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COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

(PROCESS STREAM)

THESIS ON: PRODUCTION OF ETHANOL FROM CASSAVA ROOT

A Thesis Submitted to College of Engineering and Technology Department of Chemical Engineering in Partial Fulfillment of the Requirements for the Degree of Bachelor Science *(*BSc*)* In Chemical Engineering

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DECLARATION

We, declare this thesis is our original work except for citations which have been duly acknowledged. And we here by certify that we have read as well as evaluated this thesis prepared under our guidance by. Mr. Bereh.T

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ABSTRACT

Cassava (Manihot esculenta) is one of the most important sources of fuel energy in developed countries. The crop has a high yield potential under good conditions, and compared to other crops it out class under suboptimal conditions, thus offering the possibility of using marginal land to increase total agricultural production. The use of cassava as a source of ethanol for fuel depends on finding an efficient source of energy for distillation or an improved method of separating ethanol from water. Raw cassava root starch was transformed into ethanol in a one step process of fermentation, in which are combined the conventional processes of hydrolysis, fermentation and distillation to alcohol. The influencing parameters that affect the production of ethanol from cassava are optimized. The optimal values of the parameters such as temperature, pH, and fermentation period are found to be 30°C, 4-4.5, and 72 hrs respectively. Under these optimum operating conditions, the maximum ethanol yield is achieved. Result from raw material characterization of this study was obtained by using different method. The moisture content of cassava root, chips and flour that obtained from the experiment was (63%, 14.4% and 10.4%) respectively and similarly the ash content, fat content, fiber content, protein content and carbohydrate content obtained was (0.8%, 0.4%, 1%, 1.2% and 33%) respectively. Results from this study revealed that the maximum alcohol content of fermented broth (4.2 %w/w) and the maximum ethanol yield of (48.2 %) were obtained at pH value of 4.5. Material quantities, as they pass through processing operations can be described by material balance. Such balances are statements on the conservation of mass. Similarly, energy quantities can be described by energy balance, which are statements on the conservation of energy.

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ACRONYMS

NIYAMCO	Nigerian Yeast and Alcohol Manufacturing company plc.
PLC	Private leading company
CFH	Cassava flour hydrolysate
DC	Direct Cost
DC	Discounted Cash Flow Return
FCI	Fixed Capital Investment
FPL	Forest Products Laboratory
IDC	Indirect Cost
IRR	Internal Rate of return
NPV	Net Present Value
PH	power of Hydrogen
TCI	Total Capital Investment
TDC	Total Direct Cost
TPDC	Total Plant Direct Cost
WC	Working Capital

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Cassava (Manihot *esculenta*), sometimes also called manioc, is the third largest source of carbohydrates for human consumption in the world, with an estimated annual world production of 208 million tones. In Africa, which is the largest center of cassava production, it is grown on 7.5 million and produces about 60 million tons per year. It is a major source of low costs carbohydrates and a staple food for 500 million people in the humid tropics. On infertile land where the cultivation of other crops is difficult, unless considerable inputs are applied, cassava still has a reasonable yield.

Before 1970, ethanol was generally produced by fermentation of sugar sourced from starch or cellulose, maize, guinea corn, millet and other starchy substrates. During this period, there was no serious business or industrial motive for producing ethanol and as such very little consideration was paid to economics of production, quality assurance or control, and safety considerations to name but a few.

Ethanol is traditionally produced from feedstock high in sugar and/or starch content. A third possible feedstock is lingo-cellulose. These obsolete feed stocks are attractive, but the technology to convert cellulosic material to ethanol (sometimes referred to as 'second generation') is not yet commercially available. Most used feed stocks for fuel ethanol are wheat, corn, sugar cane and sugar beet. The sugars can be fermented to ethanol, while starch first has to be hydrolyzed to obtain free sugars. Next, the sugars are fermented to ethanol which is followed by a purification step yielding pure ethanol

By 1972, the Federal Government of Nigeria received a business proposal from Volgelbutsch of Austria to make use of the waste cane molasses from the premier sugar company, Nigerian Sugar Company in Bacita, Kwara State to produce ethanol. In 1973, the Nigerian Yeast and Alcohol Manufacturing PLC (NIYAMCO) were commissioned. This was the first attempt at large scale ethanol production in Nigeria and NIYAMCO's operation depended only on the availability of cane molasses as a feedstock from the sugar company. Unfortunately, the sugar company collapsed in 1994 seriously affecting NIYAMCO's activities. This meant that an alternative feedstock for ethanol production was needed for the ethanol plant. After some period of experimentation, cassava was

found appropriate for the plant because of its availability, higher yield and product quality [1]. Ethanol fuel has been lauded as a possible alternative to petroleum-based fuels, offering not only less pollution to the environment, but also a sustainable source of energy. Ethanol fuel is an alternative to gasoline, and is manufactured from the conversion of carbon-based feed stocks such as sugarcane, sugar beets, switch grass, corn, cassava, and barley. Ethanol is currently used in gasoline for vehicles. Most vehicles run on mixtures of gas and ethanol; this mixture is common at most gas stations across the country. The process of ethanol fuel production involves fermentation, distillation, and dehydration. The process begins with photosynthesis, during which plants make sugar which is broken down into ethanol [2].

