WOLKITE UNIVERSITY

COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

BIO-ETHANOL PRODUCTION FROM MANGO PEEL WASTE AND ITS CHARACTERIZATION

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DECLARATION

We hereby declare that the thesis is based on our original work except for flotation's and citations which have been duly acknowledged. We also declare that it has not been previously or currently submitted for Wolkite University

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LIST OF ABBREVIATION AND ACCRONOMY

GEC	General Expense Cost
POHC	Plant over Head Cost
EC	Equipment Cost
WC	Working Capital
FCI	Fixed Capital Investment
IRR	Internal Rate of Return
CS	Cost of Supervisory
NO_X	Nitrogen Oxides
CO_2	Carbon Dioxide
VLE	Vapor Liquid Equilibrium
CP	Specific Heat Capacity
RPM	Revolution Per Minute
FC	Fixed Charges
CEPCI	Chemical Engineer Plant Cost Index
BE	Break-Even Point
NPV	Net Present Value
PI	Profitability Index
DCFR	Discounted Cash Flow Return

ABSTRACT

Waste disposal has become one of the major concerns in country city and fruit peels are one of the major solid by-product. This project is aimed at utilizing the mango peel forthe production of bio-ethanol by using yeast saccharomyces cerevisae. The dry mango peel consists cellulose and hemicelluloses, which make it suitable as fermentation substrate when hydrolyze. This mango peel contains fermentable sugar, which is extracted from mango peel by the method of enzyme hydrolysis, simultaneous saccharafication and fermentation. The mango peel was collected and then wash by water. After it washed it is dried by sun for two days and in oven (101°C for 3hours) for further drying and to obtain easily crushable material, the 100gm of dried sample is grinded to the size of 2mm, then mixed with water in the ratio of 1:10 after that it pass through pretreatment, acid hydrolysis, fermentation and distillation in order to produce bio-ethanol and from 100gm of mango peel powder 58mL of ethanol is produced. The result obtained checked and characterized by chromic acid test, which convert the color of the chromic from orange-red to green color, it indicate that the result is bio-ethanol. The density (0.85134g/m^3*), and refractive index(1.3335) are determined to characterize the obtained result, which shows the properties of bio-ethanol. The analysis on the technical and economic feasibility of the work for ethanol production is performed. Results from the feasibility study indicated that the proposed work was feasible with internal rate of return (IRR) 12%, NPV (2,990,205.7) and the payback period of the project is estimated to be 2 years.*

Key Word: *Mango peel, Dilute Acid hydrolysis, Fermentation, Distillation.*

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Fuel is the important need of any country. Rising concerns with the contribution of fossil fuels to global warming coupled with their global depletion trends provide added impetus to the research for alternative fuels that are environment friendly. Continued utilization of these fuels and poor regeneration practices of traditional sources of fuels are the major challenges for the fast growing human population (Anonymous, 2004). Now days, due to high industrial growth, the fossil fuel sources are rapidly disappeared and day by day, cost of petrol, diesel and natural gas increases due to high demand and scarcity of sources. In last 10 years, the fuel cost increases approximately so scientists are move toward the sources of renewable energy. It has been realized that fossil energy causes greenhouse gas emission that have adverse effects on the environment. Consequently, it is an ongoing interest to find out renewable and environmentally friendly source of energy to the community or society (Anonymous, 2004).

New techniques are developed and being proposed as an alternative to transform the food processing material by microorganisms to valuable products such as biogas, ethanol, citric acid, chemicals, various enzymes, volatile flavoring compounds, fatty acids and microbial biomass (Anonymous, 2004; Madhukara *et al*., 1993; Pandey *et al.*, 2000).

Bio-ethanol is a renewable energy source produced through fermentation of sugars and used as a partial gasoline replacement in a few countries in the world. It can be produced through fermentation of fruit peels (like mango peel, orange peel, pineapple, banana peel) starches, and cellulosic material (such as paper, cardboard, wood, and other fibrous plant material). Being a waste and abundant makes fruit peels relatively inexpensive feed stocks for ethanol production. A major benefit of a well-functioned bio-fuel system is that it eliminates and converts organic waste into useful and valuable products. One of the main benefits with bio-ethanol is the replacement of expensive fossil fuel. Some advantages are connected to waste removal, like improving hygienic conditions, protection of soil, water, air and woody vegetation can be mentioned as environmental advantages. If the actual conditions are satisfactorily, the bio-ethanol technology can contribute to conservation and development (Pandia *et al*., 2004).

The fact that a bio-ethanol production can be building and operated locally creates opportunities to decrease the waste solid collection volume and land disposal costs. Furthermore, the technology has also a potential to create job opportunities locally for several thousands of people (RFA, 2007). Over the last 150 years, human activities have caused a dramatic increase in the emission of a number of greenhouse gases such as CO_2, which has led to changes in the equilibrium of the earth's atmosphere. Fuel ethanol is suggested as a sustainable fuel which can be produced from renewable resources and led to maintain or even reduce the level of greenhouse gases (ESDA, 2005). Finally, the standard of living can be enhanced which directly contributes to social and economic development of the country (ESDA, 2005).

At present, the importance/advantage of alternative energy source has become even more crucial matter not only due to the continuous depletion of limited fossil fuel stock but also for the safe, better and greener environment. Bio-ethanol is an oxygenated fuel that contains oxygen, which reduces particulate and emissions from combustion. In addition, the toxicity of the exhaust emission from bio-ethanol is much lower compared to the petroleum sources. The main advantage of bio ethanol is the possibility to blend it in low proportions with gasoline (bio-ethanol by volume) for use, without any significant change, in internal combustion engines (RFA, 2007)..

1.2. Statement of the Problem

Solid wastes such as mango peels are largely obtained as a by-product from restaurants and juice processing houses in the city. These wastes can entail serious environmental problems unless they change or convert in to some useful products or disposed properly. When improperly thrown on public road and flood passing ditch, it causes serious environmental pollution.

Transforming this mango peel waste to something valuable product, namely ethanol there by contributing towards alternative energy supply is the solution to this problem.

1.3. Significance of Study

In most developing countries, the emerging of bio-fuels industries perceived as an opportunity to enhance economic growth, provides environmental friendly alternative energy source and create jobs opportunities for the community. Since this project reveals the potential of mango peels for bio-ethanol production, the success of the project may serves as small scale industry to the community as a result; it will provide bio-ethanol as an alternative energy source for the community, clean the environment by reusing of mango peel. It may also help to lower the price of petroleum based fuel due to market competition.

1.4. Objectives

1.4.1. General Objectives

The general objective of this thesis is Bio-Ethanol Production from Mango Peel Waste and its Characterization

1.4.2. Specific Objectives

- ✓ Physicochemical analysis of mango peel
- ✓ To investigate the possibility of using and transforming mango peel waste to something valuable product, namely ethanol.
- ✓ To characterize the produced bio-ethanol
- ✓ To study economic feasibility of bio ethanol

1.5. Scope of the Study

In this project mango peel waste serves as raw material for preparation of bio ethanol and give fruitful information on the development of bio ethanol and to conduct further research on areas of data deficiency. This work could offer important understanding on bio ethanol as a whole and its status in Wolkite University. This project attempts to indicate the suggestions related with the expanded bio ethanol development and use, as it is not well understood in the country. This project work involves the Collection of waste mango peel from juice house, hotels and homes. Then after an analysis made to determine physical and chemical properties of waste mango peel for the production of bio ethanol as fuel and hydrolysis by using microorganism and diluted sulfuric acid and adjust the pH by using sodium hydroxide. Then prepare fermentation media and fermentation process were carried out. Finally, the fermented product was distilled/purified and characteristics of produced product are analyzed by different analyzer, such as alcoholmeter, refractor-meter were investigating the chemical and physical characteristics of bio ethanol.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Overview of Bio-ethanol

Ethanol, also known as ethyl alcohol with the chemical formula C_2H_5OH, is a flammable, clear, colorless and slightly toxic chemical compound with acceptable odor. It can be produced either from petrochemical feedstock by the acid-catalyzed hydration of ethane, or from biomass feed stocks through fermentation. On a global scale, synthetic ethanol accounts for about 5-10% of total production while the rest is produced from fermentation of biomass mainly sugar crops, e.g. cane and beet, and of grains (mainly corn (Asli, 2010).) Ethanol as a neat fuel or even in the blended form with gasoline has a long history as automotive fuel. In 1860, German inventor Nicholas Otto used ethanol as a fuel in an early prototype of an internal combustion engine because it was widely available throughout Europe for use in spirit lamps. A few years later, Henry Ford built his first automobile with an engine that could run on ethanol. In 1908, Ford unveiled his Model T engine equipped with carburetors that could be adjusted to use alcohol, gasoline or a mixture of both fuels (Sanchez, 2007) Ethyl alcohol as "the fuel of the future" was presented by him for the first time. In 1925, he told the New York Times: “The fuel of the future is going to come from fruit like that sumac out by the road, or from apples, weeds, sawdust – almost anything. There is fuel in every bit of vegetable matter that can be fermented. There's enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years.” However, fossil fuels were predominantly used for automobile transportation throughout the last century, obviously due to their lower production cost. As an automotive fuel, hydrous ethanol can be used as a substitute for gasoline in dedicated engines. Anhydrous ethanol, on the other hand, is an effective octane booster when mixed in 5% to 30% with no engine modification requirement (Asli, 2010).

Bio-fuels: - are alcohols, ethers, esters and other chemicals made from cellulose-based biomass. This includes herbaceous and woody plant, agricultural and forestry residues and a large portion of municipal and industrial waste materials (Dufey, 2006).

Bio-fuels are renewable since they are produced from biomass organic matter, such as plants. They generate about the same amount of carbon dioxide (a greenhouse gas) from the tailpipe as fossil fuels, but the plants that are grown to produce the bio-fuels actually remove carbon dioxide from the atmosphere. Therefore, the net emission of carbon dioxide will be close to zero. The bio-fuels industry has evolved from using first generation feedstock (typically food crops) to using second and third generation feed stocks, for both ethanol and biodiesel. While the term bio-fuels denote any fuel made from biological sources, for most practical uses, the term refers to either ethanol or biodiesel. The last few years have seen tremendous growth in bio-fuels (Sanchez, 2007).

Biodiesel: - is an ester that can be made from several types of oils, such as vegetable oils and animal fats. Biodiesel is typically used as a blend 20 percent biodiesel and 80 percent petroleum diesel called B_{20}. B_{20} can be used in a conventional diesel engine with essentially no engine modifications. There is also a growing interest in using biodiesel where workers are exposed to diesel exhaust, in aircraft to control local pollution near airports, and in locomotives that face restricted use unless emissions can be reduced (Nirbhay Gupta, 2008).

2.2. The history of fuel ethanol

The use of ethanol as an automobile fuel is not a new invention. Already in 1908, Ford’s model T could be adjusted to run on either gasoline or alcohol (DiPardo, 2000). However, after World War II the interest in using ethanol as a fuel declined because cheap gasoline made from petroleum was available. In the 1970’s, the interest in fuel ethanol was renewed due to the oil crisis (DiPardo, 2000). More recently, ethanol has become used as an additive in gasoline. MTBE (methyl tertiary butyl ether) is used as a gasoline additive to increase the oxygen content and the octane number. During the last few years, the use of MTBE has been banned in several states in the USA due to the risk of contamination of water. Many companies have replaced MTBE with ethanol to give the gasoline similar clean burning and octane boosting properties as MTBE-blended gasoline. Today there are several flexi fuel automobile models (vehicles that can run on mixtures of ethanol and gasoline containing up to ethanol) available from various manufacturers.

About 99% of the fuel ethanol is produced from cultivated crops (Ajila *et al*., 2007). Brazil has for a long time been the leading ethanol producer of the world. However, during the last years USA has increased its production and today both countries have an annual production of about 16,000,000 m^3 (Ajila *et al*., 2007). The Brazilian ethanol is mainly produced from sugarcane. Brazil is the world leader in the use of ethanol as an automobile fuel. In Brazil, the ordinary gasoline, which is used in about 7, 000, 000 cars, contains about ethanol. In addition, 4, 000, 000 automobiles drive on a blend of ethanol and water. In the USA, ethanol is mainly produced from corn. In Sweden, about 55000 m^3 of fuel ethanol is produced per year from wheat and about 18 000 m^3 from spent sulphite liquor. In Sweden, the ordinary gasoline typically contains ethanol and the number of flexi fuel automobiles is increasing. The Swedish ethanol production does not cover the demand and therefore Sweden is a net importer of ethanol. However, initiatives have been taken to increase the future national ethanol production. In 2004 an ethanol-from-lignocelluloses pilot plant was inaugurated in the city of Örnsköldsvik. Agro-ethanol plans to expand its production of ethanol from grain with 150,000 m^3 in 2008 (Ajila *et al*., 2007).

2.3. Property of Ethanol

Ethanol or ethyl alcohol CH_3CH_2OH, has been described as one of the most exotic synthetic oxygen-containing organic chemicals because of its unique combination of properties as a solvent, a germicide, a beverage, antifreeze, a fuel, a depressant, and especially because of its versatility as a chemical intermediate for other organic chemicals. Ethanol is a volatile, flammable, colorless chemical compound. It is a monohydric primary alcohol and it boils at. It is miscible (i.e., mixes without separation) with water in all proportions and is separated from water only with difficulty;

Ethanol that is completely free of water is called absolute ethanol. Ethanol forms a constant-boiling mixture, or zoetrope with water that contains 95% ethanol and 5% water and that boils at. Ethanol is a psychoactive agent and it produces a variety of physiological and behavioral effects.

2.3.1. Physical properties

Bio-ethanol is a colorless liquid, with specific scent. In storage and manipulation conditions, bio ethanol is a stable product if it's storage in sealed tanks at room temperature, otherwise appears the risk of water vapors absorption from the air. Also, from physically and chemically stability point of view, bio-ethanol does not suffer accidental polymerization. Bio-ethanol contains acetic acid and therefore it corrodes aluminum alloys. It also absorbs the lead in alloys and finally the surfaces become porous; same phenomena appear on zinc alloys (Al and Zn) (Israilides etal. 2008). In order to avoid this issue, it is recommendable a nickel cladding for all those surfaces. Same phenomena may appear on plastic parts of carburetors or injection systems as the carburetor bowl, fuel pump and injector inside parts, filters or any plastic – rubber gaskets. It is recommendable to be manufactured of nylon or rayon. Thus, different part of the classic fueling systems, carburetor or injection systems, must be replacement or protected for ethanol use (Ray and Miglani, 2011).

2.3.2. Chemical properties

Bio-ethanol has a low volatility expressed by a low value of the superficial tension at ambient temperature and also by a low value of the Reid vapors pressure. Thus, because the vapors pressure of the bio-ethanol (at is almost 4 times lower comparative to gasoline, the vaporization of bio ethanol at temperatures below becomes difficult. Different research's show that this situation could be improved if very volatile additives would be used, such as iso-pentane or dimethyl ether (DME), or by a special intake air heating device use, especially in situations when higher bio-ethanol percentage in blend with gasoline or and pure bio ethanol is used (Maurice, 2011). Other physical properties of bio-ethanol are: firing point- auto ignition point lower explosive limit

(Volume percent in air at and) – Higher explosive limit (Maurice, 2011).

Using bio-ethanol in spark ignition engine with higher values of the compression ratio becomes possible due to its higher octane number with a research octane number value up till 106. Also the higher combustion rate of bio-ethanol is directly related with the engine efficiency improvement. If bio-ethanol is use as single fuel another important issue is related to the lower value of the caloric power registered for bio-ethanol comparative to gasoline. As any other alcohol, the bio ethanol has a low caloric power comparative to gasoline. This deficiency leads to the necessity of increasing the ethanol consumption and also of the storage capacity on board of the vehicle; this last issue requires larger fuel tanks in case of bio-ethanol use as single fuel.

