine starts long time ago (Alonso & Liu, 2012). Besides grape wines we have rice wines and innumerable fruit wines, of which some of the best-known are pomegranate wine, banana wine and blackberry wine. In this paper banana was used as a raw material for the production of wine. Fruit wines are fermented alcoholic beverages made from a variety of base ingredients, they may also have additional flavors taken from fruits, flowers and herbs. Banana wine is one of fruit wine made from the juice of banana. Fermentation of banana juice takes place in temperature controlled vats. The result is a soft, dry, fruit wine with a strong pineapple bouquet. banana juice consists of water, carbohydrates, organic acids and trace amounts phenolic, vitamins, minerals and nitrogenous compounds. The sugars, organic acids and phenolic give the juice its flavor, while the vitamins, minerals and nitrogenous compounds are, in many cases, essential to yeast growth and fermentation. Wine is an alcoholic beverage typically made from fermented fruit juice (Saranraj et al. (2017)). 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 (Matei, 2017).

Banana:- Banana (*Musa Sapientum*) is a fruit common in the tropics and is non-seasonal. It is readily available in Ethiopia. Due to its high sugar content, it is suitable for the production of wine (Idise, Okiemute Emmanuel* and Odum, Edward Ikenna, 2011). 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. Bananas flavor is due, amongst other chemicals, to isoamyl acetate which is one of the main constituents of banana oil (Ji and Srzednicki (2013). Bananas were originally found in South East Asia, mainly in India. They were brought west by Arab conquerors in 327 B.C. and moved from Asia Minor to Africa and finally carried to the New World by the first explorers and missionaries to the Caribbean. The mass production of bananas started in 1834 and really started exploding in the late 1880's. Before the 1870's most of the land that bananas were grown on in the Caribbean had been previously used to grow sugar. After this time low marsh land started to be drained along with forests that were cleared in Central America for banana monocrops (which is growing one crop to increase productivity). In the early years of Central American banana trade the head of United Fruit had a marriage for political gain to the daughter of the Costa Rican President.

1.2. Statement of the Problem

Most of the time wine produced in Ethiopia from grape but grape grown in limit area or agro-ecological and in addition that it is seasonal. Because of this there is a lack of wine for the matter of insufficient availability of raw materials. But Ethiopia has a good agro-ecological for banana production for year-round. So, if wine produced from banana sufficiently it can be distributed to the demand with low cost. According to the Ethiopian Horticultural Development Association, at least 11,400 farmers are involved in the project in a land covering 3100 hectares in the Southern Nations, Nationalities, and People's region. But the farmers sell raw banana in small price beside this if it get ripe need at their hand they sell it even at low price to brokers or selling agents or it gets perished due to these the farmers face a great challenge in the competitive market. As a result setting or developing alternative means for

banana usage can alleviate or reduce such a threat and add value for the banana fruit through wine production.

1.3. Objectives

1.3.1. General objective

- The general objective of this study is to Produce wine from banana.

1.3.2. Specific objectives

- Raw material preparation for banana wine.
- To produce wine from banana and determine some characteristics of wine (PH, alcoholic content, specific gravity, density).
- Analyzing the effect of fermentation parameter like; Temperature and Retention time.

1.4. Significance of the study

The significance of this study is Knowing wine production process clearly, to develop additional way of using banana, to reduce the decay of banana, to determine health benefits of banana wine, and to enhancing job opportunity for society.

1.5. The Scope of Study

This project work ranges from raw material preparation, characterization through studying effect of fermentation parameter up to characterization of fermented wine.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. General over view of wine

Wine is alcoholic beverage produced from grapes of various species. It is produced by fermentation of the juice of grape. However, Wines is produced from other fruits, such as apples and berries, are usually named after the fruit from which they are produced combined with the word "wine" (for example, apple wine and elderberry wine) and are generically called fruit wine or country wine (not to be confused with the French term vin de pays). Besides the grape varieties traditionally used for wine making, most fruits naturally lack either a high amount of fermentable sugars, relatively low acidity, yeast nutrients needed to promote or maintain fermentation or a combination of these three characteristics. This is probably one of the main reasons why wine derived from grapes has historically been more prevalent by far than other types and why specific types of fruit wine have generally been confined to regions in which the fruits were native or introduced for other reasons. Other wines, such as barley wine and rice wine (e.g. sake), are made from starch-based materials and resemble beer more than wine, while ginger wine is fortified with brandy. In these slater cases, the term "wine" refers to the similarity in alcohol content rather than to the production process. The commercial use of the English word "wine" (and its equivalent in other languages) is protected by law in many jurisdictions. Wine is made basically by fermentation of grapes, during which their sugar content, or part of it, is converted into ethanol and carbon dioxide by yeast. Traditionally, the natural yeasts on the grape skins are used, but in modern industrial wine making yeast may be added. White wine is made by fermenting only the grape juice obtained by pressing grapes. To make red wine, the grapes are crushed, and fermentation takes place before the juice is separated from the residue. Rose wine is made by fermentation beginning when the grapes are crushed; however, the juice is run into a separate vat after a short time. Red wine gets its color from the skin of the grapes, and its chemical composition is altered due to the presence of tannin's in the skin. The sweetness of the wine depends

on the sweetness of the grapes and on the length of fermentation; in the production of sweet wines, fermentation must be stopped before all of the sugar is converted into ethanol. In this way juices and wines made from various fruits are discussed. As a guideline to this research project, common parameters and methods were looked at. Bananas belong to the family pg. 14pg. 15 Musaceae and genus *Musa*. *Musa* spp. already provided Man with food, tools and shelter prior to recorded history. This is the major crop of West and East Africa and is grown in some 120 countries throughout the developing world. 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. In addition, any application to produce a Marketable, value-added product will improve banana farming economics and eliminate the large environmental problem presented by banana waste. 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 (Kiple & Ornelas, 2000). 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. In this chapter juices and wines made from various fruits are discussed. As a guideline to this research project, common parameters and methods were looked at. Bananas belong to the family Musaceae and genus *Musa*. *Musa* spp. (Lopes et al., 2020). This is the major crop of West and East Africa and is grown in some 120 countries throughout the developing world. It is a seasonal and highly perishable fruit, which can be available all year round (Orsini et al., 2013). The large quantity of bananas and plantains provides the potential for industrial use. In addition, any application to produce a Marketable, value- added product will improve banana farming economics and eliminate the large environmental problem presented by banana waste (Alzate Acevedo et al., 2021). Banana could then compete in the market, either as banana juice or as mixtures with other juices because of its flavor and aroma (Ezemba & Archibong, 2022).