$C_6H_{12}O_6$ ===>$2C_2H_5OH$ +$2CO_2$ (fermentation)

Ethanol is traditionally produced from feedstock high in sugar or starch content. Most used feed stocks for fuel ethanol are wheat, corn, sugar cane, cassava and sugar beet. Cassava is high in starch content (70 – 85%, dry base and 28 – 35% wet base) and the starch from cassava is of a high quality compared to other starch sources. Cassava starch is used as raw material in many industries, among which paper, food and textile industries. Also, the technology of producing ethanol from starch is internationally well -developed [3]. Wild cassava sub-species were cultivated and domesticated in west-central Brazil about 10,000 BC. Around 6,000 BC, cassava pollen spread to the Gulf of Mexico as was proved by finds at the San Andrés archaeological site. Although Manihot esculenta probably originated in Brazil and Paraguay, the first evidence of cassava cultivation was found at a 1,400-year-old Maya site in El Salvador. Thanks to its ability to grow in nutrient-poor soils and hot climates, it soon became a staple food of native South American people and the Caribbean. Ethanol can be made from mineral oil or from sugars or starches. The starchy crop with highest energy content is cassava, which grows in tropical countries. Thailand already had a large cassava industry in the 1990s, for use as cattle feed and as a cheap admixture to wheat flour. Nigeria and Ghana are already establishing cassava-to ethanol plants. Production of ethanol from cassava is currently economically feasible when crude oil prices are above US$120 per barrel. The overall energy efficiency of cassava-root to ethanol conversion is around 32%



Figure 1 Cultivation of cassava

1.2 STATEMENT OF THE PROBLEM

Today the demand of fossil fuel such as petroleum, coal, and natural gas in the world increases through time and huge amount of fuel is used as energy source; this huge demand in fuel requirement increases the price of fuel to increase through time and also the depletion of fossil fuels, amount of greenhouse gas and different health problems; As a result, there is a great deal to find out an alternative renewable energy sources such as ethanol which is manufactured from feed stocks such as: sugarcane, sugar beets, corn, cassava, and barley. Currently, the amount of ethanol availability in Ethiopia is insufficient. There are government owned factories such as Fincha and Metahara sugar factory that produce ethanol from molasses, but it is insufficient for local consumption. Cassava was found appropriate for the ethanol production because of its availability; higher yield and product quality; on the other hand, on infertile land where the cultivation of other crops is difficult, but Cassava thrive better in poor soils than in any other major food plant. As a result, fertilization is rarely necessary, and it can be surviving even during the dry season when the soil moisture is low, but humidity is high; as well as Cassava crop is can be grown and harvested throughout the year than many other traditional crops which grown seasonally.

1.3 OBJECTIVES

1.3.1 General objectives

The general objective of this thesis work is production of ethanol from cassava root.

1.3.2 Specific objectives

- To characterize the raw material.
- To investigate the optimum parameters of fermentation.
- To determine the alcohol content of the fermented wash.
- To calculate the material and energy balance.

1.4 SIGNIFICANCE OF STUDY

Energy is one of the most fundamental parts of our universe. We use energy to do work. Energy lights our cities. Energy powers our vehicles, trains, planes and rockets. Energy warms our homes, cooks our food. Energy powers machinery in factories and tractors on a farm. Everything that is doing is connected to energy in one form or another. Energy is defined as: “the ability to do work”. Work means moving something, lifting something, warming something, lighting something. All these are a few of the various types of work.

The aim of this thesis works mainly focused on production and characterization of ethanol by measuring optimum parameters, alcohol content and density. It also addresses characterization of feedstock’s (cassava) by determining critical parameters like moisture content, protein, fat, ash and carbohydrate content. All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as bio-fuel, solar, wind, geothermal, and hydrogen. But we'll need to continue to use fossil fuels and nuclear energy until new, cleaner technologies can replace them.

1.5. LIMITATION

During the laboratory analysis there were so many hindrances like:

- Shaking incubator for the fermentation. shaking incubator is not functioning, the atmospheric condition where difficult to manage it (fluctuation of temperature)
- Shortage of time
- Absence of hydrometer for measuring of density
- Absence of Refractometer for measuring degree of bricks
- Thermostats: - to control temperature of the sample under experiment (distillation) isothermally at the set point.

CHAPTER TWO: LITERATURE REVIEW

Cassava (*Manihot esculenta*), also called manioc, yuca, balinghoy, mogo, mandioca, kamotengkahoy, and manioc root, a woody shrub of the Euphorbiaceous (spurge family) native to South America, is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy, tuberous root, a major source of carbohydrates. Cassava is the third-largest source of food carbohydrates in the tropics [4].

Cassava is a major staple food in the developing world providing a basic diet for around 502 million people. It is one of the most drought-tolerant crops, capable of growing on marginal soils. Nigeria is the world's largest producer of cassava. It grows in dry conditions all year round, and needs very little water for cultivation. This makes it the perfect drought-tolerant crop, especially in sub-Saharan regions of Africa and rocky, mountainous landscapes in South America. Cassava root is the primary energy source for 800 million people all over the planet, and there are wonderful efforts going on right now to teach even more communities how to grow and harvest cassava. Cassava is a tropical root vegetable. However, it is not known in most parts of Ethiopia which forces as to extract starch from it to create awareness and to enhance the cultivation of this valuable crop. Dried cassava is often available in specialty stores, with fresh cassava root being much rarer, since it spoils easily [5]. The plant grows tall, some reaching 15 feet, with leaves varying in shape and size. Cassava is well adapted within latitudes 30° north and south of the equator, at elevations between sea level and 2000 meters above sea level, in equatorial temperatures, with rainfalls of 50 millimeters to five meters annually, and to poor soils with a pH ranging from acidic to alkaline. These conditions are common in certain parts of Africa and South America. The edible parts are the tuberous root and leaves. The tuber or root is somewhat dark brown in color and grows up to 2 feet long. The crop is highly efficient in producing starch, is available all year round, is tolerant to extreme stress conditions, and fits nicely within traditional farming systems. Fresh roots contain about 30% starch. Cassava starch is one of the best fermentable substances for the production of ethanol [2].