2.4. Production process of Ethanol

Ethanol can be produced in two different ways. Either chemically, by hydration of eth ylene, which is derived from crude oil or natural gas, or by fermentation of sugar containing feeds, starchy feed materials or lingo-cellulosic materials. About of the ethanol produced in the world is a petroleum product. Petroleum ethanol product is made by the catalytic hydration of ethylene with sulphuric acid as the catalyst. It can also be obtained via ethylene or acetylene, from calcium carbide, coal, oil gas, and other sources. The two primary ways of producing fuel ethanol from cellulosic feedstock are: Biochemical conversion process and Thermo chemical conversion process (Magus Bertilsson, Feb 2007)

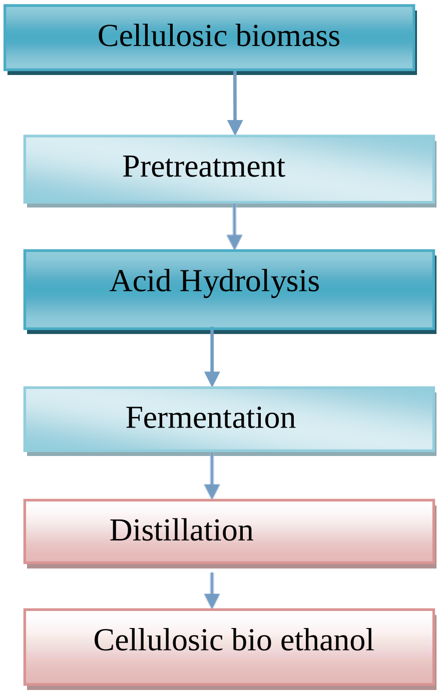


Figure2.1. Schematic diagram of cellulosic ethanol production

For production of ethanol from cellulosic feed stocks, four major unit operations are required: pre-treatment, hydrolysis, fermentation, and separation purification

2.4.1. Pre-treatment of mango peel powder

The purpose of the pre-treatment was to remove lignin, reduce cellulose crystalline and increase the porosity of the materials. Pre-treatment must meet the following requirements: Improve the formation of sugar, avoid the degradation or loss of carbohydrate, avoid the formation of by-product inhibitors and must be cost effective. The material is dried by sun for two days and in oven (101℃ for 3 hr.) to obtain easily reducible material. After drying, the samples were milled. The maximum particle sizes of the grinded sample were 2 mm. The sample of larger particle size than 2 mm was grinded over and over again until all particle size became fit with required size, 2 mm. The sample was kept at low temperature until the next stage of experiment. Grinding of mango peel into powder form increases the surface area of the sample which enhances the contact between hemicelluloses and cellulose with dilute acid to reduce cellulose crystalline Steam Pre-treatment: The powders of mango peel were treated inside Autoclave; every different sample will treat separately. Steam pre-treatment uses steam at 121℃ temperatures. Flow through processes steam at temperature of 121℃ through the hemicelluloses and cellulosic material. First, the mango peel powders were treated and it feed as batches, every batch contains of screened mango peel powder with 10:1(v/w) ratio of water to the sample. The temperature was applied at 121℃; then released the pressure until the pressure became low. The retention time for every batch was 15min. Finally the samples was kept in autoclave for the given pre-treatment time and temperature and allowed to cool to be for the next process.

2.4.2. Hydrolysis

There are two methods of extraction of ethanol from cellulose.

1 .Simultaneous Saccharication and Fermentation (SSF) and
2 .Separate Hydrolysis and Fermentation (SHF)

2.4.2.1. Simultaneous saccharification and fermentation

In SSF, enzymatic cellulose hydrolysis and glucose fermentation to ethanol by yeast proceed simultaneously within one vessel. Compared with saccharification in the absence of yeast, simultaneous saccharification and fermentation (SSF) using Trichoderma cellulose and saccharomyces cerevisae enhanced cellulose hydrolysis rates by 13-30 percent (JesperNorgard, 2005). The optimum temperature for SSF was 350^{O}C.

It is a combination of acid hydrolysis, enzymatic hydrolysis and fermentation. Here, the cellulose feedstock is pre-treated dilute acid pretreatment using H_2SO_4 or SO_2. The process is often run as a steam explosion treatment of acid impregnated material, where the hemicelluloses are removed and the digestibility of the cellulose is enhanced. H2SO4 is a strong catalyst that highly improves the hemicelluloses removal but also easily yield inhibitors but also, a less extended hemicelluloses hydrolysis (Magus Bertilsson, Feb 2007).

The choice of enzymes preparation used in SSF is subject of great importance due to very high cost of the enzymes. However presently a combination of cellulose and Saccharomyces cerevisae (yeast) is used. Cellulose catalyzes the saccharification while the yeast is used to produce ethanol.

2.4.2.2. Separate Hydrolysis and Fermentation (SHF*)*

In SHF, hydrolysis and fermentation are carried out in separate vessels under their own optimal conditions; however, end-product inhibition of enzymes‟ activity and contamination problems is associated with this process. In order to eliminate drawbacks of the SHF process, SSF that combines hydrolysis and fermentation in one vessel has been developed. Sugars produced during hydrolysis are immediately fermented into ethanol and thus, problems associated with sugar accumulation and enzyme inhibition as well as contamination can be avoided. The main drawback of SSF is the different optimum temperatures of the hydrolysis and fermentation processes. Most fermenting yeasts have an optimal temperature around 30-35^{o}C while hydrolyzing enzymes show optimal activities around 50 ^{o}C (Galbe and, 2004).

Separate hydrolysis and fermentation, which can be sub-divided into:

1. Acid hydrolysis and fermentation.
2. Enzymatic hydrolysis and fermentation

Acid hydrolysis and fermentation

Fermentation;-most of the glucose and xylems are converted to ethanol and CO_2. Hydrolysis is the feed stock heating at high pressure with an acid catalyst (H_2SO_4). Most of the hemicelluloses are converted to xylems. Depending on the concentration of the acid and the other parameters can be determined i.e. dilute acid maybe used at high temperature and pressure while concentrated acids maybe used at very low temperature and pressure. In the case when sulfuric acid can be concentrated (25-80%) or dilute (3- 8%), measured as the weight of acid in the weight of acidified aqueous solution that is present with the feedstock (Harris and Sherrard, 1953).

Enzymatic hydrolysis and fermentation

Enzymatic hydrolysis is the utilization of enzymes to release the fermentable sugars from the biomass. Hydrolysis of cellulosic materials can be catalyzed by a class of enzymes known as celluloses. Enzymatic hydrolysis is sensitive to the substrate concentration. In addition to substrate concentration, pretreatment of cellulosic materials and hydrolyzing conditions such as temperature and pH are among factors influencing the effectively of enzymatic hydrolysis (Duff and Murray, 1996; Galbe and Zacchi, 2002).

Enzymatic hydrolysis requires low utility cost because the process runs at low temperature and allow very high rate of conversion. However, the cellulose accounts for up to 50% the cost of hydrolysis due to the requirement of large amount of cellulose. From the methods by relating the availability to local area we select enzyme based acid hydrolysis for the following reasons:-

- Cost of reagent**:** The reagents in the enzyme hydrolysis are more costly as compared to acid hydrolysis**.**
- Availability of reagents **:** The reagents for acid hydrolysis are abundant than that of the enzyme hydrolysis
- Rate of reaction: The rate of conversion of cellulose of the mango peel is faster in acid hydrolysis than that of enzyme hydrolysis.

The cellulose molecules which are composed of long chains are broken down to simple sugar, before it is fermented for alcohol production. Even if there are many types of hydrolysis types, dilute acid hydrolysis is an easy, workable and productive process and the amount of alcohol produced in case of acid hydrolysis is more than that of alkaline hydrolysis. Each sample had to pass through five primary experiments that were in series to get the final result ethanol, that is: size reduction, pre-treatment, hydrolysis, fermentation and distillation. The three- parameters were applied to hydrolysis step of the experimentation. The hydrolysis experiments for ethanol production and optimization is conducted in a completely randomized design 100g of grinded fruit peels is used for experiment

And the factors for hydrolysis are time, hydrolysis temperature, and acid concentration.
Hydrolysis reaction:

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{\qquad\qquad} nC_6H_{12}O_6 \; \square H = 22.1n \text{ KJ/mol}$$

$$(C_5H_8O_4)_m + mH_2O \xrightarrow{\qquad\qquad} mC_5H_{10}O_5 \; \square H = 79.0m \text{ KJ/mol}$$

2.4.3. PH Adjustment

Before addition of any micro-organism to the prepared samples, pH of these samples must to be adjusted. Otherwise the micro-organism will die in hyper acidic or basic state.

2.4.4. Sterilization

The reactor and all the equipment that were used for fermentation purposes were sterilized (autoclaved). The sterilization was carried out at a temperature of for 15 minutes.

2.4.5. Fermentation

Fermentation is a bio-chemical process wherein commercial products are obtained through the activity of micro-organism. The chemical changes are brought about in an organic substrate through the action of enzymes by micro-organism. Fermentation is directly caused by the life processes of minute organisms. Micro-organisms, which include; bacteria, yeast and molds, feeds on the organic materials, if they are supplied with the necessary energy, along with other needed nutrients, this process is of utmost interest to the manufacturer. These micro vegetative organisms will not only grow and multiply, but will change the substrate into other chemical substances (Galbe and, 2004).

Fermentation reaction:

$$3C_5H_{10}O_5 \xrightarrow{\text{yeast}} 5C_2H_5OH + 5CO_2 \qquad \square H = -74.986\ \text{KJ/mol}$$

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2C_2H_5OH + 2CO_2 \qquad \square H = -84\text{KJ/mol}$$

2.4.6. Distillation

Distillation is one of the steps of the purifications. Distillation is the method used to separate two liquid based on their different boiling points. However, to achieve high purification, several distillations are required. This is because all materials have intermolecular interactions with each other and two materials will co-distil during distillation. This means that proportion between two materials, in this case ethanol and water can be changed, and still, there are two materials in layers, the liquid and the vapor layers. Ethanol is separated from water when its boiling temperature is attained.

2.4.7. Dehydration

After distillation, about 5% of water remains in ethanol. Especially, this water is a big problem for fuel ethanol because the presence of this amount of water enhances the molecular polarity of ethanol when it is mixed with gasoline. Consequently, they separate into two phases, ethanol phase and gasoline phase. It is easy to imagine that this in homogeneous fuel is not acceptable. Thus, dehydration can be another issue (Onuki, 2005). For the ethanol to be usable as a fuel, water must be removed. Most of the water is removed by distillation, but the purity is limited to 95-96% due to the formation of a low boiling water ethanol azeotrope. For blending with gasoline, purity of 99.5 to 99.9% is required, depending on temperature, to avoid separation. Currently, the most widely used purification method is a physical absorption process using molecular sieves and another method is azeotropic distillation.

Molecular sieves: There is a lower bound on the fraction of ethanol entering the molecular sieve (0.8). Adsorption takes place at 95 °C. Heat exchanger heats the inlet stream from the mixer up to 95 °C. The molecular sieve is a bed of zeolite that operates in semi-continuous mode. The bed is saturated with water after a period of time and is then regenerated. Hence, there are usually two sieves being operated in parallel – one being saturated with water while the other is being regenerated (or dehydrated) using air under vacuum. Heat exchanger heats air with an assumed relative humidity of 70% at 20 °C to 95 °C. The air at the outlet of the dehydrating molecular sieve is cooled down to 25 °C in heat exchanger and this stream leaves this exchanger saturated with water at 25 °C (Mariano Martín and Ignacio E. Grossmann, Carnegie Mellon University

2.5. Factors affecting ethanol production

There are some parameters affecting ethanol production process. These are temperature, pH, substrate concentration and yeast concentration as discussed below.

2.5.1. Temperature

Fermentation condition is an important parameter of fermentation process. Controlled condition can ensure maximum product from fermentation. Ethanol production is maximized by controlling fermentation temperature. Bio-ethanol production increases with the increase in temperature and reaches maximum value at 35℃. Further increasing temperature reduces the percentage of ethanol production and it is mainly due to the denature of the yeast cells.

2.5.2. PH

PH is one of the factors affecting ethanol production. The sample, which is fermented at different pH values between 1.0 and 8.0 obtain maximum yield of bio-ethanol by adding lime or sulphuric acid. The samples will be kept in anaerobic condition for a period of three days and the fermented solution was analyzed for every 12hrs intervals.

2.5.3. Substrate concentration

The amount of the substrate is the other factor affecting bio-ethanol production. The sample will be fermented with different quantity of peel powder concentration such as 50 gm/l, 100 gm/l, 200 gm/l, 300 gm/l and 400 gm/lit an optimum operating condition. The concentration of bio-ethanol increases along with the increase in sugar concentration and reaches maximum ethanol production at sugar concentration of 1 and further increasing sugar concentration inhibit the ethanol productivity.

2.6. Mango waste Utilization

Mango waste has both a necessity and challenge. This waste is used as cattle feed or dumped in open areas where it generates environmental pollution. The presence of high amount of reducing sugars in dried and fresh mango peel prompted as to make an attempt to utilize it as raw materials for ethanol production and development of cheap medium.

2.7. Chemical component of mango peel

Mango peels contain 5.65 to 7.65% protein, 54.45% polyphenol, 59.98% moisture, 10.97% dry mass lipid crude pectin, 1.07% starch and 1.87% ash, cellulose, hemicelluloses (Jailed al., 2007). In general the level reducing sugar, non- reducing sugar, protein and cellulose varies depending on cultic.

2.8. Bio ethanol Demand in Ethiopia

Ethanol production in Ethiopia is connected with sugar factories and aimed for import substitute of petroleum products, to enhance agricultural development and agro processing extension, job creation, and export earnings. However, only a small fraction of the potentials is utilized yet, blend has accessed only in the capital city of the Country. Moreover, at present only two of the sugar factories, Fincha and Metehara, are producing bio ethanol (Gebre egziabher *et al.*, 2014).

Table 1. Different source and Feedstock for Bio-Ethanol production

Raw material	Potential of bio ethanol production( )
Sugar cane	70
Sugar beet	110
Sweet potato	125
Potato	110
Cassava	180
Maize	360
Rice	430
Barley	250
Wheat	340
Sweet sorghum	60
Bagasse and other cellulose biomass	280

CHAPTER THREE

3. MATERIALS AND METHODS

Site of Experiments

The experiments were carried out at Wolkite University in the Department of Chemical engineering laboratory. Centrifuge, Autoclave and Incubator was used in the Department of Food processing engineering and Characterizations of the product was done in the Department of Chemistry at the College of Natural Science.

3.1. Characterization of Raw material (Mango peel)

Here the amount of moisture content, fixed carbon content, ash content and volatile matter content of samples mango peel was determined.

Materials

The materials used to run the characterization of mango peel were:

Mango peel as raw material

Digital balances and

Ovens

Methods

The proximate analysis method was used to characterize the sample mango peel. Here moisture content (MC), volatile matter content, the fixed carbon content, the ash content (the inorganic residue remaining after combustion of the sample) of the sample mango peel was evaluated.

Determination Moisture Content (MC)

$\text{Mass of entering} - \text{mass leaving} + \text{generation} - \text{consumption} = \text{accumulation}$

Mass of generation = mass of consumption= 0, since during washing there is no reaction.

$\text{Therefore, input} - \text{output} = \text{accumulation}$

Also accumulation = 0, because at steady state operation.

$\text{Mango peel collected} = \text{cleaned mango peel} + \text{dirt on mango peel removed}$

Drying of cleaned mango peel

The moisture content of mango peel was dried by sun light for two days and for furtherdrying it was dried by an oven at 101℃ for 3 hrs.