2.2. Classification of Wine

A typical wine contains ethyl alcohol, sugar, acids, higher alcohols, tannins, aldehydes, esters, amino acids, minerals, vitamins, anthocyanins, minor constituents like flavoring compounds etc. (Amerine et al., 1980). This product is probably the most ancient fermented beverage and was mentioned in the Bible and in other documents from Asian countries. Depending upon the various attributes such as cultivar, stage of ripening of fruits, chemical composition of juice, use of additives to the must, vinification techniques and ageing of wine, the alcohol and sugar content, the wines are classified as natural wines (9-14 % alcohol) and dessert and appetizer wines (15-21 %alcohol). Dry wine, sweet table wine, specialty wine, champagne, muscat and burgundy wines are natural wines while sweet wine, cherries, vermouth and port wines are regarded as dessert and appetizer wines (Amerine and Singleton, 1972). The most famous types of wines are red and white wines, followed by rose and sparkling wines. There are other wine specialties around the world, such as the Portuguese Port Wine, a very rich flavor, often used by chefs in their signature dishes. Many types of wines can be divided into several groups, which are easy to remember. Depending upon product manufacturing all wines can be classified as grape wine, fruit wine, berry wine, vegetable wine, plant wine, raisin wine etc. Grape wine is made exclusively from grapes and during the production process prohibited from using any other materials (exception is made only for sugar and oak barrels). Fruit wines are fermented alcoholic beverages made from a variety of base ingredients other than grapes; they may also have additional flavors taken from fruits, flowers, and herbs. These types of wines are made from pear, apple, banana, papaya, mango, jackfruit juice etc. Cherry wine is produced from cherries, usually those cherries that provide sufficient acidity to wine. Plant wine is produced from juice of trees like maple, birch, melons, watermelons, and other garden plants such as rhubarb, parsnips and rose petals. Raisin wine is made from dried grapes (raisins). Multi sort wine is produced by mixing different kinds of grapes and wine materials (Journal of Food Research and Technology July-September). Depending on the time of fermentation grape varieties and color fruit wines are classified as in red, white and pink wines.

2.2.1. Red wine

Red wines are produced slightly differently than white wines. After crushing the skins are left in the fermentation to allow for color extraction. Like white wines, the alcoholic fermentation commences either through the action of indigenous yeasts or via direct inoculation of a starter culture. During the fermentation the grape material tends to float to the top of the vat forming a “cap.” To better enable extraction of red pigments and to influence wine flavor, winemakers typically punch down the cap or pump juice from the bottom over the cap. After a suitable period of time, the wine is separated from the grape skins and the fermentation is completed in another vessel. As described for white wines, the red wine is now “dry” and devoid of the main juice sugars.

2.2.2. White wine

For white wines the grape juice is separated away from the skins and clarified via cold settling, filtration or centrifugation. The juice is then moved to a barrel or fermentation tank and the alcoholic fermentation is carried out by yeasts indigenous to the juice, or via inoculation of a selected *S. cerevisiae* starter culture. White wine fermentations are typically carried out for roughly one to two weeks at temperatures around 10 to 18 °C. Upon consumption of available glucose and fructose, the main sugars in grape juice, the wine is considered “dry” and separated from the yeast and grape lees (sediment).

2.2.3. Rose wine

Rosé wines are expected to be pale pink, cherry, or raspberry colored, without shades of blue. The actual shade depends on the amount and type of anthocyanins found in the cultivar(s) used. Part of this probably relates to their possessing the bitterness but not the flavor of red wines, while not exhibiting the fresh crispness or fruitiness of white wines. To achieve the desired color, the duration of skin contact is sufficient to extract bitter phenolics. Correspondingly, most rosés are processed to be semi-sweet to mask their bitterness. Carbonation is often used to increase their appeal as a cool refreshing drink. Both features augment their negative connotation among wine fanciers. To counter the denigration associated with the name rosé, some

ostensively „rosé“ wines are now termed “blush” wines. Depending upon product manufacturing all wines can be classified as grape wine, fruit wine, burly wine, vegetable wine, plant wine, raisin wine etc. Grape wine is made exclusively from grapes and during the production process prohibited from using any other materials (exception is made only for sugar and oak barrels). Fruit wines are fermented alcoholic beverages made from a variety of base ingredients other than grapes; they may also have additional flavors taken from fruits, flowers, and herbs. These types of wines are made from pear, apple, banana, papaya, mango, jackfruit juice etc. Cherry wine is produced from cherries, usually those cherries that provide sufficient acidity to wine. Plant wine is produced from juice of trees like maple, birch, melons, watermelons, and other garden plants such as rhubarb, parsnips and rose petals. Raisin wine is made from dried grapes (raisins). Multi sort wine is produced by mixing different kinds of grapes and wine materials. [Wine tasting professional hand book by Ronald .S Jackson ref 4].

2.3. Uses of wine

Wine has been giving pleasure to people for over 8000 years. Indeed, it may have been significant in human life even before bread was being made. It is perhaps more than any other drink a product which has a substantial and far-ranging symbolic significance. Wine was perceived to be a foodstuff, it has a calorific value, and had some dietary benefits. There is a generally accepted relationship between the organoleptic pleasure offered by both food and wine. Louis Pasteur, one of the pioneers of modern oenology, argued that ‘a meal without wine is like a day without sunshine. In the sense that a good ‘lifestyle’ is predicated on the context of an advanced society, and perhaps even of refinement, then wine as a lifestyle drink can still be seen to reflect a civilized life. The Hearst Papyrus from ancient Egypt (1550 BC) serves as one of the oldest materials to document wine being used as a therapy. In the Old Testament, wine was mentioned as a remedy, wound dressing and medicine. The Talmud suggests that wine comforts, 45 refreshes and is nutritious and its health impact is such that if it is absent then medicines are required . A seventh century Greek author described wine as the best remedy for fatigue, distress, pain and sorrow, entities now treated with painkillers, sedatives and

Prozac. The moderate consumption of wine, particularly with a meal, offers protection against atherosclerosis, moderate blood pressure, used as a medical dressing and a water sanitizer by killing pathogenic bacteria, stimulate appetite, particularly in those recuperating from disease, those with wasting illness, and the elderly. Wine has symbolic roles for identifying, describing, constructing and manipulating cultural systems, values, interpersonal relationships, behavioral norms and expectations. Choice of beverage is rarely a matter of personal taste. In three ways, perhaps, wine has a metaphorical use. The first, very directly, is in the matter of religious faith. From the era when sacrifice required that blood was shed wine, as a deep red-colored liquid, was capable of representing a sacrifice. The second way in which wine can act metaphorically is to denote civilization. As such it promotes harmony, an appreciation of the finer aspects of life – especially good food and the arts – and its rituals and the sharing it entails encourage polite and respectful behavior. Thirdly, wine can be seen to symbolize heritage and identity.

2.4. Banana wine

Banana is a tropical fruit belonging to the family Musaceae and genus *Musa* spp. which is grown abundantly in India. Already provided man with food, tools and shelter prior to recorded history. Banana is the fourth most important crop after rice, wheat and maize and international trade in bananas is valued at around US\$5 billion per annum (Sunday Monitor, 2007). Traditional banana juice extraction and its subsequent fermentation to produce beer (tonto) is an important social and economic activity among many tribes of East Africa (Stover and Simmonds, 1987). (Journal of Food Research and Technology July-September, 2014 | Vol 2 | Issue 3 | Pages 93-100 © 2014 Jakraya Publications (P) Ltd). 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 consumed 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. (Holmaseet al.1990). 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).

2.5. Nutritional Value of Banana

Bananas are an excellent source of potassium. Potassium can be found in a variety of Fruits, vegetables, and even meats, however, a single banana provides you with 23% of the potassium that you need on a daily basis. Bananas are also an excellent source of vitamins, including: vitamin A - aids in healthy teeth, bones, soft tissue, and more, vitamin B6 - aids the body's immune system, promotes brain health, heart health, and more, vitamin C - aids in healing, growth of tissue, ligaments, and more, vitamin D - Helps the body to absorb calcium as it can be seen by the vitamins present, bananas aid in keeping the body healthy in a number of ways, but there is a major benefit to the bones and muscles in the human body. Bananas provide you with many health benefits, but in addition to all of that, most people enjoy eating bananas as well. Banana can be eaten alone or combined with a fruit salad, made into a smoothie or a milkshake. They are one of the most affordable fruits in the marketplace and can be found year round nearly everywhere in the world! (Kandasamy & Shanmugapriya, 2015).