Advantages and Disadvantages of Cassava root parts

Fresh root

Advantages

- Low cost during harvest.
- Contain fruit water having some nutrients and minerals that are advantageous to yeast fermentation.

Disadvantages

- Not available for whole year, seasonally harvested.
- Bulky, costly to transport.
- Cannot be stocked, short shelf-life due to high moisture content or high perish ability.

Dried Chips

Advantages:

- Extended shelf-life.
- Can be stored.
- Less costly for transportation.

Disadvantages:

- Higher cost than fresh roots.
- Must be dried before stored.
- High soil & sand contamination.

2.1 NUTRITIONAL PROFILE OF CASSAVA

Cassava root is essentially a carbohydrate source and it is attractive as nutrition source in certain ecosystems because cassava is one of the most drought-tolerant crops, can be successfully grown on

marginal soils, and gives reasonable yields where many other crops do not grow well. Because of the high starch content cassava is a high yielding ethanol crop. However, a distinction has to be made between yields from dried cassava chips and fresh cassava roots. For 1 kg of cassava chips, approximately 2kgs of fresh cassava roots are required. 1liter of ethanol can be produced [6]. On a per tonne cassava basis:

- 1 tonne of fresh cassava roots yields 150 liters of ethanol.
- 1 tonne of dry cassava chips yields 333 liters of ethanol.

Cassava tuber has the following composition:
Peel = 10 - 20 %
Edible portion = 80 - 90% of which:

- Almost 58% is water.
- 0. 3% fat.
- About 1.4% of protein.
- Almost 38% carbohydrates.
- fiber.1%
- Ash 1% and 0.3% other Vitamins and minerals of cassava.

Cassava is a highly productive crop in terms of food calories produced per unit land area per unit of time, significantly higher than other staple crops[4].

Nutrition characteristics of cassava:

- Cassava has moderate water content.
- It gives us a lot of energy in the form of calories, which help us to maintain our life.
- It contains little fat but of high quality and with many health benefits.
- It has moderate protein content.
- It is very high in carbohydrates, especially starches.
- It has moderate fiber content.

- It helps to remove toxins from our body, because it contains potassium.
- It helps maintain our brain function, because it contains phosphorus. In addition, together with calcium, it maintains the balance of the formation of strong bones.
- Because of its magnesium content, it helps the contraction and relaxation of muscles.
- As a result of its content in B vitamins, particularly vitamin B_9, it helps us to grow properly.
- It protects the skin and helps keep it healthy, because of vitamin A.
- It protects us from colds and helps heal wounds, because of vitamin C.
- It protects us from the toxins and aging, because it contains vitamin A, vitamin C and vitamin E.

2.2 PREPARATION OF CASSAVA

2.2.1 Fresh Cassava

The roots are washed and peeled and then packed in plastic bags or vacuum packaging. We clean, peel and store the roots to ensuring the highest quality for consumers. Cassava roots are extremely perishable, and can last less than 48 hours after harvesting.

2.2.2 Cassava Flour

Cassava Flour is very common and it can be used on its own or as a substitute for wheat flour in products like cookies, cakes and pastries without changing the taste. Cassava flour is made by grinding and sieving dried cassava chips. Its texture varies and it can be ground more coarsely to be used in bread or more finely for industrial use in starches or glues. The quality of flour is measured by dryness; while 12% of moisture content is traditionally an acceptable level. The final product will be stored in polypropylene bags, paper and cotton and will have a shelf life of up to 8 weeks at a temperature of 28 ° C and relative humidity of 69%. The advantages of cassava flour include:

- Better flavor.
- Lower production cost.
- Better cooking performance.

2.3 PRODUCTION OF CASSAVA ETHANOL

In many countries, significant research has begun to evaluate the use of cassava as an ethanol Biofuels feedstock. Under the Development Plan for Renewable Energy in the Eleventh Five Year Plan in the People's Republic of China, the target is to increase the application of ethanol fuel by no grain feedstock to 2 million tones, and that of biodiesel to 200 thousand tons by 2010. This will be equivalent to a substitute of 10 million tons of petroleum. As a result, cassava chips have gradually become a major source for ethanol production. On December 22, 2007, the largest cassava ethanol fuel production facility was completed in Beihai, with annual output of 200 thousand tons, which would need an average of 1.5 million tons of cassava. In November 2008, China-based Hainan Yedao Group reportedly invested $51.5m (£31.8m) in a new Biofuels facility that is expected to produce 33 million US gallons (120,000 m3) a year of ethanol from cassava plant [11]. The technology for the production of ethanol from starch materials involves cooking, hydrolysis, fermentation, and distillation. The basic technology in the process has been well defined but could be improved by introducing systems which require less energy, particularly in the starch conversion and distillation operations. Application of low energy requirement systems for the production of ethanol should make it more attractive as liquid fuel. The aim of the present investigation for production fuel ethanol from cassava is to establish low energy requirement systems, i.e. low temperature cooking, and pressurized distillation. Also, the technology of producing ethanol from starch is internationally well developed. Ethanol is usually made by the fermentation of sugar, cellulose, or converted starch. Ethanol can be produced from maize, guinea corn, millet, cassava, and cellulose. It has uses as food and in the pharmaceutical industry. Apart from food and pharmaceutical uses, ethanol is finding itself alternative uses for bio-fuel in most of the developed world for the following reasons:

- It is not poisonous (toxic).
- It does not cause air pollution or any environmental hazard.
- It does not contribute to the greenhouse effect problem (CO_2 addition to the atmosphere, causing global warming).
- It is an excellent raw material for synthetic chemicals [8].

2.4 ETHANOL FERMENTATION

Alcoholic Fermentation, also referred to as ethanol fermentation, is a biological process in which sugars such as glucose, fructose, and sucrose are converted into cellular energy and thereby produces ethanol and carbon dioxide as metabolic waste products. Because yeasts perform this conversion in the absence of oxygen, alcoholic fermentation is considered an anaerobic process. Alcoholic fermentation occurs in the production of alcoholic beverages and ethanol fuel, and in the rising of bread dough.

Microbes used in Ethanol fermentation

Yeast (Saccharomyces cereviseae):

Saccharomyces cerevisiaeis the cheapest strain available for the conversion of biomass substrate.

2.5 USES OF ETHANOL

The following are some of the various uses of ethanol:

- **Raw materials:** It is a raw material in the manufacturing of acetaldehyde, acetic acid, ethylene, glycol, dyes, detergents and cleaning solution.
- **Pharmaceutical preparation:** Ethanol is used in the preparation of cough syrups. It is also used in the preparation of antiseptics.
- **Fuel:** It is used as an additive to extend gasoline for automotive fuel, has advantage of being renewable. Fuel blended with very high ethanol content has lower hydrocarbon emission than 100% gasoline.
- **Miscellaneous:** It is also used in preparation of alcoholic beverages.

2.6 PHYSICAL AND CHEMICAL PROPERTIES OF CASSAVA ETHANOL

2.6.1 Physical Properties

Ethanol is a colorless liquid with a nice smell. It is a versatile or multipurpose solvent, completely miscible with water and organic solvents including acetic acid, acetone, benzene, carbon tetrachloride, chloroform, diethyl ether, ethylene glycol, glycerol, nitro methane, pyridine, and toluene, and is very hydroscopic.

Melting Point= -115^{o}C

Boiling Point = 78^{o}C

Specific Gravity = 0.789.

The main physical properties of cassava ethanol are; distillation range, density, viscosity, flashpoint, electrical conductivity, volatile, and colorless liquid that has a strong characteristic odor **[**9].

Chemical properties:

The two main chemical properties of ethanol are alcohol and water. Ethanol is considered to be 95 percent alcohol. The chemical contains about 5 percent water. Ethanol is classified as a primary alcohol, meaning that the carbon to which its hydroxyl group is attached has at least two hydrogen atoms attached to it as well. The chemistry of ethanol is largely that of its hydroxyl group. Ethanol can be made from any crop or plant that contains a large amount of sugar or components that can be converted into sugar, such as starch or cellulose. As their names imply, sugar beets and sugar cane contain natural sugar. Crops such as corn, wheat and barley contain starch that can be easily converted to sugar [10].

Factors limiting Ethanol yield:

PH of the substrate:

- If the PH of the substrate must be within acceptable limits of fermenter (enzymes) otherwise it will destroy the enzymes or reduce ethanol that can be fermented(4-5.5)

Temperature of the substrate:

- An acceptable limit of substrate is between 28-30^{o}C for optimum yield.

Substrate concentration:

- The amount of substrate to be fermented is proportional to the ethanol that can be fermented from it, if all other condition is maintained.

Fermentation time

- The time of fermentation is another factor affect the product yield due it needs sufficient time and condition.

CHAPTER THREE: MATERIALS AND METHODS

3.1 MATERIALS AND CHEMICALS

3.1.1 Materials

- Plastic bags: - to collect and transport samples to the laboratory.
- Knife: - for cutting the cassava in to pieces.
- Ovens: - to dry the sample.
- Miller: - to mill the dried sample.
- Sieves: - to sieve the milled sample.
- Digital pH meter: - to measure the PH.
- Fermentation and distillation set ups: - to ferment and distill respectively.
- Balance: - to weigh samples.
- Water bath. used for heating water
- Different flask. used for different purpose
- Filter: -used to filter the fermented wash
- Vessels: to hold samples and additives for hydrolysis, fermentation and distillation.

3.1.2Chemicals

- Urea: - used as media preparation.
- Dextrose sugar: - used as media preparation.
- Mg SO_4.7 H_2O:- used as media preparation.
- Yeast (*Saccharomyces cereviseae*).used for media preparation.
- Sulphuric acid and potassium hydroxide:-used for hydrolysis and in fiber content determination.

3.2 RAW MATERIAL CHARACTERIZATION

3.2.1Moisture Content

The crucible was washed and dried in an air oven for about 15 minutes (W_1= 400gm) of sample was carefully weighed into crucible, it is then dried in a hot circulating air oven at 105°c for 24hours, and finally weighed the dried sample (W_2 =147). The initial moisture content of the samples was calculated as the total moisture loss divided by total sample weight and presented in percent wet basis.