Cleaned mango peel = mass of dried sample + mass of moisture

From this the total percentage of moisture content on mango peel was calculated as follow

MC (%) = $\frac{(W1-W2)}{W1} * 100$

Where: W1= Initial weight of mango peel cleaned

W2= weight of mango peel after drying

The Volatile Matter Content (VM) Determination: Volatile matter of the mango peel was determined by heating the sample in Furness in absence of oxygen at 950^{o}C for six minutes (Abraha, 2011). The volatile matter was computed as the difference between the initial weight and final weight of the sample to the ratio of the original weight of the sample as follows

VM (%) = $\frac{(W1-W2)}{W1} * 100$

Where: W1= Original weight of sample

W2= weight of sample after cooling

Sieving of sample

After crushing, the dried mango peel sample were grinded by using coffee grinder, we used sieving for separation purpose and sample particle size to about 2mm.

The sample size above 2mm was grinded again and again until 2mm.Therefore; the final prepared dry weight of sample mango peel powder was 0.86 kg which obtained after grinding process.

Mango Peel chemical composition

Fresh mango peel contains significant amount of moisture. Mango peel is rich in pectin, cellulose, hemicelluloses, lipids, proteins, polyphenols and carotenoids (Ajila et al. 2007). In general, the level of reducing sugars, nonreducing sugars, protein and cellulose varies depending on cultivar. Typical composition of fresh and dried mango peel is given in Table 2. The dried mango peel contains high amounts of reducing sugars. Therefore, it can be used as substrate for fermentative production of ethanol, organic acids and other industrial bio products. In recent years, this fruit processing waste has received much attention as a potential source of 1902 bio-energy and other value-added products. Value addition can be successfully achieved through biotechnological route.

Table 2 the average composition) of mango peel

Content	Fresh mango peel	Dried mango peel
Moisture	70	10
Total solid	25	70
Reducing sugar	7	30
Non reducing sugar	5	4
Protein	3.5	4
Cellulose and lignin	25	23

Source: (Reddy etal.2011)

3.2. Experimental for Bio ethanol production

In this sub title, the major experimental analysis was discoursed in detail for bio ethanol production from mango peel waste

3.2.1. Materials

Chemicals: Mango peel waste as raw materials**,** 98% Sulfuric Acid (H2SO4) used as a pretreatment and hydrolysis mango peel, Sodium Hydroxide (NaOH) used to adjust the pH of soluble cellulose, Yeast extracts (Agar) used as media preparation, Urea used as media preparation, Dextrose sugar used as media preparation and Mg SO4.7 H2O used to media preparation.

Equipment: plastic bags to collect the samples and transport to the laboratory for processing, knife for cutting the mango peel wastes in to pieces , ovens to dry the required sample, mortar and pestle to reduce the size/crush the dried sample, sieves to sieve the grinded sample to the particle size of 2mm, balances to weigh samples and chemical required, digital pH meter to measure the pH, centrifuge to separate the soluble liquid from non-soluble part, autoclave for sterilization and hydrolysis and Fermentation and distillation set ups to ferment and distill respectively the samples.

3.2.2. Methods

The methods of this thesis were: production of bio ethanol from mango peel wastes by using separate hydrolysis and fermentation (SHF) methods in the laboratory scales. The major experimental processes for production of bio ethanol from mango peel wastes were summarized in the following procedures.

3.2.1. Collections of mango peel

The mango peels were collected from juice house of Gubre town. Then, it was dried in the sun for two days and for 3hrs in the oven at 101°C for further drying. Size reduction (grinding) of mango peel to 2mm mesh size by using mortar and pestle to get the powdered form and sieving was continued. The sample was characterized before pretreatment process was started. The sample was kept at room temperature until the next stage of the experiment

Grinding of mango peel into powder form increases the surface area of the sample which initiates and enhances the contact between hemicelluloses and cellulose with dilute acid to reduce cellulose crystalline.

a) Mango peel collected b) Cutting in to pieces c) drying in the oven

Figure 3.2. Mango peel collected, Cutting in to pieces and drying in the oven

a) Dried Mango Peel b) grinding by using mortar and pestle c) sieving

Figure 3.3. Dried Mango Peel, grinding by using mortar and pestle and sieving

Figure 3.4 Prepared mango peel powder

3.2.2. Pre -Treatment of mango mixed Powder

Pretreatment method was used to destroy hemicellulose, lignin shell, to protect cellulose or avoid the degradation or loss of carbohydrate and to decrease crystallinity of cellulose, to increase the porosity of the materials. The pretreatment was done by mechanical stirrer at 200 rpm for 24 hrs. in the laboratory

Steam Pretreatment: The powders of mango peel were treated inside autoclave; the sample were treated and conditioned. Steam pretreatment uses steam at $121°C$ temperatures. The steam flow through the hemicelluloses and cellulosic material at temperature of $121°C$ First, the mango peel powders were treated and it feed as batches, every batch contains $50g$ of screened mango peel powder with 10: 1(v/w) ratio of water to the sample that means for 1gm of mango peel sample, it requires 10ml The temperature was applied at $121°C$; then released the pressure until the pressure became 0 bars. The retention time for every batch was $15min$. Finally, the samples were kept in autoclave for the given pretreatment time and temperature and allowed to cool for the next procedure

3.2.3. Procedures in Steam Pretreatments

50g of mango peel sample were added in to conical flasks and 500ml of distilled water were added. Then the conical flasks were capped with the help of rubber plugs. The sample autoclaved at a temperature of 121℃

After finishing the given pretreatment time and temperature the sample in autoclave were allowed to cool and the soluble part was separated from the non-soluble portion. The non-soluble portion was hydrolyzed in the next steps and the soluble solution was placed in another conical flask

3.2.4. Dilute Acid Hydrolysis

In this step the pretreated sample that means the cellulose part can be degraded or converted to glucose. The weight of the solid part (cellulose) of the sample after pretreatment was decreased to 220grams. This sample was hydrolyzed with three factors and three levels and its explains further in the experimental design procedure. Literature works on the dilute acid hydrolysis of different lignocellulosic materials have defined optimal process conditions for temperature, dilute sulfuric acid and reaction time as follows:

Temperature 100-132℃,

Sulfuric acid concentration 0.5–1%, and

Reaction time 5-30 min (Izmirlioglu & Demirci, 2012).

So, for this experiment the dilute acid hydrolysis procedure was started by adding 0.5%, 0.75%, and 1% (v/v) diluted sulfuric to the distill water and mango peel sample was added to each of the solution prepared. Then, the mango was hydrolyzing in the autoclave at three levels of temperature (100, 116, and 132℃), time of (30, 50, and 70min). But in response surface CCD (central composite design) understands as five levels by adding two other center points for each experimental solution. So, the hydrolysis step requires three different solutions with 0,5% H2SO4 , 0.75% H2SO4,1% H2SO4 with constant amount of pretreated mango peel 50gm for each solution. Same way the temperature and time also minimized in to three. Temperature (100,116 and 132℃) and time (10, 15 and 30mins). These three-parameters were applied to hydrolysis step of the experimentation with 10-minute time, 100 ℃ temperature and 0.5% of acid concentration at minimum levels and 30-minute time, 132℃ temperature and 1% acid concentration at maximum levels.

The cellulose molecules which are composed of long chains are broken down to simple sugar, before it is fermented for alcohol production. Even though there are many types of hydrolysis types, dilute acid hydrolysis is an easy and productive process and the amount of alcohol produced in case of acid hydrolysis is more than that of alkaline hydrolysis. Each sample had to pass through five primary experiments that were in series to get the final result ethanol, that is: size reduction, pretreatment, hydrolysis, fermentation and distillation. The three -parameter were applied to hydrolysis step of the experimentation. 100g of grinded fruit peels were used for each experiment and the factors for hydrolysis were time (5 to 45 minutes), hydrolysis temperature (100 to132^{0}C), and acid concentration (0.5 to1%).

Table 3. Minimum and Maximum values of parameters

Factors	Minimum	Maximum
Hydrolysis time(minutes)	5	30
Hydrolysis temperature(^{0}C)	100	132
Acid concentration (% by volume of distilled water	0.5	1

Table 4. Experimental design formulated for hydrolysis stage

S. Number	Actual Value		
	Acid con.	Temp (^{0}C).	Time(Min)
1	0.50	100	10
2	0.75	120	15
3	1	132	30

After hydrolysis the solid part was separate from the liquid by vacuum filtration as shown (to remove the non-fermentable lignin portion). Finally, the soluble component was mixed with the previously filtered solution from the pretreatment step for the next procedure

Figure 3.5 Centrifuge separation

3.2.6. Procedures in pH adjustment

Before addition of any micro-organism to the above prepared sample, pH of this sample was adjusted. This was done because of the micro-organism will die in hyper acidic or basic state. A pH of around 5 -6 was maintained. Pretreated and hydrolyzed sample was mixed, shaken substrate primarily checked for pH using a digital pH meter. Since, the mixed sample was more acidic media, and then it must maintain the pH (5-6) by adding sodium hydroxide solution. Then the pH was maintained 5.5 and it was stored until the next procedure.

3.2.7. Sterilization

The reactor and all the equipment's that were used for fermentation purposes were sterilized (autoclaved). The sterilization was carried out at a temperature of for 15 minutes.

3.2.8. Media Preparation

Chemicals that were used for preparation 100 ml media for the fermentation process were: 10 gm of Sugar (Dextrose), 1.0 gm Mg $SO_4.7H_2O$, 1.0 gm Urea, 0.2 gm yeast extractor, make up water 100ml, and the pH is adjusted as 5.5. The media was autoclaved at 121℃ for 15 min to destroy some microbes. Then the flask was placed in shaking incubator for 24 hrs. at 30 ℃ and 200rpm.

a) Media preparation b) prepared media c) media in shaking incubator

Figure 3.6 media preparation, prepared media and media in shaking incubator

3.2.9. Fermentation

Fermentation of the hydrolyzed sugar was continued to produce bio-ethanol. First the optimum (maximum) result was selected from hydrolysis step for fermentation process. After well mixing the sample and the media, it was placed on shaking incubator at a temperature of 30 ℃ and at 200rpm for 72 hours to ferment the produced glucose to bioethanol in the biochemical engineering laboratory as shown in the figure. General Fermentation Procedures: Major processing steps in alcoholic fermentation are: Raw material (substrate) preparation, Yeast propagation (inoculums preparation), and Final fermentation.

The sample was conditioned at temperature of 30℃ before fermentation step was started. ϖ

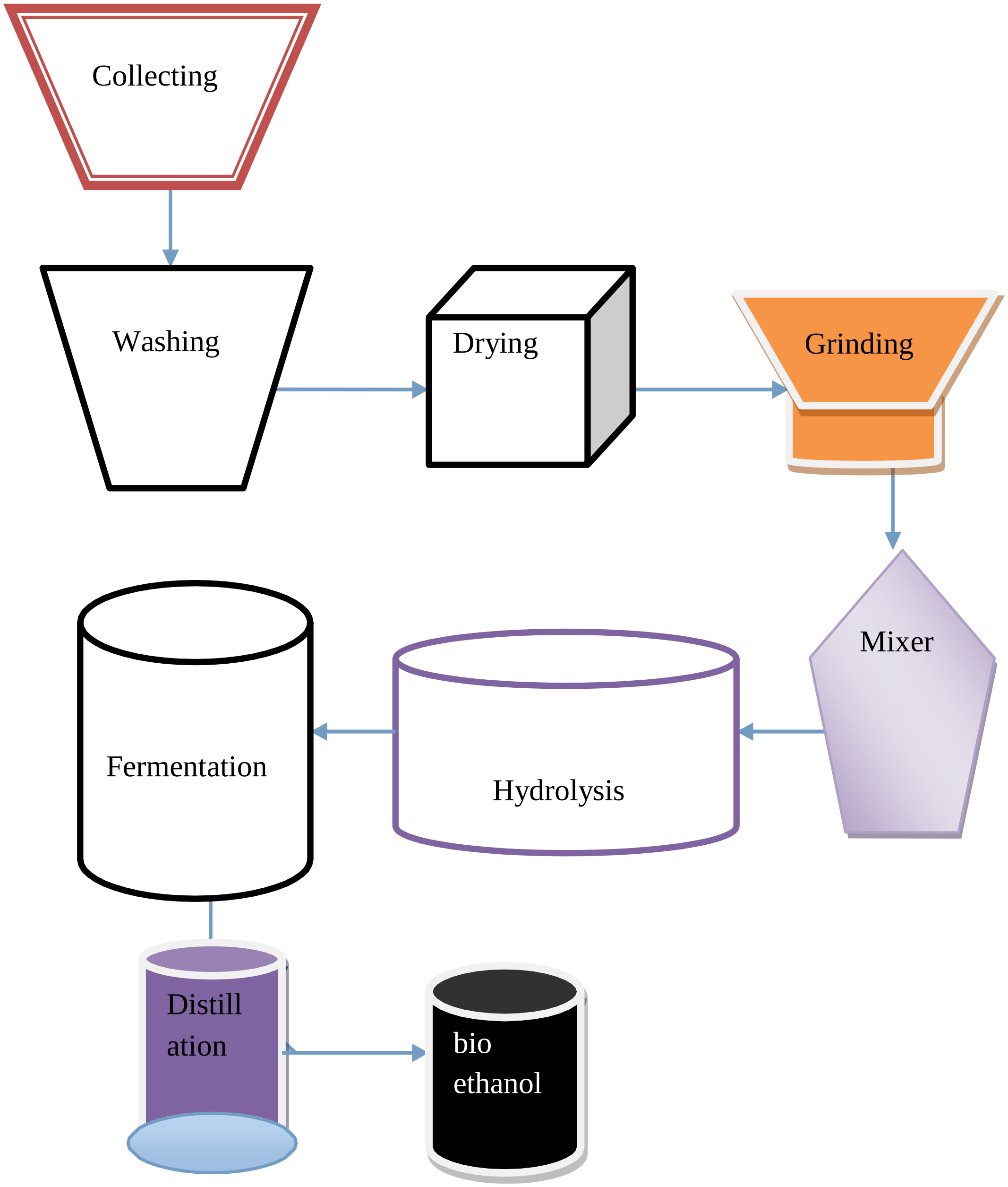
The adapted media with the proportion of 1:10 to the soluble sample was Autoclave set at 30 ℃ and 200 rpm and then mixed the prepared sample with the media prepared into the autoclave using sterilized funnel.

The parameters of fermentation i.e. fermentation time, yeast concentration (yeast proportion) and fermentation temperature were set to be at 72 hour, 10% (with the proportion of 1:10 that was the prepared media and sample respectively) and 30 ℃ respectively. And after 72 hours of fermentation, the samples were taken out and distilled.

3.2.10. Distillation

Distillation was the last step in the production of ethanol from mango peel experiments. It is the purifications steps. Distillation is the method used to separate two liquid based on their different boiling points. However, to achieve high purification, several distillations are required. In this

Figure 3.7. Simple distillation



Flow Chart 3.1 Flow diagram for bio ethanol production from mango peel

3.3. Characterization of the product

The produced bio ethanol was characterized by using different technique such as:

3.3.1. Color:

The standard bio ethanol is colorless that is the same to our produced bio ethanol.

3.3.2. Chromic acid test:

When react with chromic acid, bio ethanol changes the color of chromic acid from orange red to green

3.3.3. Density measurement:

The density of the sample was obtained by using hydrometer equipment. Density measurement has calculated by using pycnometer.

$$Specific\ gravity\ of\ sample = \frac{X2 - X1}{X3 - X1}$$

Where, X_1: weight (gm.) of empty pycnometer

X_2: weight (gm.) of sample+ pycnometer

X_3: weight (gm.) of sample+ water

3.4.4. Refractive index:

Refractive index of ethanol is determined by refract meter which identifies the wavelength of ethanol (i.e., how much light moves through it

3.4.5. Ethanol yield (%)

$$\text{Ethanol yield (\%)} = \frac{\text{mass of ethanol produced}}{mass\ dried\ mango\ peel\ consumed} * 100$$

CHAPTER FOUR

4. RESULT AND DISCUSSION

This work was consisting of four major parts: pretreatment to remove lignin, reduce cellulose crystalline, sterilize the mango peel and increase the porosity of the materials, dilute sulfuric acid hydrolysis to degrade cellulose to glucose, fermentation of glucose to produce bio-ethanol and distillation to separate pure ethanol. The experimental outcomes of those particular results were measured in the hydrolysis of cellulose to know the yield of sugar concentration. There were 20 experiments conducting by varying hydrolysis time, hydrolysis temperature and diluted sulfuric acid concentration. The amount of product obtained for each sample in the hydrolysis was measured and recorded, to select the optimum value for further process like fermentation, and distillation to obtain final product bioethanol and finally chemical composition of this product (bioethanol) were analyzed.