2.6. Properties of Banana

The fruit has a mild laxative property like; is used as a remedy of constipation in children, forms the part of diets of children suffering from malnutrition, the core of the stem is believed to be useful in stomach upset and diabetes, and the fruit is believed to reduce the worm problems.

source:(Aziz & Sharma, 2001).

Table 1: Average composition of banana.

Water	74.2 g
Energy	92 kcal
Fat	0.48g
Protein	1.03g
Carbohydrates	23.43
Fiber	2.4g
Potassium	396mg
Phosphorous	20mg
Iron	0.31mg
Sodium	1mg
Magnesium	29mg
Calcium	6mg
Zinc	0.16mg
Selenium	1.1mg
Vitamin C	9.1mg
Vitamin B1 thiamin	0.045mg
Vitamin B2 riboflavin	0.10mg

2.7. Wine Manufacturing Technology

Making wine, as far as the actual steps are concerned, looks to be a rather simple and straight forward process. Grapes are harvested and crushed, the crushed material or juice is fermented by yeasts and bacteria, the organisms and insoluble materials are removed, and the wine is aged and bottled. In reality, the process is far from easy, and each of these pre-fermentation, fermentation, and post-fermentation steps must be carefully executed if high-quality wine is to be consistently produced (Conde et al., 2007).

2.7.1. Harvesting and Preparing Grapes for Wine Making

According to both viticulturists and ecologists, the first step in wine making is considered to be one of the most important. Grapes must be harvested at just the right level of maturity. This means that the concentrations of sugars and acids (and the sugar/acid ratio), pH, the total soluble solids, and even the phenolic constituents must be at just the right level for the particular cultivar and the type of wine being made. In addition, berry size and weight also influence the time at which grapes are harvested. In general, grapes should be sampled sometime before their expected harvest time and their composition assessed (at minimum °Brix and pH should be measured) to make sure that over-ripening does not occur. Unfortunately, there is no exact or objective set of rules to ensure or predict the optimum time for harvesting grapes. Rather, grapes are frequently harvested based on more subjective criteria. As grapes ripen on the vine, the sugar concentration, as well as flavor and color components, increase, and acids usually decrease, so identifying the correct moment for harvesting can be a real challenge. It is possible, moreover, for grapes to over-ripen, such that the harvested grapes contain too much sugar or too little acid or be too heavily contaminated with wild yeast and molds. Once the grapes have been deemed properly mature, it is essential that they be picked and harvested quickly, since the composition can continue to change. Even in this twenty-first century, when so much of modern agriculture has become automated and mechanized, a sizable portion of grapes for wine making is still harvested manually. Only recently has mechanical harvesting begun to displace manual harvesting. In the United States, the majority of grapes are now harvested by mechanical means; however, manual picking of

grapes is still done for premium quality American wines and in much of Europe.

2.7.2. Crushing and Maceration

The purpose of crushing is to extract the juice from the grapes. Before the grapes are crushed, however, leaves, large stems, and stalks are removed. crushers consist of a pair of stainless steel cylinder shaped rollers. Another type of crusher, called the Garolla crusher, not only performs the crushing step, but also removes stems. It consists of a rotating shaft contained within a large horizontal stainless steel cylinder or cage. Arms on the shaft are attached to paddles or blades such that when the shaft turns, the grapes are moved and pressed against the side of the cylinder. Perforations on the walls of the cylinder allow for the juice (along with the skin, seeds, and pulpy material) to pass through into collectionvats, whereas the stems gather at the end.

The crushed grape material, as noted above, contains juice, seeds, and skins. Pigments, tannins, and other phenolic compounds are located in the skins and seeds, and their extraction into the juice takes time. Endogenous pectinases and other hydrolytic enzymes within the grapes enhance extraction and must also be given time to work. This extraction step, where the crushed grape material is allowed to sit, is referred to as maceration. Maceration conditions are not the same for all wines. For red wines, where pigment extraction is especially important, long maceration times at high temperatures are usually employed. In general, maceration is done at around 28°C for up to five days. The shorter the maceration times and the lower the temperature, the less material will be extracted. Thus, lighter red wines, such as Beaujolais, are macerated for just a few days at no higher than 25°C. In contrast, deeper red wines, such as Bordeaux, are macerated for up to twenty eight days at 30°C. Since fermentation begins shortly after the grapes are crushed, maceration and fermentation essentially occur at the same time. In fact, the ethanol made by fermenting yeasts enhances extraction. This situation only occurs, however, if the musts are not treated with sulfur dioxide. As noted above, maceration at low temperatures (<15°C) ordinarily results in only moderate pigment extraction and little fermentation. However, if they must macerated at a low temperature (between 5°C and 15°C), but for longer time, extraction of

anthocyanins and aroma and flavor compounds can be enhanced. This technique, called cold maceration, simulates the natural conditions in cooler wine-producing areas, such as the Burgundy region of France. For white wines, the maceration step is done at lower temperature and for much less time. Typically, only a few hours at 15°C is sufficient. For most white wines, the producers remove the seeds and skins immediately after crushing. As for red wine, the maceration conditions used for white wines influence the amount of pigments and tannins that are extracted. Wines made from Sauvignon grapes where little maceration occurs typically have a low phenolic concentration, whereas Riesling and Chardonnay musts, which are often macerated in the cold, may contain appreciable amounts.

2.7.3. Microbial Ecology and Spontaneous Wine Fermentations

In the absence of SO₂ addition, the indigenous micro flora is relied upon to initiate and then carry out a spontaneous or natural fermentation. This is one of the best studied of all fermentations, and much is now known about the ecology of wine and the yeasts that participate in the wine fermentation. In reality, however, the yeast fermentation is but one of two distinct fermentations that occur in wine making. Yeasts, of course, ferment sugars to ethanol, CO₂, and small amounts of other end products. A second fermentation, called the malolactic fermentation, is carried out by specific lactic acid bacteria that are either naturally present or added for this purpose. The malolactic fermentation, to be discussed later, is now regarded as nearly as important to wine quality as the ethanol fermentation. As noted above, the surface of grapes usually contain less than 10⁴ yeast cells per grape (or per ml of juice). This number may increase during ripening on the vine, especially if the temperature is warm. Although ten or more yeast genera may be represented, the primary organism most frequently isolated from grape surfaces and the fresh must is *Kloeckera apiculata*. In contrast, *S. cerevisiae*, the yeast most responsible for the wine fermentation, is rarely observed on grapes. Rather, *S. cerevisiae* and other related strains are introduced into the must during grape handling and crushing steps directly from the equipment.

The most is inoculated, in other words, by the yeasts originating from the grape surface as well as by those residing on the winery equipment.