$Xw = [(W_1-W_2) / W1]*100$

Where: Xw = moisture content on wet basis, W_1 = Initial weight of sample, W_2 = Final weight of sample after drying.

3.2.2 Proximate Compositions

The Association of Analytical chemists' method was used to determine the carbohydrate, moisture, protein, fat, fiber and ash content of the samples [11]. The proximate composition was determined after drying in an air oven at 105^{o}c for 24hours.

I. Ash Content Determination

A dry silica dish containing about 2gm sample a muffle furnace set at 550^{o}c for 1hr and by allowing to cool in a desiccators and weighing it, the ash content was determined by applying a simple formula:-

Total ash [%] = $[(W_2-W) / (W_1-W)]*100$

Where: W = weight in gram of empty dish =150gm

W_1 = weight in gram of the dish plus the dried test material = 152gm

W_2 = weight in gram of dish plus ash = 150.016g

II. Fat Content Determination

Soxhlet extractor was used. An extraction flask was thoroughly washed and dried 5g of sample was accurately weighed and transferred into a rolled ash less filter paper and placed inside the extractor thimble. The thimble was placed into Soxhlet extractor. The heater was switched on and the set up was heated for about 3 hours at low temperature and extracted oil. Finally, the extracted oil was dried

at 100^{o}c and weighed. The difference in the weight of empty flask and the flask with oil gives the oil content of the sample. The percentage fat is thus calculated as;

% Fat = [C-A/B]*100

Where; A = weight of empty flask, B = weight of sample, C = weight of flask plus oil after drying.

From our experiment: A = 30.66gm, C = 30.68gm, B = 5gm

III. Fiber Content Determination

2g of the sample was collected (W_1) 150ml of preheated H_2SO_4 was added and heated to boiling for 30 mins. It was then filtered and the residue washed three times with hot water.150ml preheated KOH was added and heated to boiling for another 30 mins, filtered, washed three time with hot water and three times with acetone before drying at 130^{o}c for 1 hour. The sample was then weighed (W_2), ashes at 500^{o}c and the ash also weighed (W_3).

The fiber content is thus calculated;

% Fiber = $[(W_2-W_3)/W_1]*100$

Where, W_1 = weight of sample, W_2 = weight after pretreatment and drying, W_3 = weight after ashing.
From our experiment: W_1= 2gm, W_2 =0.45gm, W_3 = 0.43 gm

IV. Carbohydrate Content Determination

The carbohydrate content was determined by difference (i.e. by subtracting other constituents in the sample from 100%).
Carbohydrate Content (%) = 100% - [%Fat + % Ash +%Moisture + %Fiber].