4.1. Results of Physicochemical Characterization for Raw Material (mango peel)

The Moisture Content (MC) Determination

Mass of entering − mass leaving + generation − consumption = accumulation

Mass of generation = mass of consumption= 0, since during washing there is no reaction.

Therefore, input - output = accumulation

Also accumulation = 0, because at steady state operation.

4kg of mango peel collected = 3.1 kg of cleaned mango peel + dirt on mango peel removed

Mass of dirty removed on mango peel = 0.9kg

Drying of cleaned mango peel (3.1kg)

The moisture content of mango peel was dried by sun light for two days and for furtherdrying it was dried by an oven at 101℃ for 3 hrs.

Cleaned mango peel (3.1kg) = mass of dried sample (0.89kg) + mass of moisture (kg)

Mass of moisture on mango = 2.21kg

Table 5. Result obtained from the preparation

Fruit peel	Weight before drying(kg)	Weight after drying (kg)	Moisture content(kg)
Mango	3.1	0.89	2.21

From this the total percentage of moisture content on mango peel was calculated as follow

MC (%) = $\frac{(W1-W2)}{W1} * 100$

MC (%) = $\frac{(3.1-0.86)}{3.1} * 100$

=0.70(70%)

Where: W1= Initial weight of mango peel cleaned

W2= weight of mango peel after drying

The Volatile Matter Content (VM) Determination: Volatile matter of the mango peel was determined by heating the sample in Furness in absence of oxygen at 950^{o}C for six minutes (Abraha, 2011). The volatile matter was computed as the difference between the initial weight and final weight of the sample to the ratio of the original weight of the sample as follows

VM (%) = $\frac{(W1-W2)}{W1} * 100$

Where: W1= Original weight of sample

W2= weight of sample after cooling

VM (%) = $\frac{(0.86-0.24)}{0.86} * 100$

=0.72(72%)

Sieving of sample

After crushing, the dried mango peel sample were grinded by using coffee grinder, we used sieving for separation purpose and sample particle size to about 2mm.

The sample size above 2mm was grinded again and again until 2mm.Therefore; the final prepared dry weight of sample mango peel powder was 0.86 kg which obtained after grinding process.

Mango Peel chemical composition

Fresh mango peel contains significant amount of moisture. Mango peel is rich in pectin, cellulose, hemicelluloses, lipids, proteins, polyphenols and carotenoids (Ajila et al. 2007). In general, the level of reducing sugars, nonreducing sugars, protein and cellulose varies depending on cultivar. Typical composition of fresh and dried mango peel is given in Table 2. The dried mango peel contains high amounts of reducing sugars. Therefore, it can be used as substrate for fermentative production of ethanol, organic acids and other industrial byproducts. In recent years, this fruit processing waste has received much attention as a potential source of 1902 bio-energy and other value-added products. Value addition can be successfully achieved through biotechnological route.

Table 6 the average composition) of mango peel

Content	Fresh mango peel	Dried mango peel
Moisture	70	10
Total solid	25	70
Reducing sugar	7	30
Non reducing sugar	5	4
Protein	3.5	4
Cellulose and lignin	25	23

Source: (Reddy etal.2011)

4.2. Characterization of products

4.2.1. Density measurement

The density of the sample was obtained by using hydrometer equipment.

Density measurement has calculated by using pycnometer

$$Specific\ gravity\ of\ sa\text{mple} = \frac{X2-X1}{X3-X1}$$

Where, X_1: weight (gm.) of empty pycnometer and X_1= 46.94X_2: weight (gm.) of sample+ pycnometer and X_2= 105

X_3: weight (gm.) of sample+ water and X_3=115.14

$$\text{Specific gravity of sample} = \frac{(98.04-46{,}94)}{(102.37-46.94)} = 0.85134$$

Density = Specific gravity*density of water

$= 0.85134 * 1g/m3 = 0.85134\ g/m3$

Specific gravity of ethanol can identify the alcohol content of ethanol from specific gravity table.

As explained in Perry's chemical engineering hand books 6th edition, at room temperature standard alcohol content of ethanol is 97%, specific gravity is 0.79648 but, the specific gravity of obtained result is 0.85134 that results the alcohol content of 75%. This result deviates from standard due to the existence of water in the obtained sample.

4.2.2. Color

Color is the physical property of the substance which characterizes that substance. The color of bio ethanol which was produced from mango peel powder is colorless. Therefore, it attains one of the properties of bio ethanol which is used for fuel and one of bio ethanol characterization was attained.

4.2.4. Testing product by Chromic Acid

This characterization method depicts the chemical properties of ethanol. When ethanol reacts with chromic acid, it oxidized. Taking some drops of normal ethanol (which is produced in industry) then mix with small amount of drop of chromic acid, the color obtained was intense sky blue and changed to green after the addition of concentrated sulfuric from orange-red.

acid and the same is true for our sample(i.e., the bio ethanol produced from mango peel); when we added the same amount and mix the same color was obtained with the former one which was green color. This characterizes the chemical property of ethanol that is oxidation.

4.2.4. Refractive Index Test

Refractive index of ethanol is determined by refract meter which identifies the wave length of ethanol (i.e., how much light moves through it). The standard of refractive index of ethanol is 1.364. But, the refractive index of our produced ethanol is 1.3335, this due to ineffective separation during distillation.

There is some deviation when compared with the standard one. This is due to the fact that for purification process we used simple distillation .But; simple distillation is typically used for components which have boiling temperature difference greater than 25. However, the boiling temperature difference for ethanol- water mixture is 22 .Therefore; the component does not

Completely separate that the product gotten didn't fit the standard completely. On the other hand, to get the purified ethanol dehydration step is essential. But, to dehydrate molecular sieve is required and in order to get pure ethanol up to 99.9%. However, due to the existence of high amount of water in our product, it didn't the attain the property of standard ethanol

4.2.5. Ethanol yield (%)

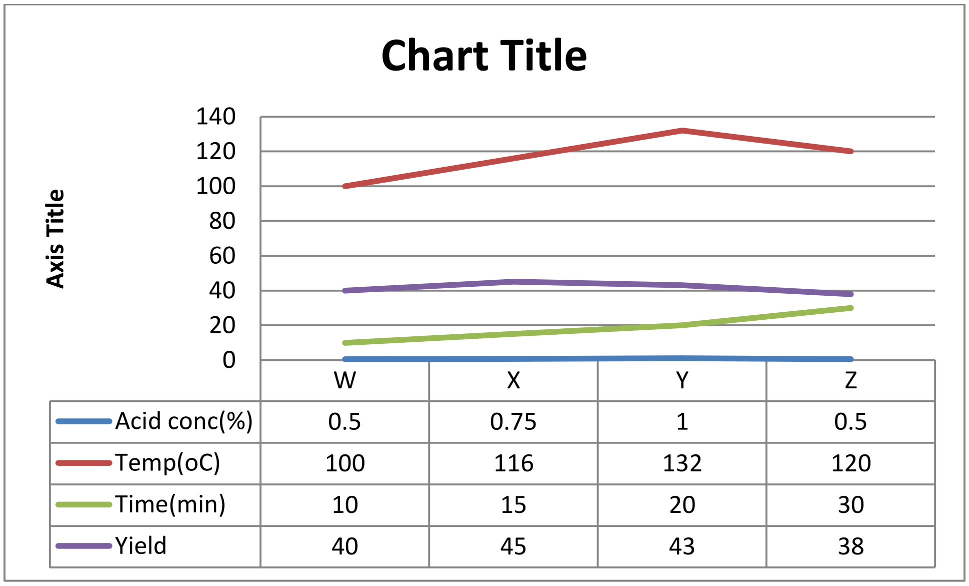
$$\text{Ethanol yield (\%)} = \frac{\text{mass of ethanol produced}}{mass\ dried\ mango\ peel\ consumed} * 100$$

$$= \frac{58\text{ml} * 0.780\text{gm/ml}}{100gm} * 100$$

$$= 45.24\%$$

4.3. Product of Analysis

In this study experimental design techniques were used to determine the effects of the acid concentration, hydrolysis time and temperature on the efficiency of ethanol yield. A total of 4 experiments were carried out for optimization purpose where the effect of each factor was analyzed by using lower and higher values from optimized conditions. The ethanol yields obtained from experiments were used as a response parameter for optimization and table 4.1 show respective yields of each run with the factor.



	W	X	Y	Z
Acid conc(%)	0.5	0.75	1	0.5
Temp(oC)	100	116	132	120
Time(min)	10	15	20	30
Yield	40	45	43	38

Figure 8.Ethanol yield and parameters condition

As we see from the above figure 4.1 high yield of ethanol were observed at 0.75% acid concentration, at 116^{0}C temperature and at the time of 15min. In this study experimental design techniques were used to determine the effects of the acid concentration, hydrolysis time and temperature on the efficiency of ethanol yield. A total of 4 experiments were carried out for optimization purpose where the effect of each factor was analyzed by using lower and higher values from optimized conditions. The ethanol yields obtained from experiments were used as a response parameter for optimization and table 4.3 show respective yields of each run with the factor.

Table 7.optimization of product

Run No	Acid conc.(% by weight)	Temperature (^{0}C)	Time (min)	Yield of Ethanol (%)
1	0.5	100	10	40
2	0.75	116	25	45
3	1	132	30	43
4	0.5	120	15	38

At the lower and higher levels of acid concentration and time, the production of ethanol yield level decrease since it has effect of the hydrolysis treatment. At lower acid concentration and time the cellulose might not hydrolysis to simple glucose and at higher acid concentration and time the cellulose might convert to other molecules which might not be fermentable. Hence both acid concentration and time have strong relationship for the yield of ethanol production.

CHAPTER FIVE

5. MATERIAL AND ENERGY BALANCE

Material and energy balances are very important in an industry. Material balances and energy balance are fundamental to the control of processing, particularly in the control of yields of the products. The increasing cost of energy has caused the industries to examine means of reducing energy consumption in processing. Energy balances are used in the examination of the various stages of a process, over the whole process and even extending over the total production system from the raw material to the finished product. The first material balances are determined in the exploratory stages of a new process, improved during pilot plant experiments when the process is being planned and tested, checked out when the plant is commissioned and then refined and maintained as a control instrument as production continues. When any changes occur in the processthe material balances need to be determined again.

The energy balance determinations are also made to determine the energy requirements of the process, the heating, cooling and power required. In this plant operation it is thought that an energy balance (energy audit) on the plant will show the pattern of energy usage and suggest areas for conservation and savings. The basic principle for both material and energy balance is simply basedon the following equation:

Input + Generation = Output + Consumption + Accumulation

5.1MATERIAL BALANCE

In all the mass balance calculations, no mass accumulation in the design process is assumed. Since the mass balance involved reaction, it is calculated by using the mole flow of each compound whenreaction is involved in the process. Each reaction depends on the conversion of reaction since all thereactions are assumed in equilibrium and the number of moles consumed in the reaction

$$\sum (Fi)\ \text{input} + \sum (Fi)\ \text{generated} = \sum (Fi)\ \text{output} + \sum (Fi)\ \text{consumed}$$

Basis of calculation: one operation day/24hr

Production (plant capacity) = $\frac{\text{yield}}{\text{annual}}$ $=3.4\times10^{6}$ lit/yr.

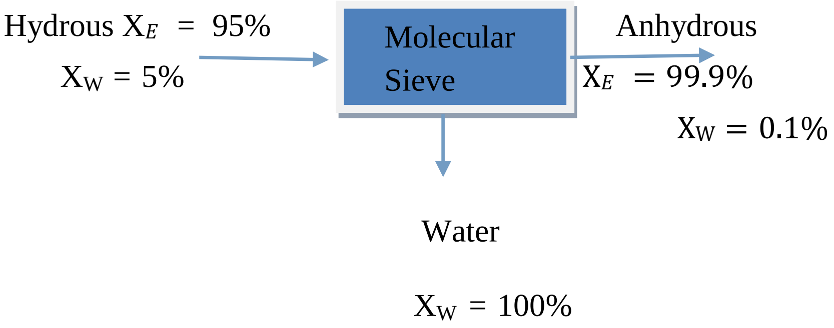
With plant operation = 330 calendar day /year

Anhydrous ethanol (lit/hr.) =$\frac{\text{Capacity (lit/yr)}}{330\ \text{day/yr}\times 24\text{hr/day}}$ =429.3lit/hr.

M=$\frac{429.3\text{lit/hr.}\times 790\text{kg/m\^{}3}\times 1\text{m\^{}3}}{1000\text{lit}}$=339.14kg/hr×24hr/1day×330day/1yr=2,686 ton/yr.

5.1.1 Material balance for molecular sieve

Molecular sieve is an equipment which following the distillation column and bring theethanol concentration from 95% − 99.9%.



$$\text{Hydrous ethanol enter in to sieve} = \frac{\text{Anhydrous}}{\text{Hydrous ethanol fraction}} = \frac{339.14Kg/hr}{0.95} = 357\text{kg/hr.}$$

We can also calculate the water trapped by the molecular sieve as follows;

$\text{Mass flow rate of hydrous ethanol}$

$= \text{mass flow rate of water leave sieve} + \text{mass flow rate of anhydrous ethanol leave the sieve.}$

$M_{HE} = M_W + M_{AE}$

Where,

M_{HE} =mass flow rate of hydrous ethanol

M_{AE} =mass flow rate of anhydrous ethanol

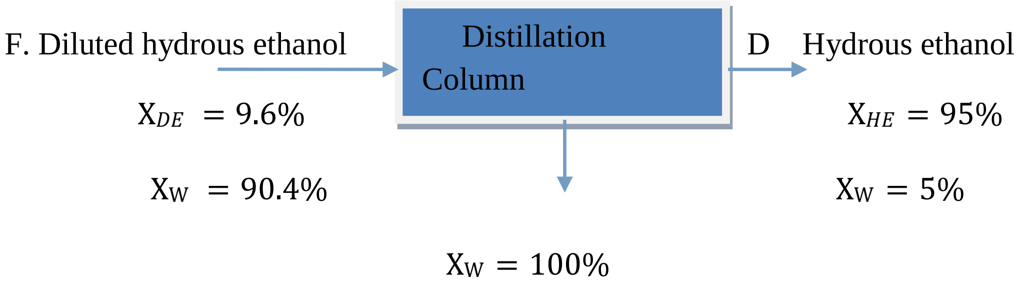
M_W = mass flow rate of water

$M_W = M_{HE} - M_{AE}$

$M_W = 357kg/hr - 339.14kg/hr = 17.86Kg/hr.$

5.1.2. Material Balance on Distillation

Distillation is used for the purification of ethanol from the mixture of ethanol-water. The mixture from fermentation enters in to the distillation with the mixture of 9% ethanol and the rest is water (i.e. 91%), then the purified ethanol comes to 95%.