2.7.4. Separation and Pressing

After the maceration step, or in the case of most white wines, almost immediately after crushing, the juice is separated from the seeds, skins, and pulp (collectively referred to as the pomace). For red wines, some fermentation will have already occurred prior to the separation step, whereas for white wine, fermentation follows the separation and clarification steps. The juice that separates from the pomace simply by gravitational forces is called the “free run.” Screens are typically used to catch any large particles. The free run juice is pumped into vats or barrels. Since the free run juice contains less than 75% of the total juice volume and the rest is present within the pomace, the latter is usually pressed to recover the remaining juice. Several types of presses and configurations are used. Hydraulic or pneumatic wine presses squeeze the juice from the pomace. Screw- or auger type devices force the juice against perforated cylinder walls and have the additional advantage of being continuous. The so-called first press juice can be collected and either added back to the free run juice or kept as a separate portion. The free run fraction is considered to have an appreciably higher quality and is used for premium wines. Juices containing mixtures of free run and pressed fractions are used for lower quality wines. Finally, for white wine, the juice is clarified to remove any remaining solids. Clarification is done via settling and decantation, filtration, or centrifugation.

2.7.5. Fermentation

The wine fermentation begins as soon as the grapes are crushed. However, when a starter culture is used and SO₂ is added to control the indigenous organisms, limited ethanol fermentation is occurred prior to addition of the culture. In the case of white wine production, the culture is added to the must after pressing and clarification, whereas for red wine, culture addition is doing prior to seed and skin removal. Thus, for red wines, fermentation occurs during maceration, just as it would for a natural fermentation. Traditionally, fermentations is performed in open barrels or vats with a capacity of 500 L or

less. Such barrels still are used today; however, enclosed stainless steel tanks are now more common.

2.7.6. Adjustments, Blending, and Clarification

After the fermentation is complete, the wine has contain little or no sugar and about 12% to 14% ethanol. Still, because of differences in grape composition, microflora, and wine manufacturing practices, variations in wine composition and sensory quality are to be expected. Therefore, adjusting the wine after fermentation (and sometimes before) is a normal step. Except for very small wineries, which may have only a few vats of wine, most modern wineries have many individual vats of wine. Each one is unique, in that a particular vat may contain wine made from grapes harvested at a time or place different from the grapes in a neighboring vat. Wines within a single winery may be made from different grape varieties. Therefore, another common procedure, especially for premium wines, is to blend different wines to optimize or enhance the organoleptic properties. Blending also produces wines with consistent flavor, aroma, and color from year to year. Filtration is another method used to clarify wine. This can be especially effective if fining agents, such as bentonite, albumin, or gelatin, are used as filtration aids. If micropore filtration membranes are used, it is even possible to sterilize wines. Clarification may occur after racking or after aging.

2.7.7. Aging

Aging actually begins just after fermentation. Thus, aging occurs when the wine is racked, as well as beyond. Aging conditions vary considerably. Some wines are aged for several years, whereas others are “aged” for only a few weeks. Some wines are aged in expensive oak barrels, others in stainless steel, and yet others depend on bottle-aging, or a combination of all of the above. Thus, long, careful aging should be reserved for only premium wines made from high quality grapes. By analogy, Cheddar cheese manufactured for the process cheese market cannot be expected to develop into a flavorful, two-year Cheddar, no matter how carefully it may have been aged.

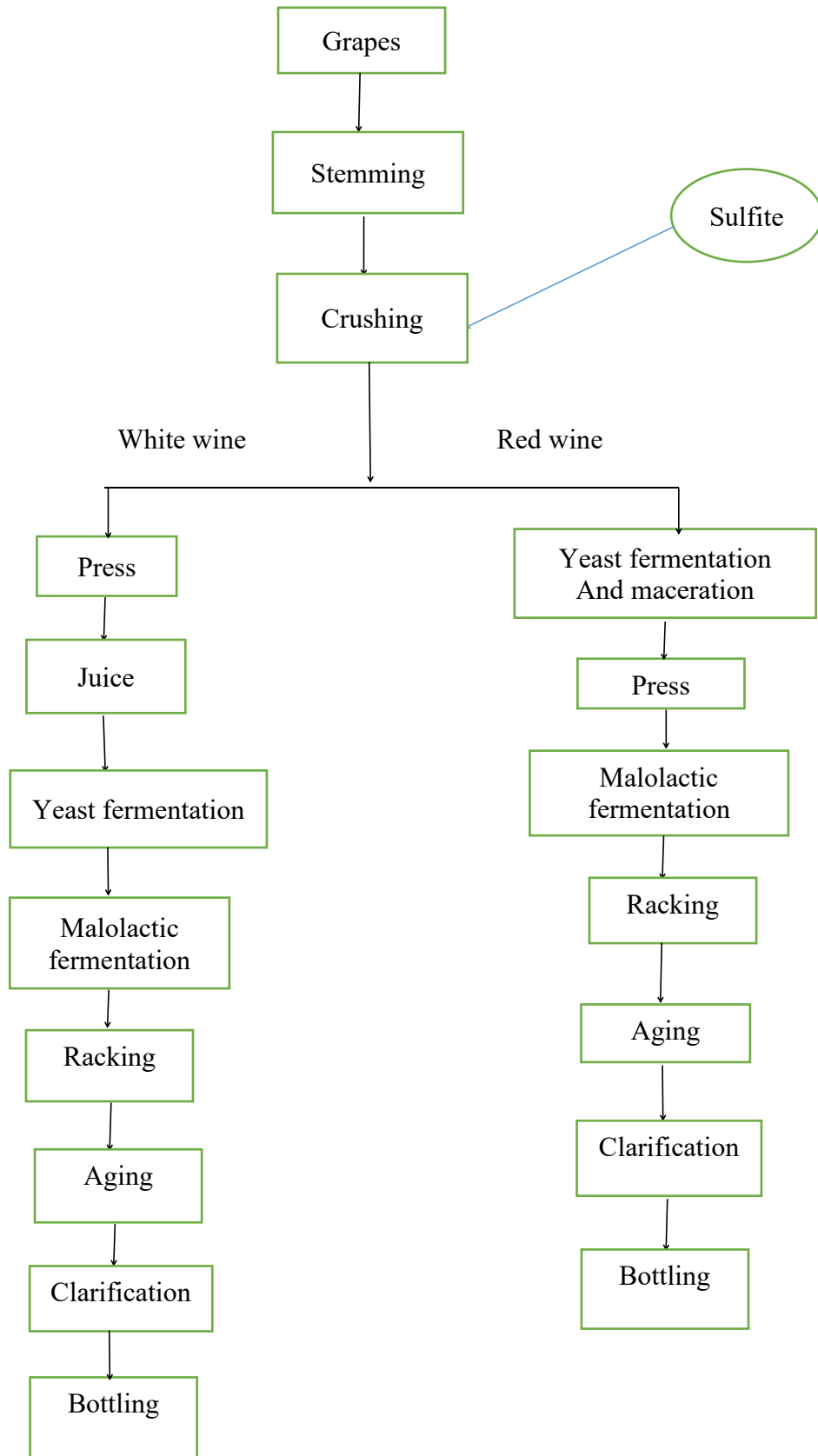


Figure 1: wine production block diagram

2.8. Banana wine making technology

The wine making process involves a series of simple steps, each of which has to be done correctly for one to achieve good results. To make the final product safe and appealing to consumers, the processor has to maintain a high level of hygiene throughout the entire process. The banana and all the equipment used should be cleaned, the environment in which the wine is made should be clean and the persons involved in the process should be clean and free from communicable diseases. The key materials and equipment needed for the process are; mature bananas, Sugar, Water, Yeast, Metallic cooking pans, Glass bottles, Nylon cloth, Plastic buckets, and Firm wooded stirrer.

Below are the key steps taken to make banana wine.