3.3 METHOD

3.3.1 Experimental Procedure and Description

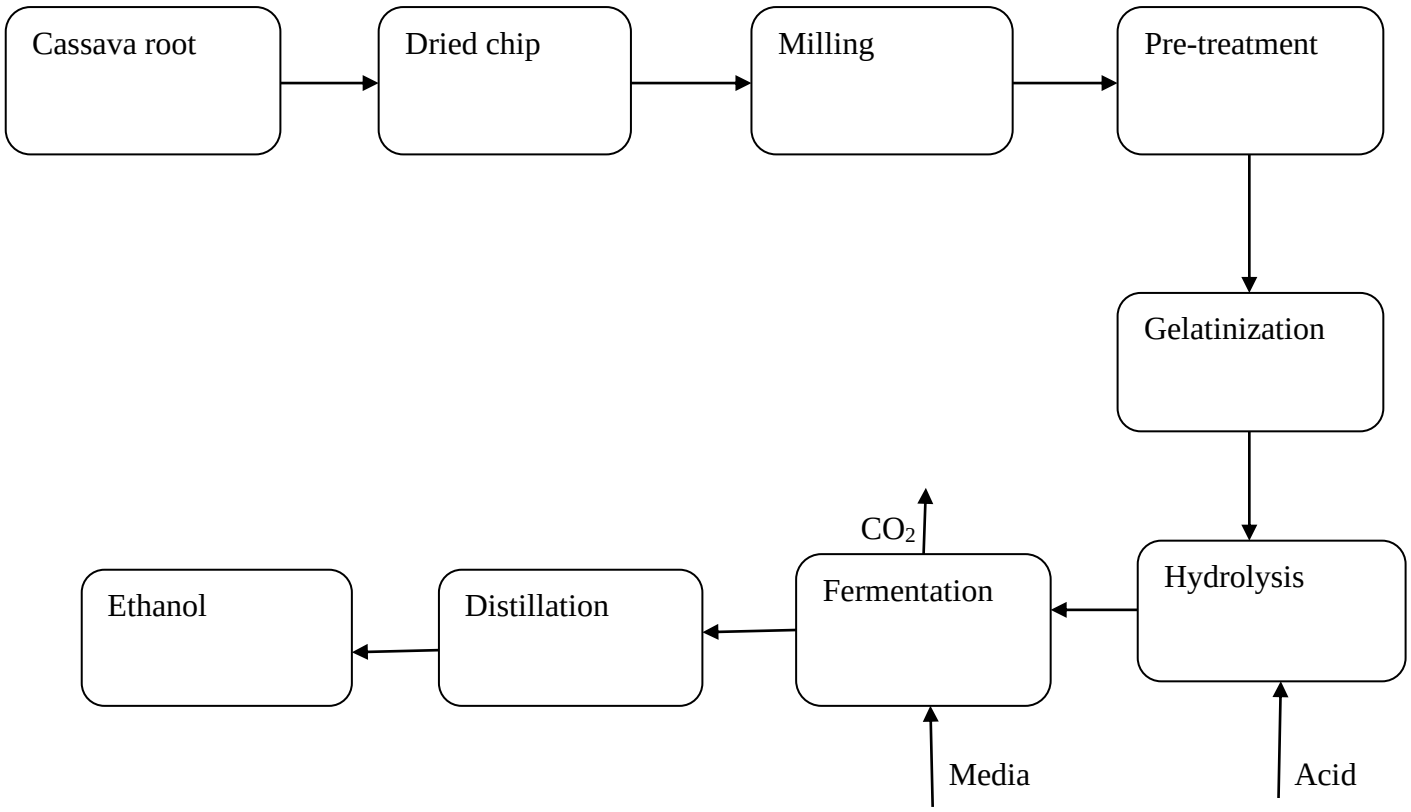


Figure 2 Cassava Ethanol block flow diagram

Procedures

Cassava root harvested and collect from wolaita zone and prepared by the following procedures:

1. Sorting and Weighing

The harvested cassava roots are sorted to select wholesome roots, as well as, to remove immature roots and foreign materials before weighing.

2. Washing and Peeling

The cassava roots are washed in potable water to remove adhering and then manually peeled with knives and washed again to further remove sand and other dirt.

3. Chipping or chip processing

The washed, peeled cassava roots can be manually chipped into small chips of about 1-2 centimeter thickness and 6-7cm long by using knife.

4. Drying

The wet chips are dried in the presence of sunlight at room temperature and oven dryer to low moisture level (less than 14%).

5. Milling

The samples were ground into fine powder with the help of hammer miller and milled to flour in a disc mill (sized 63-425μm) and stored at 25°c for further analysis.

6. Pre treatment

Pretreatment is performed in order to remove foreign materials from flour and to improve the uniformity. In our case it is sieving, sorting of prepared flour for next steps.

7. Gelatinization

Cassava flour of 100g weight was taken and added into the prepared conical flasks containing 1000ml distilled water and thoroughly mixed the flour with water using hand shaking. The aqueous slurry of starch was heated at a temperature of 90^0c for 30min to induce gelatinization. Gelatinization is a transition which is caused by heating a starch source in the Production of Ethanol from Cassava root. And kept the sample in liquid form and cooled the samples at room temperature (25^oC).

8. Acidic Hydrolysis

Hydrolysis is the chemical reaction that converts the polysaccharides in the raw feedstock to simple sugars. Acid hydrolysis of starch uses different concentrations of acids, in our case, dilute Sulfuric acid was used. The samples were then subjected to acid hydrolysis by adding 1% Sulfuric acid to samples and mixed thoroughly and the samples were then hydrolyzed at 120^oC for 15 min (Autoclave) and allowed to cool at room temperature. The hydrolyzed and cooled samples were adjusted by adding 1% NaOH drop wise until the pH became in between 4 and 5.5 because the microorganisms will die in high acidic or basic state. After adjusting the pH of the samples a growth or fermentation medium is prepared.

Media Preparation for fermentation

Prepared 100ml media

Sugar (Dextrose) = 10 gram, Yeast extract = 1 gram, Urea = 1.0 gram DAP =1.0 gram, Distilled water = 100ml, MgSO4.7H2O = 1.0 gram. Then conical flasks are properly covered with aluminum foil. The conical flask is then going to place in shaking incubator for 24 hrs, at temperature of 25^0c.

9. Fermentation

Then the prepared media with the proportion of 1:10 was added to the sample mixture and then placed in the water bath. The fermentation was carried out under anaerobic condition at a temperature of 30^0c. Fermentation takes three days. The optimum parameter like PH and Temperature was 4.5, 30^0c respectively and time 72 hrs the alcohol content of fermented cassava was 4.2%w/w before distillation was performed the solid part was separated from the liquid part by using muslin filter.

10. Distillation process.

About 400 ml of the fermented cassava flour hydrolysate was measured into a volumetric flask and added into the distillation flask then the fermented mixture was heated using a heater. The sample was distilled slowly by simple distillation into the same 250 ml volumetric flask at temperatures between 78 - 80°c for 3 hours and 100ml of ethanol was produced.