Where, X_{DE}= Fraction of diluted hydrous ethanol

X_{HE} =Fraction of hydrous ethanol

From ethanol component balance

$$F * X_F = W * X_E + D * X_{HE}$$

$$F = \frac{W * XE + D * XHE}{XF}$$

$$= \frac{0+357*0.95}{0.09} = 3768Kg/hr$$

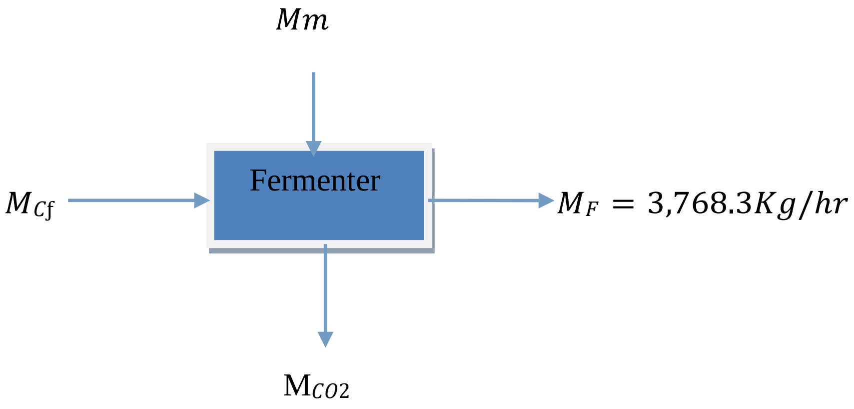
From total balance, $F = W + D$

$$W = F - D$$

$$= 3{,}768.3kg/hr - 357kg/hr$$

$$= 3{,}411.3kg/hr.$$

5.1.3 Material Balance for fermentation



Where, M_{Cf} = mass of centrifuge

M_m = mass of media

M_F = mass of fermenter

M_{CO2} = mass of carbon dioxidefrom the fermentation reaction:

$C6H12O6 \longrightarrow 2C2H5OH + 2CO2$

180gm/mol $\longrightarrow$ $92gm/mol$ ethanol $+88gm/mol\ of\ CO2\ for$ 100% conversion

But $1-3\%$ is not changed from literature and we take the value 98% efficiency.

$$Thus, \frac{MGF}{180} = \frac{357Kg/hr}{2*46}$$

$M_{GF} = 698.5\text{kg}/hr$

$And\ amount\ of\ CO2\ Produced$ is

$$M_{CO2} = \frac{698.5*88}{180} = 341.5Kg/hr$$

And Mass of media is 10% of mass of centrifuge, thus from total mass balance:

$M_{Cf} + Mm = M_F + M_{CO2}$

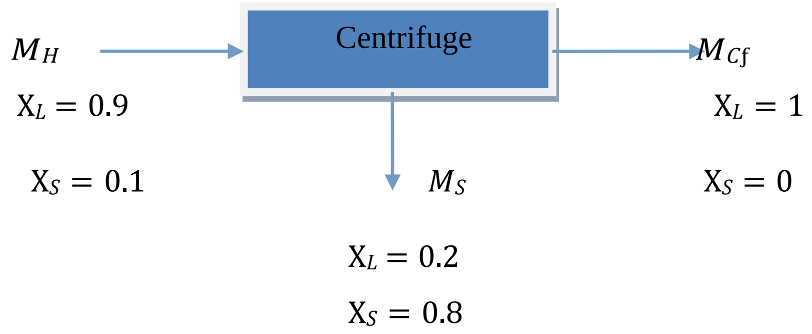
$M_{Cf} + 0.1M_{Cf} = 4{,}109.8\text{kg}/hr 1.1M_{Cf} = 4{,}109.8\text{kg}/hr$

$M_{Cf} = 3{,}736.2Kg/hr$

$Mm = 0.1 * 3736.2\text{kg/hr.} = 373.62\text{kg}/hr$

5.1.4. Material Balance for centrifugal separation

Centrifuge is used for separating incurable solid from liquid; moisture content ofcentrifuge solid is 20% (Wondale, 2012).



Where,

M_H =mass of hydrolysis

M_S =mass of solid exit from centrifuge

X_L=Liquid fraction

X_S= Solid fraction

From solid component balance:

$$M_H X_S = M_S X_S$$

$$M_H * 0.1 = M_S X_S$$

$$M_H = M_S X_S / 0.1$$

From liquid component balance:

$$M_H * X_L = M_S * X_L + M_{Cf} * X_L$$

$$M_H * 0.9 = M_S * 0.2 + 3736.2kg/hr$$

$$\frac{0.9 * MSXS}{0.1} = 0.2M_S + 3{,}736.2kg/hr$$

$$0.72M_S = 0.02M_S + 373.62kg/hr$$

$$0.7M_S = 373.62kg/hr$$

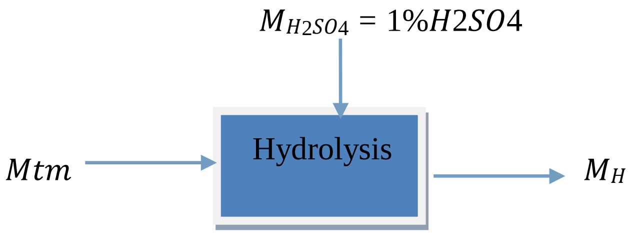
$$M_S = 533.7kg/hr$$

$$MH = \frac{MSXS}{0.1} = \frac{533.7 * 0.8}{0.1}$$

=4269.6kg/hr.

5.1.5. Mass Balance for Dilute acid treatment (Hydrolysis)

The pretreatment sample was soaked and treated with 1% H_2SO_4 to convert cellulose to glucose and serve as catalyst to glucose and serve as catalyst meaning it has no any reaction with cellulose.



Where, M_{H2SO4} = Mass of sulfuric acid

Mtm = mass of treated mixture

M_H= mass of hydrolysis

From the reaction during hydrolysis:

$$C6H10O5 \xrightarrow{H_2SO_4} C6H12O6$$

1mole of cellulose → 1mole of glucose for 100% conversion

But not complete conversion and assume that 95% Cellulose convert to glucose

$Mtm/162 = MH/180$

$$Mtm = \frac{(162 * 4{,}269.6 * 0.95)}{180} = 3{,}650.5kg/hr$$

Applying total mass balance:

$M_{tm} + M_{H2SO4} = M_H$

$M_{H2SO4} = M_H - Mtm$

$= 4{,}269.6kg/hr - 3{,}650.5kg/hr$

$= 619.1kg/hr$ of 1% diluted sulfuric acid

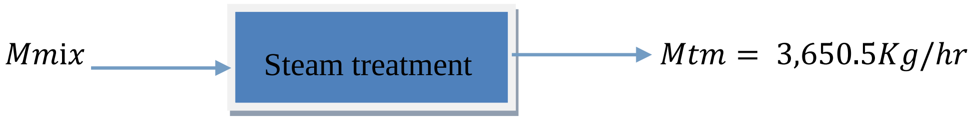
From this component;

mass of sulfuric acid = 0.01 * 619.1kg/hr=6.19kg/hr and

0.99*619.1Kg/hr of distilled water

5.1.6. Mass balance for pretreatment

Pretreatment is the method to prepare the sample for dilute acid treatment.

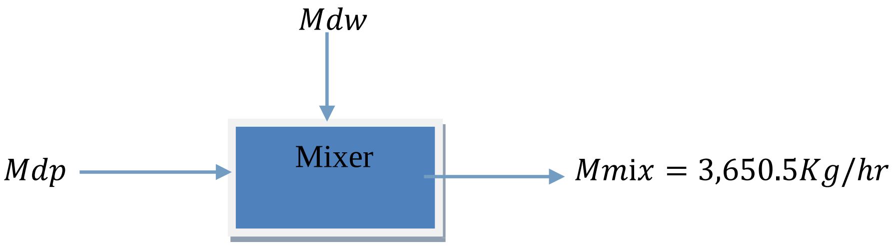


$Where\ Mmix = mass\ flow\ rate\ of\ mixture\ and\ Mmix = Mtm$

$Thus, mass\ of\ mixture\ is\ = 3{,}650.5\text{kg}/hr.$

5.1.7. Material Balance for mixing

Here mixer is the equipment used to make homogenous suspension of distilled water anddry fruit peel powder (mango peel) powder.



$Where, Mdp\ = mass\ flow\ rate\ of\ dry\ peel\ powder$

$Mdw = mass\ flow\ rate\ of\ distilled\ water$

$From\ general\ mass\ balance,$

$M_{\text{in}} = M_{out}$

$M_{dp} + M_{dw} = M_{\text{mix},}\ but\ assume\ that\ M_{dw} = 10 * M_{dp}$

$M_{dp} + 10M_{dp} = 3{,}650.5kg/hr$

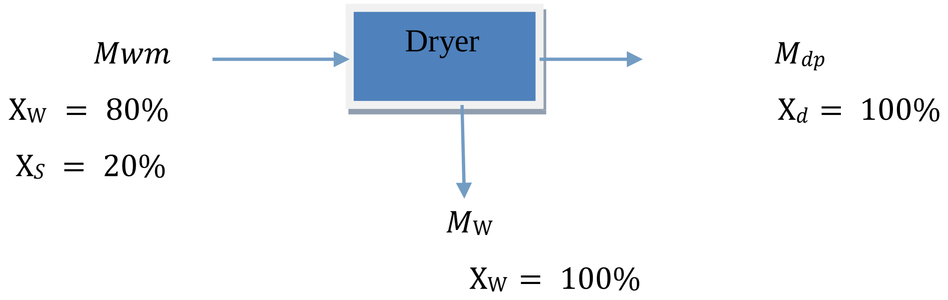
$11M_{dp} = 3{,}650.5kg/hr$

$M_{dp} = \ 332\text{kg}/hr$

$M_{dw} = 10 * 332\text{kg}/hr\ = \ 3{,}320\text{kg}/hr.$

5.1.8. Material Balance for Dryer

Used to dry mango peel to agreeable for easily crushing. The wet mango peel contains 20% solid part and other water (Wondale, 2012)



Where, M_{wm} = mass flow rate of wet mango peel

X_w = fraction of water in mango peel

Xs = fraction of solid in mango peel

Mdp = mass flow rate of dry mango peel

Component mass balance for mango peels

$$MwmXs = M_{dp} * X_d$$

$$Mwm = \frac{Mdp*Xd}{Xs} = \frac{\frac{332Kg}{hr}*1}{0.2}$$

$$= 1{,}660kg/hr$$

From over all material balance:

$$Mwm = M_w + M_{dp}$$

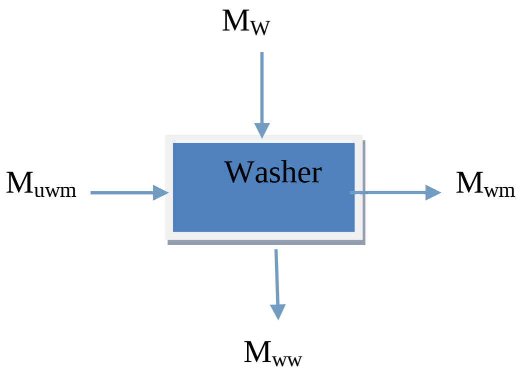
$$Mw = M_{wm} - M_{dp}$$

$$= 1{,}660kg/hr - 332kg/hr$$

$= 1{,}328kg/hr$ (Amount of water removed from mango peel.)

5.1.9. Material Balance for Washer

It is used to clean the mango peel to enhance drying process.



Where, M_{uwm}= Mass flow rate of un cleaned wet mango peel
M_w=mass flow rate of water
M_{ww}=mass flow rate of waste water

Here, 10 − 14% of waste will be removed the peel during washing.Assume that 1kg of mango peel require 2kg of water to be cleaned

Total mass balance

$$M_{uwm} + M_w = M_{ww} + M_{wm}$$

$$M_{uwm} + 2M_{uwm} = M_{ww} + 1{,}660kg/hr$$

$$3M_{uwm} = M_{ww} + 1{,}660kg/hr \ldots\ldots\ldots\ldots\ldots(1)$$

Mass balance on solid part of uncleaned mango peel:

$$\mathrm{M_{uwm} = M_{wm} + M_{sw}}$$

Where, $\mathrm{M_{sw}}$ = mass of dirt solid leave out with waste water

$$\mathrm{M_{uwm} = M_{wm} + 0.12M_{uwm}}$$

$$\mathrm{(1 - 0.12)M_{uwm} = 1{,}660kg/hr}$$

$$\mathrm{M_{uwm} = (1{,}660kg/hr)/0.88}$$

$$\mathrm{= 1{,}886.4kg/hr}$$

Hence, $\mathrm{Msw = 0.12 * 1{,}886.4kg/hr = 226.4kg/hr}$

$$Mw = 2 * 1{,}886{,}4kg/hr = 3{,}772.8kg/hr$$

And from equation(1) above,

$Mww = 3 * 1{,}886.4 kg/hr - 1{,}660 kg/hr = 3{,}999.2 kg/hr$

Therefore, Mass of waste mango peel required to produce $3.4 * 10^6$

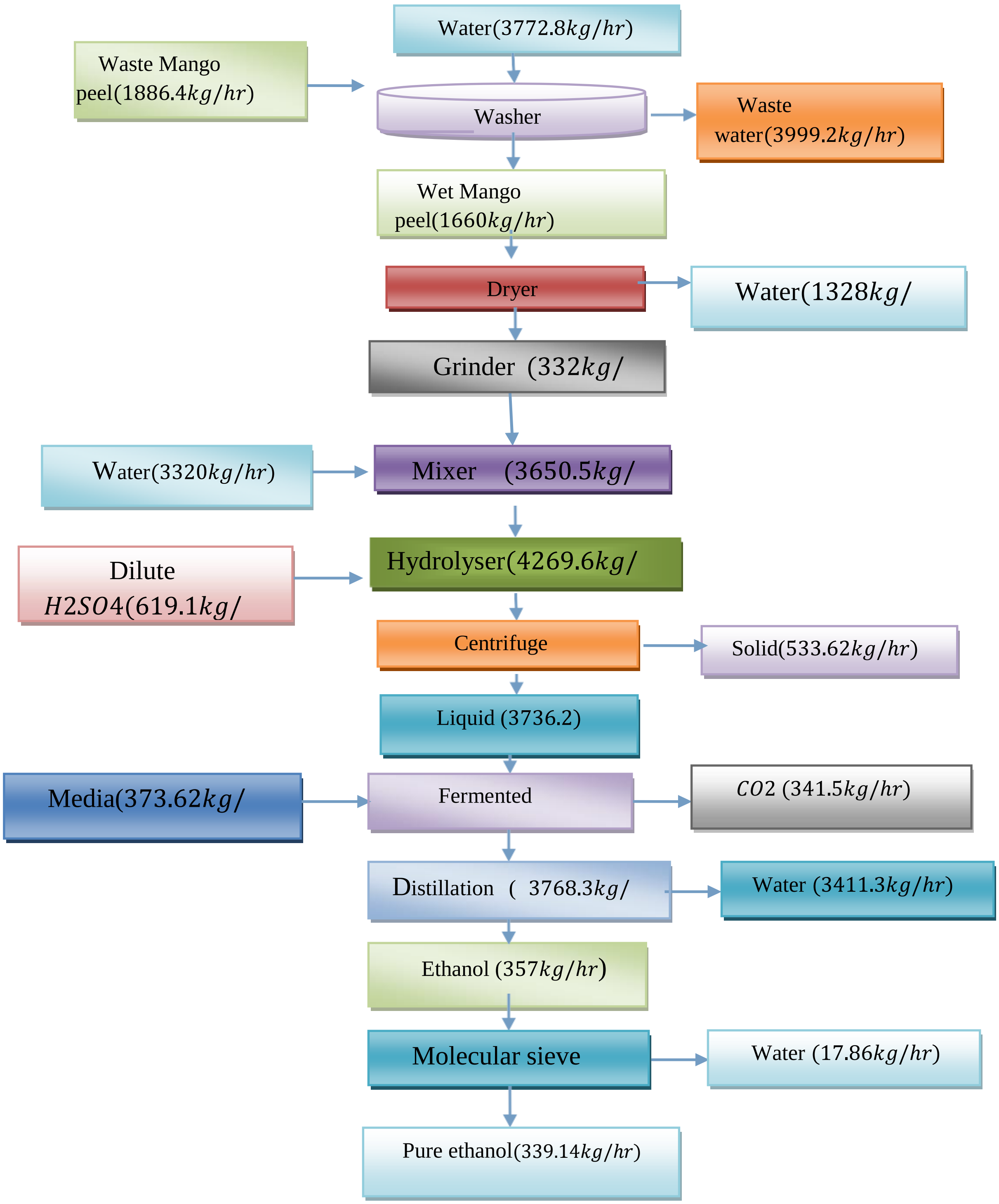
$lit/year$ is,

$M_{uwm} = 1{,}886.4 kg/\cancel{hr} * 24 \cancel{hr}/\cancel{day} * 330 \cancel{day}/yr$