2.8.1. Selecting the right/suitable banana varieties

Banana wine can be made from most banana varieties irrespective of whether they are cooking, brewing or dessert type. A few varieties like Apple banana that remain hard even after ripening are not suitable for wine making.

2.8.2. Harvesting and ripening the banana fruit

Harvest a mature banana bunch and hang it over a fire place to allow it to ripen. Placing the banana over a fire place quickens the ripening process. Ripening can also be achieved by heaping bananas in a dry warm place or in a pit lined with banana leaves. The heap is then covered with multiple layers of fresh banana leaves followed by a thick layer of dry banana leaves to allow heat to accumulate within the heap. When fully ripe, the banana husk turns yellow and the pulp soft.

2.8.3. Peeling and boiling the ripe banana

Peel the ripen banana into a sack. As you peel, sort out and discard any split bananas since these may be contaminated. The husk will easily peel off if the bananas are fully ripe. Unripe bananas should not be used since these will not cook at the same rate as the ripe ones. Boil the bananas on moderate fire while stirring with a firm clean stick until the bananas can easily break when the stick is passed through.

2.8.4. Filtering

While the bananas are still hot, filter out the juice using a clean porous sack or cloth. To ensure that as much juice as possible is obtained, suspend the sack containing the banana and squeeze out the juice into a clean pan using a clean rope entangled around the sack. Take care not to be burnt by the steam from the banana. The banana pulp will remain in the sack or cloth and can be used to feed animals like poultry and pigs.

2.8.5. Addition of other ingredients

After filtering, add 1 kg of sugar, juice from two medium sized lemons, and 1g of yeast for every 1200 mililiters of the juice. Stir the mixture thoroughly for the sugar.

2.8.6. Fermenting and maturing

Put the juice in a covered bucket or Jeri can under a roof at room temperature for 3 days. Filter the juice through a fine white and clean nylon cloth to remove all the remaining residues that will have settled at the bottom of the bucket. If a large quantity of juice will be filtered at once, align a strong and clean porous cloth or sack on the lower side of the nylon cloth to reinforce it. Allow the juice to flow freely through the cloth without squeezing to avoid any sediment from passing through. To prevent the cloth from falling into the bucket during filtering, tie it firmly around the bucket. Keep the filtered wine in a covered bucket or Jerry can in a room at room temperature for 2-3 months to mature. During the maturation period, make a whole on top of the cover of the container to allow for aeration and prevent bubbling. Because insects may find their way into the container through this hole, insert one end of a long thin plastic tube into this hole and put the other end in a bucket of clean water. This way, any insect that will try entering the wine through the tube will drown in the container of water.

2.8.7. Packaging and Preservation

The mature wine should be packed in clean containers for storage and marketing. Proper packaging is necessary if the wine is to have a long shelf life and be appealing to consumers. Glass bottles are very suitable for packing

as they are easy to keep clean. The bottles in which the wine will be packed should be sterilized to ensure the microorganism load is reduced substantially.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Procurement's and raw material preparations

Mature and healthy banana fruit was obtained from Gubre which is found in Gurage zone around Wolkite University.

The sample preparation was done in Wolkite University College of Engineering in department of Chemical Engineering and Food engineering laboratory. During the sample preparation ,banana fruits was cleaned by hand to remove any foreign matters that come along with the fruits.

3.2. Chemicals and Equipment

Chemicals

Chemicals used for this experiment were: Baker's yeast (*saccharomyces cerevisiae*) which was used to convert the sugars in the fruit juice into alcohol and carbondioxide, sugar used as a food for the yeast, ripened banana, distilled water used to reduce chemical reaction during fermentation, and water. Some of the chemicals was purchased from the local market and laboratory analysis chemicals used from chemical engineering laboratory.

Equipment's

Equipment's used for this experiment were: mixer was used to mixing or homogenizing, knife used to reduce the size of sample, beaker used to hold sample, nylon cloth for filtration, stove was used for boiling, PH meter was used for reading PH, Refractometer for reading °brix, balance for balancing and alcohol-meter used to identify alcohol content of wine.

The produced banana juice has a sugar content of 12.9° brix, specific gravity of 1.05216, and PH of 5.3.

3.3. Experimental procedure

Ripen banana was selected and peeled then 2 kg was balanced and then reduced its size by using knife. Then 0.5L tab water was added and immersed then boiled on stove to kill micro organisms. Then after that it was cooled for

10 minutes and yeast was propagated. 2 litre of distilled water was added then mixed by using mechanical mixer to homogenize. After that filtration process was carried out by using nylon cloth and then 1Kg of sugar was added in order to increase the juice °Brix and also mixed by using mechanical mixer. Then after it was added to the beakers and 0.85g of baker yeast was added to the beakers. Then each of them were covered and fermentation process was started for three different days time intervals, the first days fermentation was stopped in 7 days, the second fermentation was for 10 days, the third fermentation was for 13 days. After 7, 10, and 13 days then filtered by using nylon cloth to stop fermentation process. Then the fermentation was stopped and their characteristic was recorded step by steps. After that we recorded the characteristics like PH, alcohol content, ° brix, specific gravity and density. Then packed by glass materials.

Working temperature 17-25°C

- Below 17°C the yeast was inactive and above 25°C the yeast was ineffective due to overheating (Cavallius & Merrick, 1998).

Fermentation time 7-13 day

- Below 7 day low fermentation yield and above 13 day yeast was dead and undesired product was collected

Table 2: Procedure for acquiring data and wine characterization

Time(day)	pH	Specific gravity	Alcohol content by weight	Alcohol content by volume	density
7					
10					
13					

3.4. Characterization of Banana Wine

After filtering and stopping the fermentation process of banana wine, the following term were characterized:

3.4.1. Determining PH

PH is a figure expressing the acidity or alkalinity of a solution on logarithmic scale on which 7 is neutral, the lower values are more acid and values are more alkaline(Boyd et al., 2011). PH was determined by cleaning and drying sample site of PH meter, then took sample of wine produced and measure or read PH(Undid et al., 2014).

Procedure

Before determining PH, the PH meter was adjusted by using distilled water. Then the distilled water was added to small beaker and putted PH meter in the beaker which contains the distilled water and wait until that solution was to be stable means the PH was until to be 7. After that the sample was measured by using the stabled PH meter and recorded the PH by subtracting the buffer solution PH from sample PH and recorded.

3.4.2. Density determination

Measuring the density of wine was used to identify specific gravity of wine. It was determined by measuring the mass of sample and volume, then divided the mass to volume(Semitela et al., 2019a).

Density= mass/volume

3.4.3. Specific gravity

Specific gravity of the wine was determined by dividing density of the sample to the density of water(Semitela et al., 2019b).

Density =mass /volume

Specific gravity =density of sample/density of water

Density of water is = 997 this approximately to 1000

Specific gravity has no unit.

3.4.4. The Alcohol content

To determine the ethanol concentration the sample was first filtered and decanted to remove the yeast and stop fermentation. After taking the supernatant, determination of ethanol level involves measurement of the sample by the use of alcohol meter. The standard alcohol content of wine was from 9% to 15% (la Porte et al., 2010). The alcohol content of the sample was determined by using alcohol meter (Estevão et al., 2021). The procedure was carried out by adding the sample to measuring cylinder and measured by alcohol meter recorded that value.