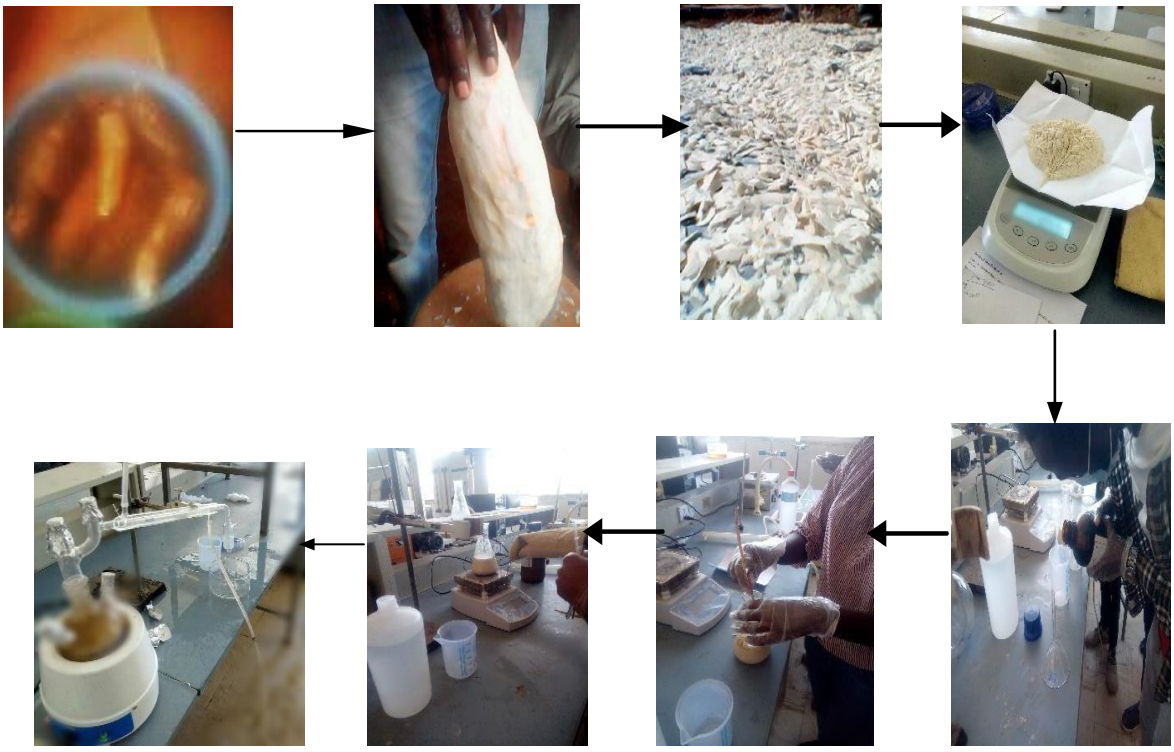


Figure 3 Experimental set up

3.4. DETERMINATION OF ETHANOL PROPERTIES

3.4.1. Ethanol yield

Ethanol concentration was monitored using alcoholmeter

Theoretical alcohol yield

Under anaerobic condition, glucose is converted to ethanol and carbon dioxide by means of glycolsis. The overall reaction produces 2 moles of ethanol and carbon dioxide for every mole of glucose consumed.

$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2CO_2$ + Energy (stored as ATP)

Every gram of glucose converted will yield 0.511 g of ethanol (Maiorella et al., 1981).

Thus, 1 g glucose = 0.511 g ethanol

Yield (%v/w) = [volume ethanol actual / weight of cassava flour] *100

3.4.2 PH Test

PH meter was first adjusted then placed into the sample (ethanol) and the readings were obtained.



Figure 4 Determination of pH

3.4.3 Determination of Alcohol content

The alcoholic content of the samples was calculated from regression equation derived in BGI Ethiopia, St. George Brewery. The regression equation is:

Alcoholic content by weight:

[Al. (%w/w)] = [0.2965*RI – 295.8*SG + 291.285 – 0.04]. Where, RI is refractive index and SG is specific gravity.

Alcoholic content by volume:

[A (%v/v)] = [A (%w/w) *SG] /0.791

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 RAW MATERIAL CHARACTERIZATION

The moisture, fiber, ash, carbohydrate and gross energy content of raw cassava were within the range stated in the literature [12,]. The low crude protein value obtained here was in line with the fact that cassava root is a poor source of protein, as well as lipids. The low crude fiber value obtained may be due to the age as well as variety of cassava used [13].

Samples	W_1 (gm)	W_2 (gm)	Moisture content %
Cassava root	400	147	63
Chips	10	8.56	14.4
Flour	50	44.8	10.4

Table 1 Experimental value of moisture content for wet cassava root, chip and flour

As shown in the table above, the moisture content was conducted by inserting the samples (Cassava root, chips and cassava flour) in to the oven dryer for about 24 hrs at 105^{o}c according to (Olumide O. Tewe, 2004). The moisture content of cassava root, chips and flour that obtained from the experiment was 63%, 14.4% and 10.4% respectively. It is almost similar result that obtained from (Olumide O. Tewe, 2004) which is 62%, 14% and 10% moisture content cassava root, chips and cassava flour respectively.

Composition	Ash %	Fat %	Fiber %	Protein %	Carbohydrate %
value	0.8	0.4	1	1.2	33
Stad.value	1	0.3	1	1.4	38

Table 2 Experimental values of protein lipid, ash, fiber, carbohydrate, and other composition

Table 2 contains the result of proximate composition of our raw material cassava root obtained from experiments and the standard values were collected from literature (Olumide O. Tewe, 2004). As shown in the table the ash content, fat content, fiber content, protein content and carbohydrate

contents are fluctuated. It's assumed that it's because of the variety of cassava used and the method used to conduct this experiment.

4.2 ETHANOL CHARACTERIZATION

The pH, Specific Gravity, refractive index, and alcohol content of fermented cassava slurry was determined after fermentation, as well as yield of ethanol was determined after distillation. The following table contains pH, RI, S.G, and alcohol content of fermentation broth in addition to fermentation temperature and time.