$= 14{,}940{,}288 kg/yr$

$= 14.940288 * 10^3 \, ton/yr$

Summarization of Material Balance



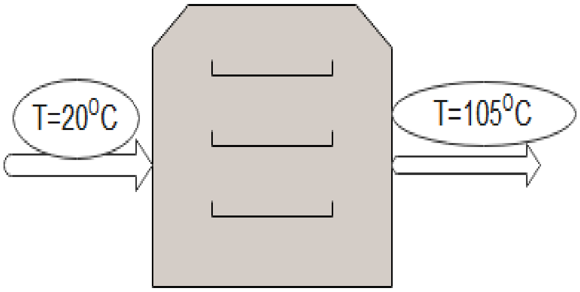
Flow chart 5.1 Summarization of Material Balance

5.2. Energy Balance

The conservation of energy is so differ from that of mass due to the fact that energy can generated (consumed) in a chemical process and can change from one form to another. In mass balance the total mass flow into a process unit must be equal to the flow out from a process at steady state. This is not true for energy. The total energy of outlet streams does not equal to that of the inlet streams if energy is generated or consumed in the process due to heat of reaction. In process design energy balances are made to determine the energy requirements of the process. It shows the pattern of energy usage and suggests areas for conservation and savings. In an open system, mass is allowed to cross the system boundary as the process occurs, the energy is usually governed by the following balance equation: $Q = MCp\Delta T$

5.2.1. Energy Balance for Dryer

Cp of mango Peel $= 3.78\ ^{kJ/}{}_{kg.k}$



$$\Delta T = T_f - T$$

$$= 105 - 20 = 85°C = 85°K$$

$$Q = mcp\Delta T$$

Where m = mass of wet mango peel

= $1{,}660 kg/hr$ from material balance

C_p= specific heat of mango peel

The energy required is

Mass of mango peel from material balance = $1{,}660\ kg/hr$

$$Cp = C_{pf} * X_f + C_{pf} * X_w$$

$$= 3.78 * 0.2 + 4.2 * 0.8$$

$$= 4.116 kJ/kg.k$$

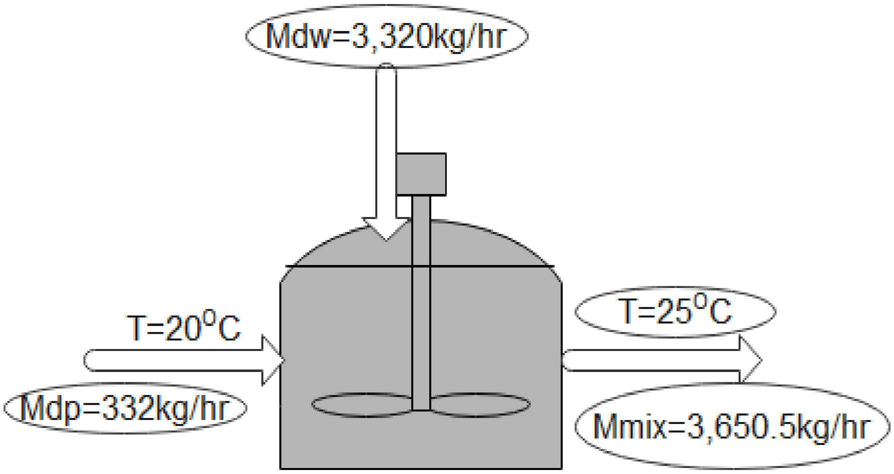
$Q = mcp\Delta T$

$=1{,}660 kg/hr * 4.116 kJ/kg.°K * 85°K$

$Q = 580{,}767.6 kJ/hr$

5.2.2. Energy balance for mixing.

It is the energy used for mix the grind mango peel and distilled water to make suspension



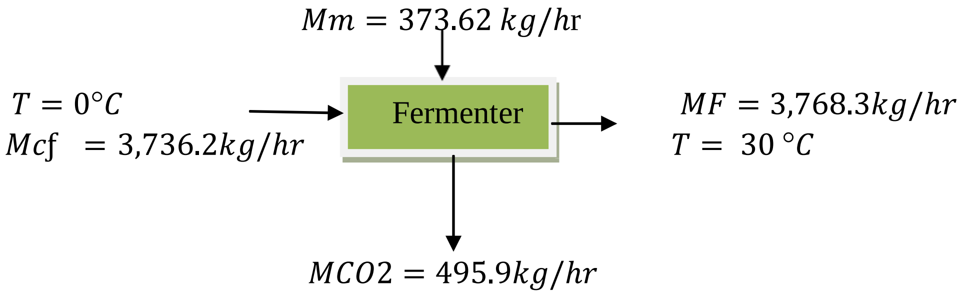
$$Cpmix = \frac{3{,}320*4.2+332*3.78}{3{,}320+332} = 4.162 kJ/kg.k$$

The heat required for mixing is $Q = MmixCp\Delta T$

$= 3{,}650.5 kg/hr * 4.12 kJ/kg.k * (25 - 20)\ °K$

$= 75{,}963.6 kJ/hr$

5.2.3. Energy Balance for fermenter



Fermentation is an exothermic reaction (heat releaser process) that generated inside the fermenter and the outlet temperature is $30°C$. The energy balance in thefermenter is at $30°C$. The energy balance in the fermenter at $0°C$ reference temperature.

$Cpmix\ at\ 30°C = 4.162\ kJ/kg.k$

$C_p\ of\ CO_2\ at\ 30°C = 0.846kJ/kg.k$

$Q_{mix} = Q_{CO2} + Q_F + Q$

$Q = Q_{mix} - Q_{CO2} - Q_F$

$= M_{mix}\ cp_{mix}\ \Delta T - M_{CO2}CP_{CO}2\Delta T - M_F CP_F \Delta T$

$CP_F = Cp_{mix} * X_{mix} + Cp_{CO2} * X_{CO2}$

$X_{CO2} = \frac{341.5}{3650.5+373.62} = 0.085$

$X_{mix} = 1 - 0.083 = 0.915$

$CpF = 4.162 * 0.915 + 0.085 * 0.846$

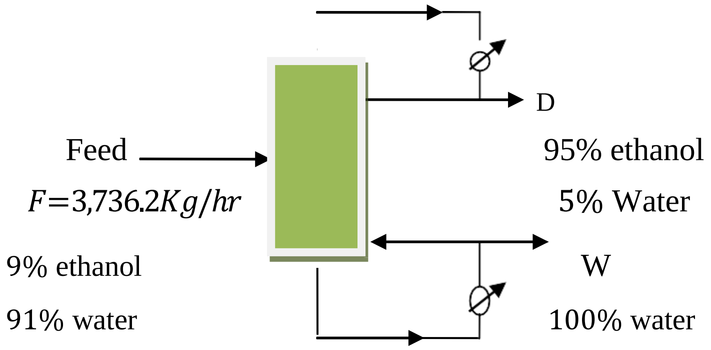
$CpF = 3.88kj/kg.k$

$Q = MmixCpmix\Delta T - MCO2CpCO2\Delta T - MFCpF\Delta T$

$= 3650.5 * 4.162 * 30 - 341.5 * 0.846 * 30 - 3736.2 * 3.88 * 30$

$= 12{,}240.5\text{kJ/hr}$

5.2.4. Energy Balance on Distillation Column



From the ethanol component balancing:

$F * XF = D * XD$

$3736.2 * 0.09 = D * 0.95$

$D=\frac{3736.2*0.09}{0.95}=354Kg/hr$

$W = F - D$

$W = 3736.2Kg/hr - 354Kg/hr W = 3382.2Kg/hr$

$CP_{C2H5OH} = 2.72kJ/kg.k$

Energy Balance

Basis $25°C$, 1hr

Heat capacity on top CP, distillate $= 0.95 * 2.72 + 0.05 * 4.2 = 2.794kJ/kg.k$

Heat capacity on bottom, C_P water $= 4.2kJ/kg.k$

Balance around main condenser

Reflux ratio, $R = 1.35$ (Here average is taken from coulson)i.e.1.2-1.5

From $R = L/D$

$L = RD$

$= 1.35 * 354 = 478kg/hr$

$V = L + D$

$= 478 + 354 = 832kg$

From vapor-liquid equilibrium data, the boiling point of 95% ethanol=78.4$°C$ at steady state, accumulation $= 0$

$Input = output$

$HF = HD + HL + QC$

$QC = HF - HD - HL$

Assuming complete condensation operation Enthalpy of vapor $= latent + sensible\ heat$

$HV = MV\lambda V + MV\lambda V\Delta T$

$= 832 * 790 + 832 * 2.72 * (78.4 - 25)$

$= 778{,}126.3 k\text{j}/hr$

$QB = QC + HD + H\text{W} - HF$

$Where, Hw = heat\ capacity\ of\ bottom$

$HF = heat\ capacity\ of\ feed$

$QB\ =\ re - boiler\ heat\ \text{input}$

$QC = condenser\ cooling$

Heat capacity of feed, $HF = MF * CP * \Delta T$

$= 3736.2 * 3.88 * (35 - 25)$

$= 144{,}964.6 k\text{J}/hr$

Heat capacity of bottom,

$HW = M\text{W} * CP * \Delta T$

$= 3382.2 * 4.2 * (100 - 25)$

$= 1{,}065{,}393 k\text{J}/hr$

$QB = QC + HD + H\text{W} - HF$

$= 778{,}126.3 k\text{J}/hr + 0 + 1{,}065{,}393 k\text{J}/hr\ - 144{,}964.6 k\text{J}/hr$

$= 1{,}698{,}554.7 kJ/hr$

Q_B-is supplied by condensing steam

Latent heat of steam at $274KN/m2, \lambda V = 2174 k\mathrm{J}/kg$

Steam required $QB/\lambda V = MS = \frac{1{,}698{,}554.7\mathrm{KJ/hr}}{2174 kJ/kg}$

=781.3kg/hr

Q_C-is removed by cooling water with a temperature rise of $30°C$

$Q_C = M_W C_P \Delta T = HV$

$M_W = \frac{Qc}{Cp\Delta T} = \frac{778{,}126.3 kJ/hr}{\frac{4.2kJ}{kg.k} * 30k} = 6175.6 kg/hr$

CHAPTER SIX

6. COSTING AND ECONOMICAL FEASIBILITY ANALYSIS

The aim of this economic analysis is to present information regarding the economic feasibility for the production of bio-ethanol from mango peel waste. So, before initiating the development of a process, at various stages in its development and before attempts the design of a process and plant, it is the responsibility of the chemical engineer to make economic evaluation. The evaluation determines whether one should undertake the project, abandon it, continue with it (but with further research) or take it to the pilot plant stage. Even if insufficient technical information is available to design a plant completely, we must still make and economic evaluation to determine if it is economically and financially feasible. A project economically feasible when it is more profitable than other competing project and financially feasible when management can raise the capital for its implementation.

The economic evaluation of a process proceeds in several steps. These are:-
Preparing a process flow diagram
Calculating mass and energy flows
Sizing major equipment
Estimating the production cost
Forecast the product sales price
Estimating the return on investment

This economic evaluation is based on the utilization of $14.94 * 10^{3}\ ton/yr$ mango peel waste ,and producing $3.4 * 10^{6} lit/year$. The costing for this study is based on the determination of percentage of delivered equipment cost estimation,which is commonly used for preliminary and study estimates.

The complete cost estimation of the plant is included into two main parts:-

- Total capital investment
- Total production cost

6.1. Total Capital Investment

Before a plant can be put into operation, a large sum of money must be supplied to purchase and install the necessary machinery and equipment. Land costs and service facilities must be obtained, and the plant must be erected complete with all piping, controls, and services. In addition, it is necessary to have money available for the payment of expenses involved in the plant operation. The capital needed to supply the necessary manufacturing and plant facilities is called the fixed capital investment and includes direct and indirect costs, while that necessary for the operation of the plant, in the initial phase, is termed the working capital. The sum of the fixed capital investment and the working capital is known as the total capital investment. The total capital investment is determined by percentage of delivered equipment cost estimation in this report.

Table 8.Chemical Engineering Plant Cost Index

Year	2015	2016	2017	2018
CEPCI	584.6	567.3	576.1	556.8

Cost data also obtained from table 9-50 of Perry's chemical engineering hand book (7th edition) And Coulson volume 6 (4th edition) and equipment cost manipulation is based on Marshall Swift Index of 1000.

$$New\ Cost = \ Base\ Costs\ *\ (New\ size\ /Base\ size)\ n$$

Present cost $= original\ cost * (index\ value\ at\ the\ present\ time)/(Index\ value\ at\ the\ original\ cost\ was\ obtained)$

- The index for 2021 is determined by extrapolation
- $2017 = 576.1$
- $2018 = \ 556.8$
- $2021 = \mathrm{X}$
- $\frac{(2018-2017)}{(\ 556.8-576.1)} = \frac{(2021-2018)}{(\mathrm{X}-556.8)}$
- $\mathrm{X} = -57.9 + 556.8 = \ 498.9$

A.Fixed Capital Investment

It is the capital needed to supply all manufacturing and plant facilities. FCI can also be defined as the total cost of the plant ready for startup. This includes:

Direct (manufacturing) fixed capital investment– the amount of money necessary for the installed process equipment with all auxiliaries needed for a complete process operation (e.g. purchased equipment cost, equipment installation cost, instrumentation and control cost, piping cost, electrical equipment and material cost, building (including services) cost, yard improvement cost, service facilities cost, land cost, etc.)

Indirect (nonmanufacturing) fixed capital investment – Construction overheads and all plant components which are directly related to the process operation. (E.g. engineering and supervision cost, construction expenses, contractor's fee, contingency fees, warehouse, laboratories, transportation, utility etc.)

Calculation for estimation of water storage tank cost Perivious, 2017

Cost (c_1) $= 34500$

Volume (v_1) $= 76\, m3$

Index (I_1) $= 576.1$

Recent, 2021

Cost (c_2) $=?$

Volume (v_2) $= 5.91 m3$

Index (I_2) $= 498.9$

Exponent (n) is assumed to be 0.57

$$c_2 = c_1 * (\frac{v2}{v1})^* n^* (\frac{\mathrm{I2}}{\mathrm{I1}}))$$

$= 34500*((5.91/76)*0.57*(498.9/576.1))$

$= \$6968.7$

Calculation for estimation of fermented (jacketed and agitated reactor)Perivious, 2017

Cost (c_1) $= 2520$

Volume (v_1) $= 15.14\ m3$

Index (I_1) $= 576.1$

Recent, 2021

(c_2) =?

Volume (v_2) $= 20.8m3$

Index (I_2) $= 498.9$

Exponent (n) is assumed to be 0.6

$c_2 = c_1\ ((v_2/v_1)n(I_2/I_1))$

$= 118700$*((11.3/15.14)*0.68*(498.9/576.1) = $86,245.8, and the rests are filledin the following table in the same manner.