3.4.5. The Determination of sugar content (°Brix)

Sugar in wine are at the heart of what makes wine making possible. During fermentation, sugars from banana are broken to alcohol (ethanol) and carbon dioxide (MONCALVO, 2013). Sugar content of the product was determined by using refractometer read the brix degree (Magwaza & Opara, 2015).

Procedure:

The sugar content of the fermentable banana juice and the fermented wine was measured by Cleaning and drying sample site of refractometer then after the sample was putted on the specified site and read the °brix.

CHAPTER 4

4. RESULTS AND DISCUSSION

4.1. Result

Production and characterization of banana wine after boiling and filtering the properties of clear banana juice has been found as described in the table below.

Table 3: Result of fermentation time

Temperature	Amount of sugar	Amount of banana	Yield					
			No of day	PH	Density (Kg/L)	Specific gravity	Alcohol content (%v/v)	°Brix
		2 Kg	7	4.8	1.178	1.1349	3.6	31.2
			10	4.32	1.136	1.09511	5.4	22.7
			13	4.06	1.067	1.07765	6.3	18.8

Graphical representation of wine characterization

Table 4: Result of PH

No of days	PH
7	4.8
10	4.32
13	4.06

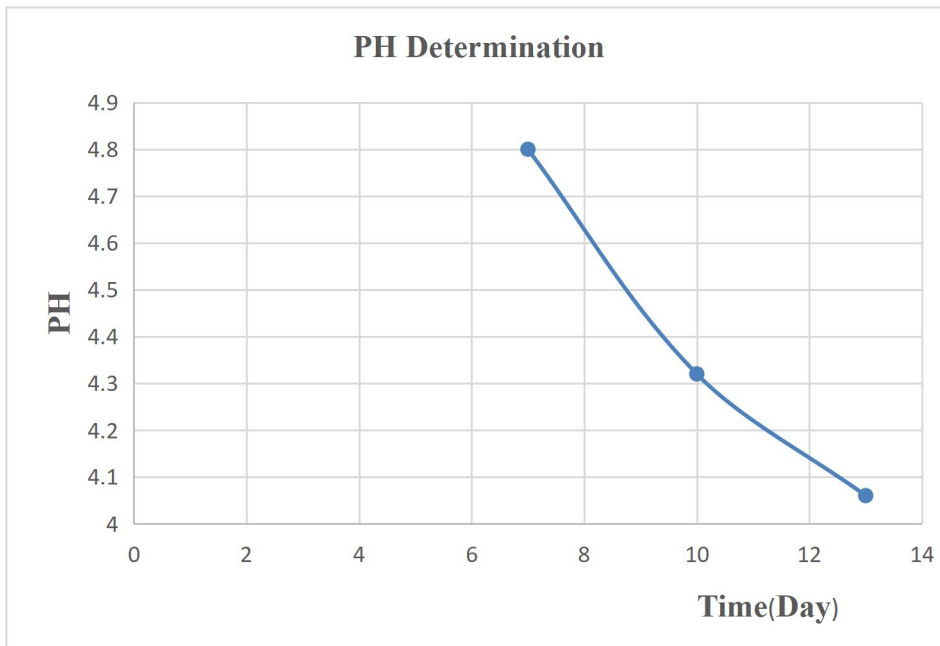


Figure 2: Relationship between time versus PH

Table 5: Result of density

No of days	Density(Kg/L)
7	1.178
10	1.136
13	1.067

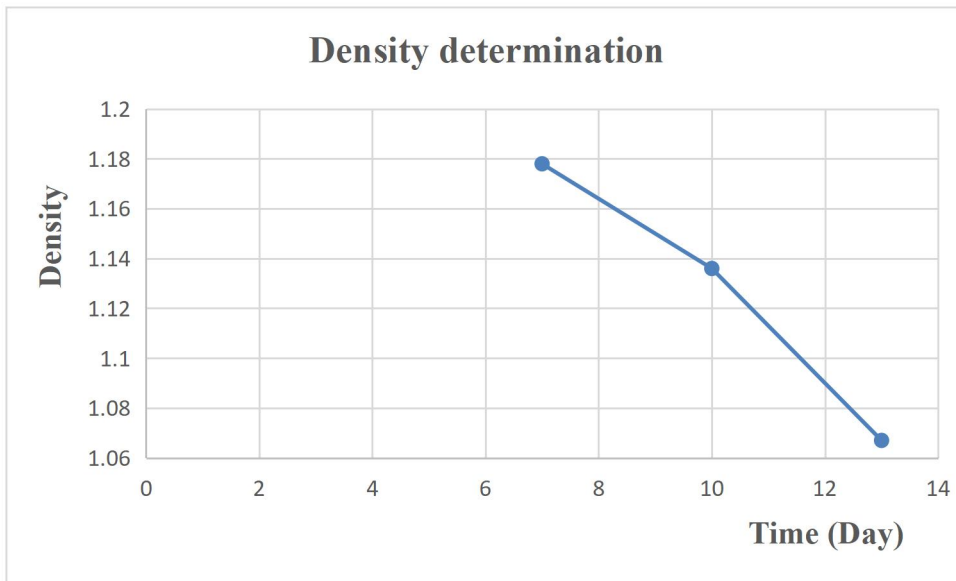


Figure 3: Relationship between time versus density

Table 6: Result of specific gravity

No Of Days	Specific gravity
7	1.1349
10	1.09511
13	1.07765

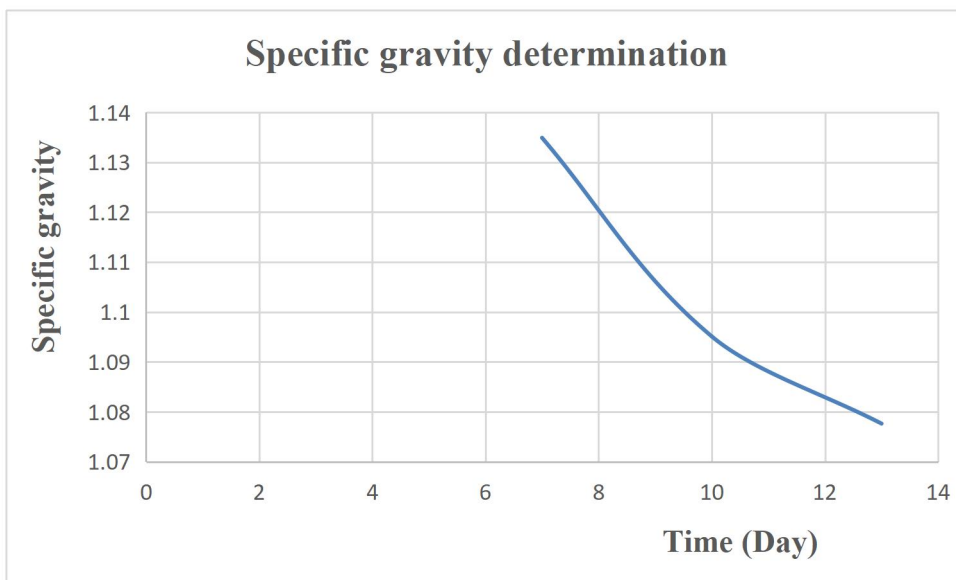


Figure 4: Relationship between time and specific gravity

Table 7: Result of alcohol content

No of days	Alcohol content
7	3.6
10	5.4
13	6.3

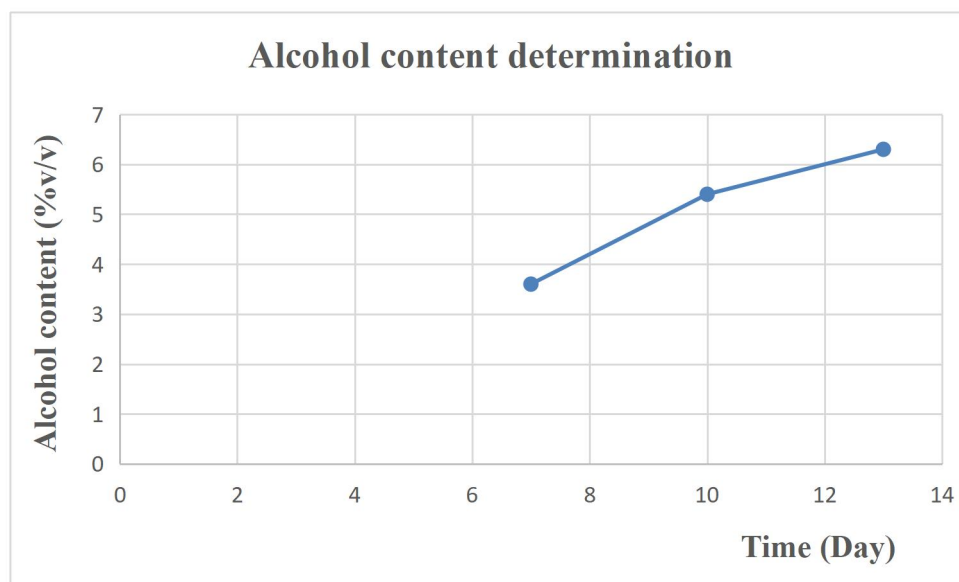


Figure 5: Relationship between time and alcohol content

4.2. Discussion

4.2.1. Discussion on the characterization of the produced wine

Alcohol Content

According to the theory of Holzberg1967.,et al the alcohol content increased gradually through as the fermentation time increases in this project. The results of alcohol content of 3.6 at 7 days, 5.4 at 10 days, 6.3 at 13 days was recorded. So that result this observation is similar to that theory. There is significant different among the mean of alcohol content because as the fermentation time increased alcohol content is increased.

PH

The PH of the banana wine in this project recorded are 4.8 at 7 days, 4.32 at 10 days, and 4.06 at 13 days so this agree with the theory that wine is more acidic with the period of fermentation (Joyeux.,et al 1984).

There is significant difference among the mean of the PH of all sample. Because different letter shows that different. This means that the PH is decreased as the fermentation time increased.

Density and Specific Gravity

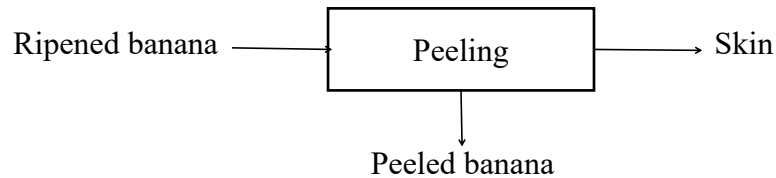
The density and specific gravity of wine is decreased as the fermentation time increased (Okeke,B.C.,et al 2015). The results of density and specific gravity in this project are agree with this theory. This means the result of density are (1.178, 1.136, and 1.067) kg/L respectively at the days of 7-13 and the results specific gravity are 1.1349, 1.09511, and 1.07765 from 7-13 days respectively.

CHAPTER FIVE

5. MATERIAL AND ENERGY BALANCE

5.1. Material balance

A. Material balance on peeling

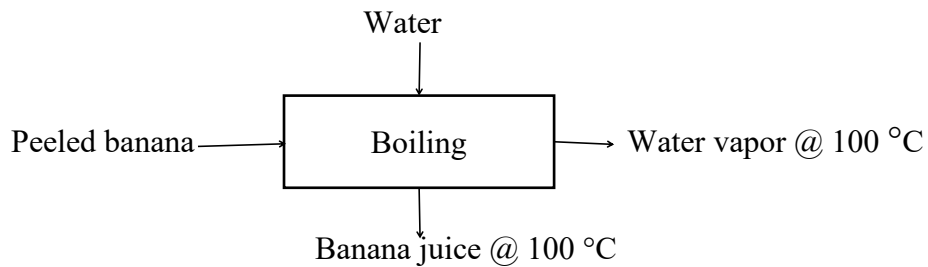


$$\text{Ripened banana} = \text{Peeled banana} + \text{Skin}$$

$$\text{Peeled banana} = \text{Ripened banana} - \text{Skin}$$

$$\begin{aligned} \text{Peeled banana} &= 2\text{Kg} - 0.25\text{Kg} \\ &= 1.75\text{Kg} \end{aligned}$$

B. Material balance on boiling



$$\text{Peeled banana} + \text{Water} = \text{Banana juice} + \text{Water vapor}$$

$$\text{Banana juice} = \text{Peeled banana} + \text{Water} - \text{Water vapor}$$

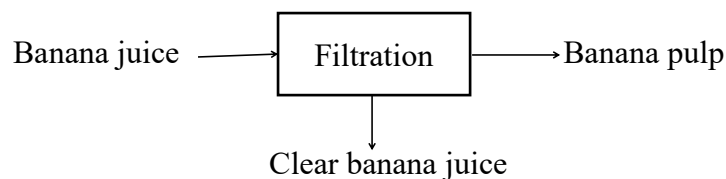
$$\text{Assume Water vapor} = 0.005\% \text{ banana juice}$$

$$\text{Banana juice} = 1.75\text{Kg} + 2\text{L} - 0.005\% \text{ banana juice}$$

$$\text{Banana juice} = 3.75\text{kg}/1.00005 = 2.746\text{Kg}$$

$$\text{Water vapor} = 0.005 \text{ banana juice} = (0.005/100) * 2.746\text{Kg} = 0.0001373$$

C. Material balance on filtration

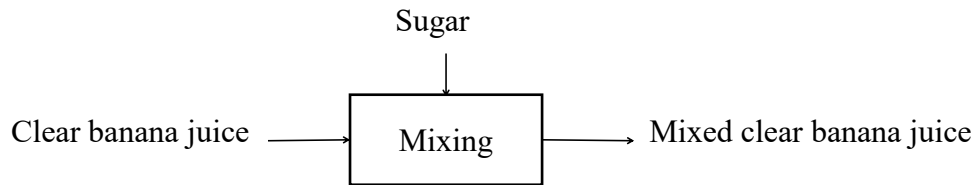


$$\text{Banana juice} = \text{Clear banana juice} + \text{Banana pulp}$$

Clear banana juice = Banana juice - Banana pulp

Clear banana juice = 2.746 - 0.259 = 2.487

D. Material balance on mixing

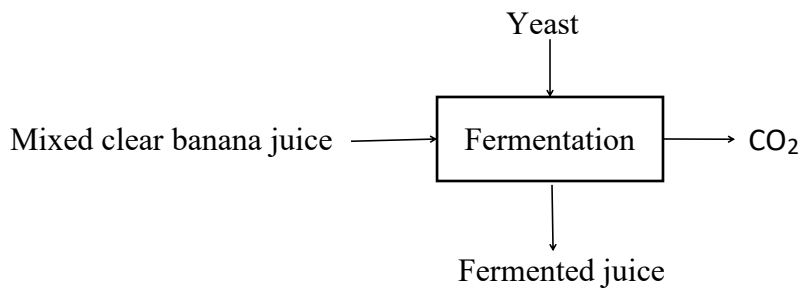


Mixed clear banana juice = Clear banana juice + Sugar

Mixed clear banana juice = 1Kg + 2.487L

Mixed clear banana juice = 3.487Kg

E. Material balance on fermentation



Mixed clear banana juice + Yeast = Fermented juice + CO₂

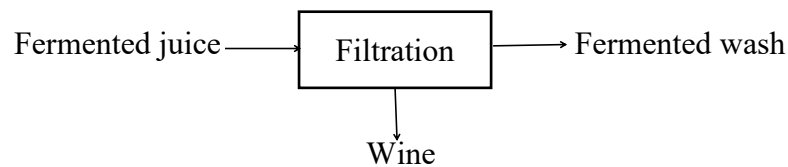
Assume CO₂ = 0.002% of fermented juice

Fermented juice = (3.487Kg + 0.001Kg) / (1+0.002%)