Table 9.Purchased equipment cost

Equipment	Capacity	Quantity	Cost⍰
Storage tank for water	$5.91m3$	1	6968.7
Dryer	$5.5m2$	1	15357.74
Storage tank for dried mango	$0.883\ m3$	1	2357.6
Roller mill	$6.5\ m3$	1	10930.87
Mixer tank	$12m3$	1	10432.8
Centrifugal separator	$0.5\ m$	1	8463.9
hydrolyzed storage tank	$3.9\ m3$	1	5497.66
Fermented (jacketed &agitated reactor) batch	$11.3m3$	1	86,245.8
Fractional distillation column	$0.25m$,with 10 plate	1	12,598.15
Molecular sieve	$339kg/hr$	1	7816 .3
Storage tank for bio-ethanol	$2.29m3$	1	11,567
Centrifugal pump	$4.1m3/hr$	1	22,070.1
Diaphragm pump	$5.9m3/hr$	1	30,234
Media tank	-	1	6700
Sieve	$332kg/hr$	1	1123
Boiler	-	2	15789
Condenser	-	2	19769.8
Total			373,933.42

Since the process of our plant is solid-fluid processing, the the fixed capital investment is calculated as given bellow.

Table 10. Estimation of fixed investment capital cost

A. Direct cost	Percentage (%)	Cost($)
Purchased equipment	100	373,922.42
Purchased equipment installation	39	145,829.75
Instrumentation and control	13	48,609.92
Piping (installed)	31	115,915.95
Electrical(installed)	10	37,392.242
Building (including service)	29	108,437.5
yard improvement	10	37,392.242
Service facilities	55	205,657..33
Land	6	22,435.34
A. Total direct cost		1,095,592.7
Engineering and Supervision	32	119,655.17
Construction expenses and Contractor’s fee	34	127,133.63
Contingency	36	134,612.07
B. Total indirect cost		381,400.9
Fixed-capital investment $(A + B)$		1,476,993.6

But, that, $TCI = FCI + \mathrm{WC}$, since working capital cost is $(10 - 20)$ % of total capital investment

$TCI = FCI + 0.15TCI$

$$TCI = \frac{FCI}{0.85} = \frac{1,476,993.6}{0.85}$$

$$= \$1,737,639.5$$

Working Capital: is the capital needed for the daily running of the plant. In other words, it is the additional investment capital needed over and above the fixed capital investment to start the plant, to operate it to the point when income is earned. This consists of the total amount of money invested in.

- ✓ Start up
- ✓ Raw material and supplies carried in stock
- ✓ Finished and semi-finished products in stock
- ✓ Accounts receivable and payable
- ✓ Cash kept on hand for monthly payment of operating expenses and Taxes payable. It is estimated that working capital is approximately 15% of total capital investment.

Therefore, Working cost $(WC) = 0.15 * TCI = 0.15 * 1,737,639.5 = \$260,645.9$

6.2. Total Production Cost

The determination of the necessary capital investment is only one part of a complete cost and evaluation estimate. Another equally important part is the estimation of the cost of operating the plant. The total production cost is generally divided into the categories of manufacturing costs and general expenses. All expenses directly connected with the manufacturing operation or the physical equipment of a process plant itself is included in the manufacturing costs. Total production cost is broken down into two: manufacturing cost and general expenses. The manufacturing costs are also subdivided into fixed operating costs, variable operating costs and plant overhead costs. The general expenses are involved in any company's operations. The total production costs are calculated on an annual basis in this project.

6.2.1. Manufacturing Costs

All expenses directly connected with the manufacturing operation or the physical equipment of a process plant itself is included in the manufacturing costs. These expenses, as considered here, are divided into three classifications as follows: -

(1) Direct production costs,

(2) Fixed charges, and

(3) Plant-overhead costs.

6.2.1.1. Direct production costs*:*

Include expenses directly associated with the manufacturing operation. This type of cost involves expenditures for raw materials (including transportation, unloading, etc.,); direct operating labor; supervisory and clerical labor directly connected with the manufacturing operation; plant maintenance and repairs; operating supplies; power; utilities; royalties; and catalysts.

6.2.1.2. Fixed operating costs (fixed charges):

Fixed operating cost are expenses which are practically constant from year to year and do not vary widely with changes in production rate. These are the bills that have to be paid whatever the quantity of “product” produced. Depreciation, property taxes, insurance, and rent require expenditures that can be classified as fixed charges.

6.2.1.3. Plant overhead costs:

These are costs that comprise hospital and medical bills, general plant maintenance, cost of safety services; payroll overhead including pensions, vacation allowances, social security, and life insurance; packaging, restaurant and recreation facilities, salvage services, control laboratories, property protection, plant superintendence, warehouse and storage facilities, and special employee benefits. etc. (Peter et al, 1990).

Table 11. Direct production cost

S.NO.	Item		Cost($)
	Direct production cost	-	
1	Raw material	-	59,497.3
2	Utility	-	76,389.14
3	Operating labor	-	60,216.61
4	Direct supervisory & clerical labor	12% COL	7,226
5	Maintenance & repair	6% FCI	88,619.62
6	Operating supplies	15% CMR	13,292.94
7	Laboratory charge	15% COL	9,032.5
8	Patent & royalties	3% TPC	26,177.26
Total			340,451.37

Table 12. Fixed charge cost

S.NO	Item		Cost($)
1.	Depreciation	10% FCI	147,699.36
2.	Local taxes	0.7 % FCI	36,924.84
3.	Insurance	2.5% FCI	10,339
4.	Rent	0.7% FCI	-
Total			194,963.16

Plant overhead cost

Plant-overhead costs ($50 - 70\%$ of cost for operating labor, supervision, and maintenance, or $5 - 15\%$ of total product cost).

The average= $\frac{(5+15)\%}{2}$ = 10% TPC

= 0.1*872,575.52

= $ 87,257.552

Therefore, Manufacturing cost (MC) =DPC+FC+POHC

= 314,274.11+194,963.16 +87,257.552

= $596,494.822

6.2.2. General Expense

Besides to manufacturing costs, general expenses are involved in any company's operations. These general expenses are administrative expenses, distribution and marketing expenses and research and development expenses.

Table 13.general expense

S.NO.	Item		Cost($)
	General expense		
1.	Administrative cost	15%(COL+CS+CMR)	23,409.34
2.	Distribution and selling cost	0.11TPC	95,983.3
3.	Research and developmentcost	0.05TPC	43,628.776
4.	Financing	0.05TCI	86,882
Total			249,903.4

Then, Total Production Cost (TPC) = MC+GE

= 596,494.822 + 249,903.4

= $872,575.52

6.2.3. Depreciation of plant equipment Assumption

The useful life of all the machines is 10 years (that is after it exceeds its salvage value, but it is still useful and effective) and the salvage value of each of the machine is assumed to be 25% of the cost price of the machines.

$$Depreciation = original\ value - \frac{salvage\ value}{useful\ life\ of\ machine}$$

$$= V - \frac{Vs}{n}$$

Table 14. Cost of depreciation

Equipment	Cost($)	Salvage value(25% EC)	Depreciationvalue ($)
Storage tank for water	6968.7	1,742.2	522.65
Dryer	15357.74	3839.44	1151.83
Storage tank for driedmango	2357.6	589.4	176.82
Roller mill	10930.87	2732.72	819.82
Mixer tank	10432.8	2608.2	782.46
Hydrolyzed(Autoclavereactor)	8463.9	2,116	634.8
Centrifugal separator	5497.66	1374.42	412.33
storage tank for hydrolyzed slurry	86,245.8	21,561.45	6468.4
Fermented (jacketed &agitated reactor) batch	12,598.15	3149.54	944.86
Fractional distillationcolumn	13,698.3	3424.6	1027.4
Molecular sieve	7816.3	1954.07	586.2
Storage tank for bio-ethanol	22,070.1	5517.52	1655.26
Media tank	6700	1675	502.5
Sieve	1123	280.75	84.22
Boiler	15,789	3947.25	1184.18
Condenser	19,769.8	4942.45	1482.74
Diaphragm pump	30,234	7558.5	2267.55
Total	20,704		

6.3 Financial Evaluation

6.3.1. Profitability

Based on projected profit and loss statement, the project will generate a profit through outs its operation life.

Production capacity $=3.4*10^6$L/yr.

Unit price $= total\, production\, cost/plant\, capacity$

$$= 872{,}575.52/3{,}400{,}000 \ = \ 0.4\$/L$$

6.3.2. Selling Price

Total income = selling price of product *production capacity

$= \$0.4/L * 3.4 * 106\ L/yr.$

$= \$2.142 * 106/yr.$

$profit\ before\ tax\ =\ Total\ income - Total\ production\ cost$

$= 2{,}142{,}000 - 872{,}575.52$

$= \$1{,}269{,}424.4$

$Income\ tax = \ 35\%\ of\ gross - \ earning$

$= 0.35 * \$1{,}269{,}424.4$

$= \$444{,}298.5$

$Net\ income\ =\ profit\ before\ tax - income\ tax$

$= \ 1{,}269{,}424.4\ -\ 444{,}298.5 = \$\ 825{,}125.83$

6.3.3. Simple Estimate on Return on Investment (ROI)

Before analyzing the detailed economic evaluation, a simple return on investment ROI is calculated as a measure of annual rate of return on capital employed in production and characterization of bio-ethanol from mango peel waste. In engineering economic evaluation, it is usually defined as the percent ratio of average yearly profit (net cash inflow) over the productive life of the project, divided by total initial investment. A positive ROI means the annual revenue is larger than the production cost; in other word, the plant is profitable.

$$ROR = \frac{Annual\ profit}{TCI} * 100\%$$

$$TCI = \$1,737,639.5$$

a) Before tax

$$ROR = \frac{\text{profit before tax}}{TCI} * 100\%$$

$$ROR = \frac{1,269,424.4}{1,737,639.5} * 100\%$$

$$= 73.05\%$$

b) After tax

$$ROR = \frac{Net\ income}{TCI} *100\%$$

$$TCI = 1,737639.5$$

$$Net\ income = 825,125.83$$

$$ROR = \frac{825,125.83}{1,737,639.5} * 100\%$$

$$=47.48\%$$

6.3.4. Pay out periods (POP)

$$\text{POP}= \frac{\text{FCI}}{\text{net profit+Depreciation}} * 100\%$$

$$= \frac{1,476,993.6}{825,125.83 + 20,704}$$

$$= 1.74\ year$$

6.3.5. Discount cash flow return (DCFR)

The discount flow rate of return is the return obtained from an investment in which all investment and cash flows are discounted. We calculated the discounted rate of return of the project at individual year and separately using starting capacity with 80% at first year and 90% capacity for the second year and with 100% capacity for the remaining project service life. Progress calculation and manipulation of the three years are shown below.

First year:

$Percent\ rate\ of\ operating\ time\ = 80\%$

$Product\ rate\ = 80\% * annual\ production$

$= 0.8 * 3.4 * 10^{6} = \$\ 2{,}720{,}000$

$Variable\ cost = 0.8 * variable\ cost\ = 0.8 * 340{,}451.26 = \$272{,}361$

$Fixed\ cost$

$= fixed\ ch\ (without\ depreciation)$

$+\ plant\ overhead\ cost = 87{,}257.5$

$General\ expense = 249{,}903.4$

$Depreciation = 0.1 * FCI\ = 0.1 * 1{,}476{,}993.6$

$= 147{,}699.36 (by\ using\ MACRS\ five\ year\ half\ convention)$

$Total\ Production\ cost$

$= variable\ cost\ + fixed\ cost\ + general\ expense$

$= 272{,}361 + 87{,}257.5 + 249{,}903.4 = 609{,}521.9$

$Annual\ sales = price\ per\ liter\ * annual\ product$

$= 0.4 * \$\ 2{,}720{,}000 = 1{,}713{,}600$

$Gross\ profit\ = annual\ sale\ - total\ product\ cost$

$= 1{,}713{,}600 - 609{,}521.9 = 1104078.1$

$Net\ income = gross\ profit\ - income\ tax$

$= 1104078.1 - 0.35 * 1{,}532{,}478.1 = 717650.7$

$Cash\ income = net\ income\ + depreciation$

$= 717650.7 + 147699.36 = 865350.1$

Second year

$Percent\ rate\ of\ operating\ rating\ time = 90\%$

$Product\ rate = 90\% * annual\ production$

$= 0.9 * 3.4 * 106 = 3{,}060{,}000$

$Variable\ cost = 0.9 * variable\ cost$

$= 0.9 * 340{,}451.26 = 306{,}406.1$

$Fixed\ cos = fixed\ charge\ (without\ depreciation) + plant\ over\ head\ cost$

$= 27257.5$

$General\ expense = 249903.4$

Depreciation =0.2 * $fixed\ capital\ investment$ (by using five years) MACRS half conversion)

= 0.2 * 1476993.6 = 295,398.7

$Total\ product\ cost = variable\ cost\ +\ fixed\ cost\ +\ general\ expense$

= 306,406.1 + 27257.5 + 249903.3 = 583,567

$Annual\ sale = price\ per\ liter\ *\ annual\ product$

= 0.4 * 3060000 = □1927800

$Gross\ profit = annual\ sale - total\ product\ cost$1927800 − 583,567 = 1344233

$Net\ income = Gross\ profit - income\ tax$

= 1344233 − 0.35 * 1344233 = 873751.45

$Cash\ income = net\ income + depriciation$

= 873751.45 + 295398.7 = 1169150.15

Third year

Percent rate of operating $time$ = 100%

$Product\ rate = 1 * 3.4 * 106 = 3.4 * 106$

$Variable\ cost = 1 * 340{,}451.26 = 340451.26$

$Fixed\ cost = fixed\ ch(without\ depreciation)\ +\ plant\ over\ head$

= 27257.5

$General\ expense = 249903.4$

Depreciation=0.2*fixed capital investment(by using 5 years MACRS halfconversion)