Fermented juice = 3.488Kg/1.00002 = 3.4878Kg

CO₂ = 0.002% * 3.4878 = 0.000069756

F. Material balance on filtration



Fermented juice = Wine + Fermented wash

Mass of wine = 2L * 1.07856 = 2.15712

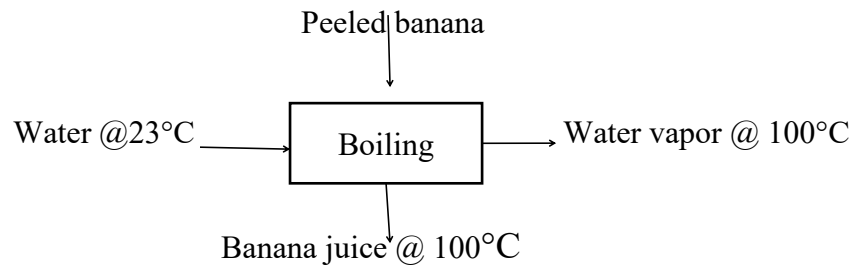
Fermented wash = Fermented juice - Wine

Fermented wash = 3.4878Kg - 2.15712Kg

Fermented wash = 1.33068Kg

5.2. Energy balance

Energy balance on boiling



Taking 23°C as a reference point

Assume Enthalpy with input (h= 0)

Enthalpy in put with banana juice = $MCP\Delta T$

$$= 8.02 * 3.43(100-23)$$

$$= 2118.1622KJ$$

Latent heat of vaporization of water = $M * h$

$$= 0.000375 * 2660$$

$$= 0.9975KJ$$

The total energy required for this operation is the sum of the out let streams energy

$$\text{Energy added} = MCP\Delta T + Mh$$

$$= 2118.1622KJ + 0.9975KJ$$

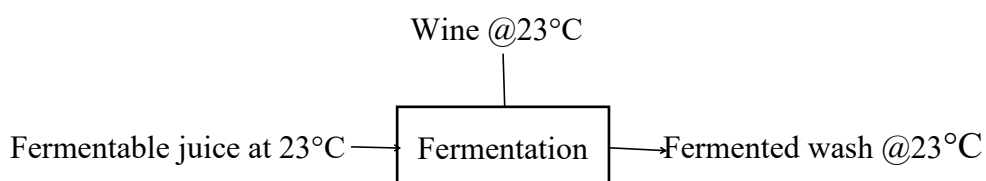
$$= 2119.1597KJ$$

Let us assume that the heat efficiency 90% than capacity of the hear become

Energy capacity of heater = $2119.1597KJ / 0.90$

$$= 2354.622KJ$$

Energy balance on fermentation



Taking 25°C as a reference point. Let us calculate energy require for this operation. The energy within in input = 0

Energy released due to reaction



	Mass(kg)	Mole	$\Delta\text{H}_f(\text{KJ/mole})$
$\text{C}_6\text{H}_{12}\text{O}_6$	4	22.22	-1262.19
CO_2	0.0003606	0.0082	-392.509
$\text{C}_2\text{H}_5\text{OH}$	0.6118	13.3	-277.690

Table 3 From material balance and thermodynamic property

$$\Delta\text{H}_r = \sum n_i \Delta\text{H}_{fi} \text{ product} - \sum n_i \Delta\text{H}_{fi} \text{ reactant}$$

$$= 13.3 * -277.690 + 0.0082 * -393.509 - (22.22 * 1262.19)$$

$$= -31742.366 \text{KJ}$$

The energy within out put

Enthalpy with wine = $MCP\Delta T$

$$= 0.6118 \text{kg} * 2.151 * (23 - 25)$$

$$= -2.632 \text{KJ}$$

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Banana (*Musa Sapientum*) is a fruit common in the tropics and is non-seasonal. It is readily available in Ethiopia. Due to its high sugar content, it is suitable for the production of wine. The procedure of banana wine production is preparing ripe banana, washing, weighing, slicing, boiling, filtrating, addition of other substrates like sugar, pitching (addition of yeast), fermentation, filtration of wine, bottling and packaging. Fermentation time is the factor used in the project. From this project five parameters are studied those are PH, alcohol content, specific gravity, density and sugar contents. The alcohol content of the produced wine was increased as the fermentation time increases from 7th day to 13th days those are at 7th day 3.6, 10th day 5.4, and 13th day 6.3. From the result the PH of the banana wine decreased as the fermentation time increased from 7th to 13th days. At 7th day 4.8, 10th day 4.32, and 13th day 4.06. Due to fermentation time increased the sugar in the banana is degraded to simple sugar then changed to ethanol or alcohol. So that the sugar content of this banana wine is decreased from first day to the last days.

6.2. Recommendation

Most of the time wine fermented at high temperature this means that greater than room temperature has high alcohol content and produce wine in short time but because of the lack of temperature controller machine this project was done at normal temperature so that if it was there, it was simple to produce high alcohol content wine. CO₂ produced during fermentation is high and increase the concentration greenhouse gas in the atmosphere, so this impact can be reduced by using the CO₂ in carbonation of beverage and as a fire extinguishers. Most of the time the yeast which use for the production of wine is *saccharomyces cerevisiae* (Mestre and mostre 1980). but there no in the laboratory so, for the future if it presents may good quality of wine will produce. The skin of ripened banana can serve as food for animals and it can be used for the production of bio fuel or biogas, in addition to this the fermented wash released from the fermenter need a further study about its treatment method. As banana plant growth largely in Ethiopia the banana wine factory can be planted near to city for ease to access of raw material, energy and labor. Awareness about banana wine also need be created on the peoples through promotion and training of farmers.

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APPENDIX



Ripen banana



Banana skin



Peeled banana

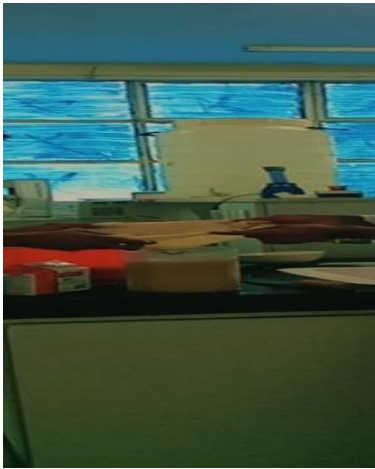
Size reduced peeled banana



Boiling



Banana juice



Filtration of juice by muslin cloth



Mixing



Sample at fermentation time



PH meter



Refractometer



Final product