= 0.2 * 1476993.6 = 295,398.7

$Total\ product\ cost = variable\ cost + fixed\ cost\ + general\ expense$

= 340451.26 + 27257.5 + 249903.4 = 617,612.16

$Annual\ sale = price\ per\ liter\ *\ annual\ product$ = 0.4 * 3.48106

= 2142000

$Gross\ profit =\ annual\ sale\ - total\ product\ cost$

= 2142000 − 617612.16 = 1524387.8

$Net\ income =\ Gross\ profit\ - income\ tax$

= 1524387.8 − 0.35 * 1524387.8

= 990,852.11

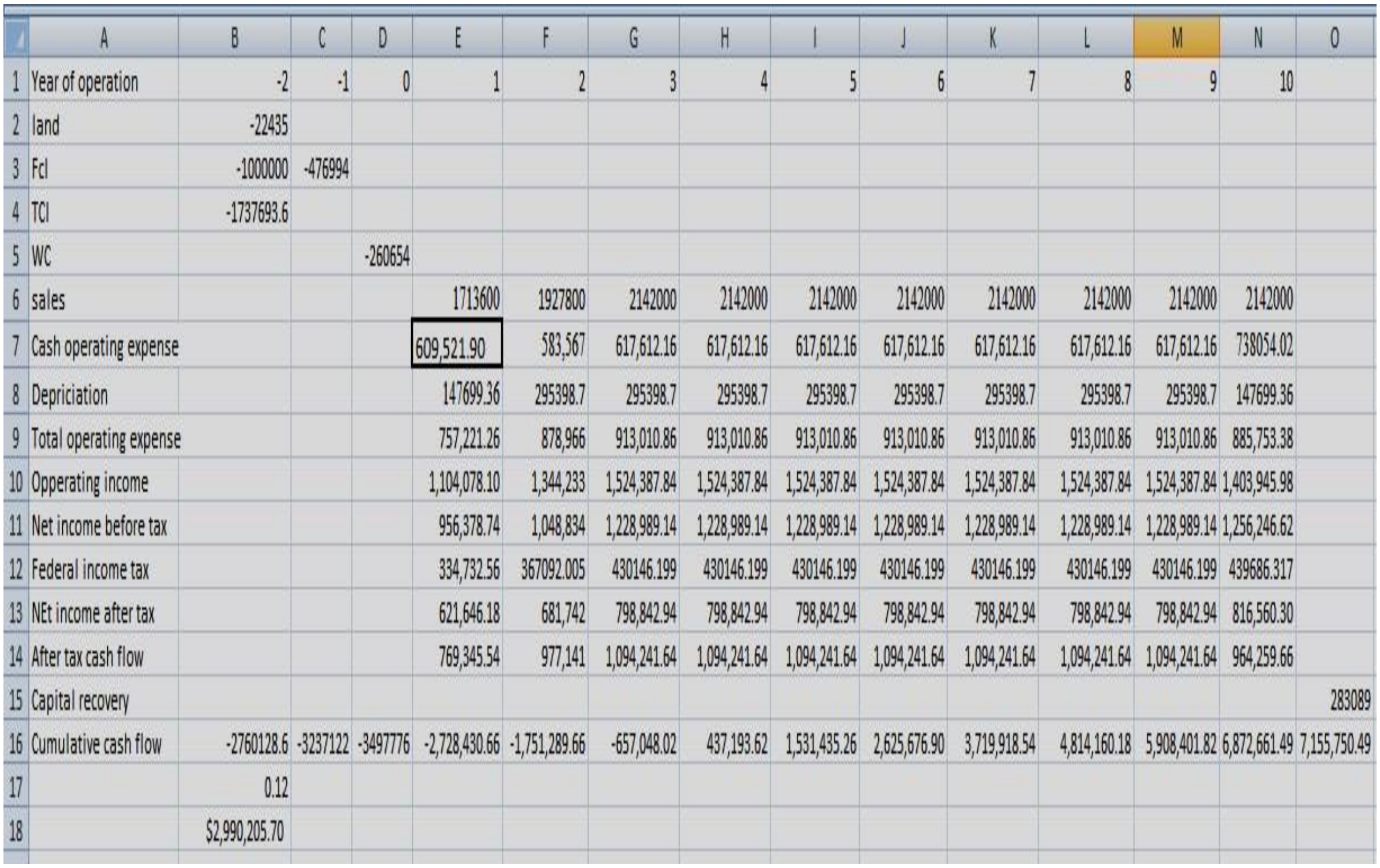
$Cash\ income = Net\ income\ +\ depreciation$

$= 990852.11 + 295398.7 = 1286250.8$

The remaining periods of project life summary economic data is given in table.
Table 15. Summary of economic data used in the DCFR

Year	Product rate (%)	Sales Revenue, SR(□10^6/yr)	Total product cost, TPC(□/yr)	SR-TPC(□/yr)	Depreciation
1	0.8	1.7136	609,521.9	1,104,078.1	147699.36
2	0.9	1.9278	583,567	1,344,233	295398.7
3	1.0	2.142	617,612.16	1,524,387.84	295398.7
4	1.0	2.142	617,612.16	1,524,387.84	295398.7
5	1.0	2.142	617,612.16	1,524,387.84	295398.7
6	1.0	2.142	617,612.16	1,524,387.84	295398.7
7	1.0	2.142	617,612.16	1,524,387.84	295398.7
8	1.0	2.142	617,612.16	1,524,387.84	295398.7
9	1.0	2.142	617,612.16	1,524,387.84	295398.7
10	1.0	2.142	738054.02	1,403,945.98	147699.36
Sum	9.7	20.77	1,931,142.92	14,522,971.96	2658588.32

Table 16 .Cash flow chart



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Year of operation	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
2	land	-22435													
3	Fcl	-1000000	-476994												
4	TCI	-1737693.6													
5	WC			-260654											
6	sales				1713600	1927800	2142000	2142000	2142000	2142000	2142000	2142000	2142000	2142000	
7	Cash operating expense				609,521.90	583,567	617,612.16	617,612.16	617,612.16	617,612.16	617,612.16	617,612.16	617,612.16	738054.02	
8	Depriciation				147699.36	295398.7	295398.7	295398.7	295398.7	295398.7	295398.7	295398.7	295398.7	147699.36	
9	Total operating expense				757,221.26	878,966	913,010.86	913,010.86	913,010.86	913,010.86	913,010.86	913,010.86	913,010.86	885,753.38	
10	Opperating income				1,104,078.10	1,344,233	1,524,387.84	1,524,387.84	1,524,387.84	1,524,387.84	1,524,387.84	1,524,387.84	1,524,387.84	1,403,945.98	
11	Net income before tax				956,378.74	1,048,834	1,228,989.14	1,228,989.14	1,228,989.14	1,228,989.14	1,228,989.14	1,228,989.14	1,228,989.14	1,256,246.62	
12	Federal income tax				334,732.56	367092.005	430146.199	430146.199	430146.199	430146.199	430146.199	430146.199	430146.199	439686.317	
13	NEt income after tax				621,646.18	681,742	798,842.94	798,842.94	798,842.94	798,842.94	798,842.94	798,842.94	798,842.94	816,560.30	
14	After tax cash flow				769,345.54	977,141	1,094,241.64	1,094,241.64	1,094,241.64	1,094,241.64	1,094,241.64	1,094,241.64	1,094,241.64	964,259.66	
15	Capital recovery														283089
16	Cumulative cash flow	-2760128.6	-3237122	-3497776	-2,728,430.66	-1,751,289.66	-657,048.02	437,193.62	1,531,435.26	2,625,676.90	3,719,918.54	4,814,160.18	5,908,401.82	6,872,661.49	7,155,750.49
17		0.12													
18		$2,990,205.70													

Thus, to get IRR Equate NPV to zero.

$$NPV = \quad 0 = CFo + \frac{CF1}{(1+IRR)} + \frac{CF2}{(1+IRR)^2} + \frac{CF3}{(1+IRR)^3} + \frac{CF4}{(1+IRR)^4}$$

$$+ \frac{CF5}{(1+IRR)^5} + \frac{CF6}{(1+IRR)^6} + \frac{CF7}{(1+IRR)^7} + \frac{CF8}{(1+IRR)^8} + \frac{CF9}{(1+IRR)^9}$$

$$+ \frac{CF10}{(1+IRR)10}$$

$$= -3497776 + \frac{-2728430.66}{1+IRR} + \frac{-1751289.66}{(1+IRR)^2} + \frac{-657048}{(1+IRR)^3} + \frac{437193.62}{(1+IRR)^4}$$

$$\frac{1531435.26}{(1+IRR)^5} + \frac{2625676.9}{(1+IRR)^6} + \frac{3719918.54}{(1+IRR)^7} +$$

$$\frac{4814160.18}{(1+IRR)^8} + \frac{5908401.82}{(1+IRR)^9} + \frac{6872661.49}{(1+IRR)^{10}}$$

After simplification the IRR is 12 % this value is accepted as per the suggested values forrisk and minimum acceptable return in investment.

$$NPv = -3497776 + \frac{-2728430.66}{1+0.163} + \frac{-1751289.66}{(1+0.163)^2} + \frac{-657048}{(1+0.163)^3}$$

$$+ \frac{437193.62}{(1+0.163)^4} + \frac{1531435.26}{(1+0.163)^5} + \frac{2625676.9}{(1+0.163)^6} + \frac{3719918.54}{(1+0.163)^7}$$

$$+ \frac{4814160.18}{(1+0.163)^8} + \frac{5908401.82}{(1+0.163)^9} + \frac{6872661.49}{(1+0.163)^{10}} = 2{,}990{,}205.7$$

$$PI = \sum_{n=1}^{10} (PV) / CFo$$

PI=3728536.5/3497776=1.065973493

Since the value of profitability index is greater than 1, the project is acceptable.

6.4. Plant Location

The geographical location of the plant has a strong influence on the success or failure of the plant. Therefore, it has a crucial effect on the profitability of the plant, and the scope of future expansion work. Therefore, a plant should be located where minimum cost of production, as well as distribution of product to selling could be obtained, amongst other factors. In order to make the design project realistic, the aspect of site selection must be given some consideration. There are a number of considerations concerning the choice of site and location for bio ethanol production plant. Some general considerations are:

Climatic condition proximity to both the raw materials supply and the market for the product selling. Political and strategic considerations.

- Location community considerations.
- Availability of suitable land .
- Proximity to major transportation networks e.g. roads, railways.
- Designation as a heavy industrial development area.
- Prior existence of similar chemical plants and location of other industrial centers
- Existing roads and services and also appropriate terrain, sub surface, drainage etc.
- Suitable access for transportation for transportation of raw materials and chemicals and for Construction of a chemical plant.
- Availability of a local workforce and distance from local communities.
- Environmental discharge regulation and cost of land and services.

6.4.1. Availability of Raw Material

The main raw materials availability for bio ethanol production from mango peel is available in Gubre. It is Looking at the probable site location, because Gubre and the place around Gubre produce a high level of mango peel which is obtained from different area such as cafeteria , hotel juice house so generally Gubre good place of main raw material for the production of bio ethanol from mango peel waste.

6.4.2. Availability of Suitable land

The suitability of land is judged based on some factors including: drainage, load bearing characteristics and flatness. The sites must therefore be evaluated to determine the need for any special foundations based on those criteria Gubre is better than other place of Ethiopia.

6.4.3. Utilities

Utility availability is necessary for plant to success such as water, electric and labor availability. Those sources are available in Goober and around Gubre.

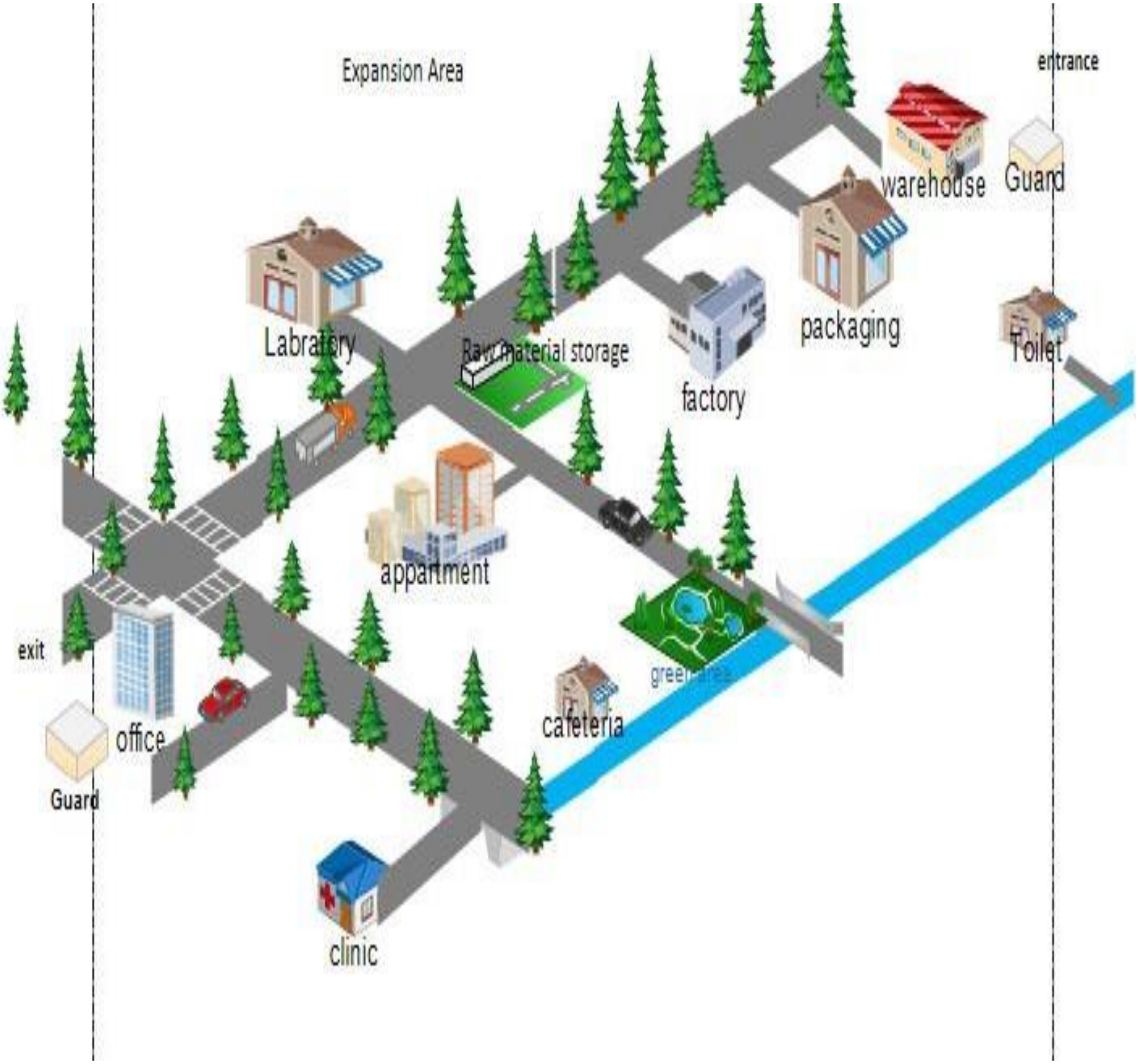


Figure 6.13 Plant Layout

CHAPTER SEVEN

7. CONCLUSION AND RECOMMENDATION

7.1 CONCLUSION

Fruit peel, particularly mango peel is a promising cellulosic biomass feed stocks for bio ethanol fuel. It is abundant by-product generated from juice house, restaurant and hotels. Its great importance in terms of renewable energy production and environmental pollution protection to convert these residues to value added products. Consequently, in this work, Mango peel waste was used to produce bioethanol by the method of separate hydrolysis and fermentation (SHF) in the laboratory scales. Here Mango peel waste was characterized before the experimental work was began and the results were found to be more or less similar to the values obtained from literature. The one which was hydrolyzed with 1% dilute H2SO4, 132℃ hydrolysis temperature and 15min hydrolysis time gives maximum glucose yield. From 100g of mango peel powder 45.24% of yield (glucose) obtained. The hydrolysis of Mango peel waste was carried out with dilute acid and characterization was carried out by some property analyzes such as refract meter and chromic acid test.The production of ethanol from mango peel is feasible from the economic point of view that its internal rate of return is calculated 12%, NPV of (2,990,205.7) and its payout period is estimated to 2 years.

In addition to protecting environment from waste, these mango peels also generate financial revenue.

7.2. Recommendation

This research would like to recommend:

- Mango peel waste should be utilized for ethanol production rather than thrown on the public road and cause environmental pollution.
- Government and institution should be involve on changing waste that generated from home, restaurant, hotels and cafeteria to valuable product such as ethanol to encourage business owners.
- In addition to dilute acid hydrolysis, Enzyme hydrolysis should be checked for ethanol production.
- Further researches have to be done to get optimum parameter to get immense amount of ethanol and to improve the potential of mango peel in producing bio ethanol.
- Government and community should know that it's possible to generate income from wastes and should involve and encourage the idea towards the conversion of waste like fruit peels to valuable product.
- The required equipment has to be fulfilled to know whether the produced product meet standard or not. It is recommended that all information about the cost of all equipment and components of the plant for different capacities should be gathered and known for detail design.

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Appendix

Appendix A. Properties of Ethanol

Appearance	Colorless, clear liquid
Acidity (pKa)	15.9
Boiling point	$78.4 \quad (351.6k)$
Melting Point	$-114.3\,^{\circ}C$
Specific Gravity	$0.790\ at\ 20$
Density and phase	$0.789g/cm3$, liquid
Surface tension	22.10 $mN/m\ at\ 20^{\circ}C$
Dipole moment	1.69D(gas)
Molecular formula	$C2H5OH$
Latent heat of Vaporization	
Btu/gal at 60	2378

Appendix B: media perparations

Appendix C:media in autoclave