No. of Exp.	**Fermt. Temp (^oC)**	**Fermt. time (hr)**	**pH**	**RI**	**Specific gravity**	**Alcohol content (%w/w)**
1	30	72	4.0	1.3368	0.9690	3.21
2	30	72	4.25	1.3371	0.9685	3.73
3	30	72	4.5	1.3375	0.9681	4.20
4	30	72	4.75	1.3381	0.9657	3.92
5	30	72	5	1.3389	0.9633	3.74
6	30	72	5.5	1.3392	0.9613	3.41

Table 3experimental value of PH, RI, and specific gravity of fermented wash

The experiment was done to see the effect of pH on fermentation by fixing fermentation time (72 hr) and fermentation temperature (30^oC). To see the effect of pH keeping the fermentation time and temperature constant and varying the pH range in between 4 – 5.5. The above Table shows that ethanol content gradually increases along with the increase in pH, and reaches maximum

ethanol content 4.2 (%w/w), when pH becomes 4.5 then it starts to decline due to lesser activity of yeasts. The maximum ethanol content here we obtained from the experiment was lower according to (Hettenhaus, 1998). It assumed that this was due to the method used; the equipment used and may be the variety of cassava used for the decreasing content of alcohol.

Productivity of Ethanol from Cassava Flour

The sample was fermented to different pH values between 4.0 and 5.5 to obtain maximum yield of ethanol by adding lime or sulfuric acid for adjustment. The samples were kept in anaerobic condition for a period of 3 days and the fermented broth was distilled for 3 hours.

As shown on the table 4, specific gravity was obtained by using pycnometer and the ethanol concentration is measure by using Alcoholmeter. The device reads accurately, because it is digital and sensitive. PH was measured by using pH meter.

No. of Exp.	Fermt. Temp ^{0}C	Fermt. time (hr)	pH	RI	Ethanol Yield (%)	S.G	Ethanol Concentration (%w/w)
1	30	72	4.0	1.3586	47.24	0.8485	25
2	30	72	4.25	1.3606	47.30	0.8414	29
3	30	72	4.5	1.3615	48.20	0.8447	39
4	30	72	4.75	1.3621	47.90	0.8346	35
5	30	72	5	1.3629	47.89	0.8271	37
6	30	72	5.5	1.3615	47.26	0.8348	31

Table 4 Experimental values of ethanol after simple distillation.

Table 4 shows that the ethanol concentration gradually increases along with the increase in pH and reaches a maximum percentage of ethanol production when pH is equal to 4.5 and later it starts to decline due to unsuitable condition for yeasts to perform their normal activity. The maximum concentration of ethanol 39% and yield of 48.2% was found to be at the temperature of 30^{o}C, time 72 hr and PH of 4.5

CHAPTER FIVE: MATERIAL AND ENERGY BALANCE

Material quantities, as they pass through processing operations can be described by material balance. Such balances are statements on the conservation of mass. Similarly, energy quantities can be described by energy balance, which are statements on the conservation of energy.

5.1 MATERIAL BALANCE

Basic data:

Density of ethanol = 0.789kg/L

Moisture content of fresh cassava root = 58%

Yeast amount = 15% of cassava flour

Mineralized media =3% of cassava flour

Acid = 0.7% slurry, and Ethanol = 16.6667% M1

To wash 1kg root half liter water is used

Impurity during washing = 0.5 - 2 %, and Peel of cassava root = 10-20%

The ratio of water to cassava flour = 5:1 and the amount of CO_2 =5%

5.1.1. Material balance of individual unit operation

From our Experiment:

From 6kg Fresh cassava root we can get:

Dry chips = 2.5 kg Ethanol = 1liter But in
Industrial scale:

Assumption:

We can take, Basis = 1 hour and M1= 1 tone fresh cassava root

Mass of output or product = density of ethanol *volume of ethanol

M= D* V

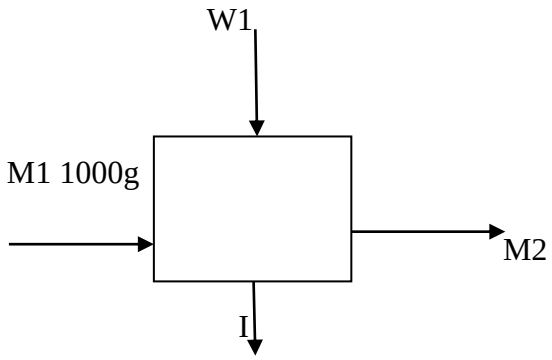
Where, v = 166.6667L and density of ethanol = 789g/l

M = 166.6667L*789g/l= 131500.0263g = 131.5kg

General mass balance

Input=output

1. Mass Balance on washer



M1 +W1 = M2 +I

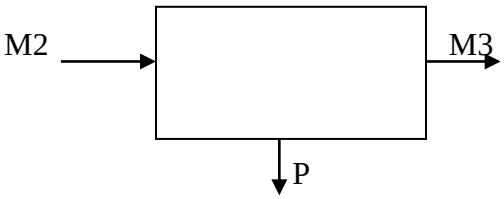
Where, I = W1+ (0.5-2% of M1= 1.25%) and W1= 50%of M1 = 0.5 * 1000 = 500g

500 + 1000 = M2 + (500+0.0125 * 1000)

1500 = M2 + 512.5

M2 = 987.5g

2. Mass balance on peeler



M 2 = P +M3

Where, p = 10 – 20%M2 = 15%M2

987.5g = 0.15 * 987.5 + M3

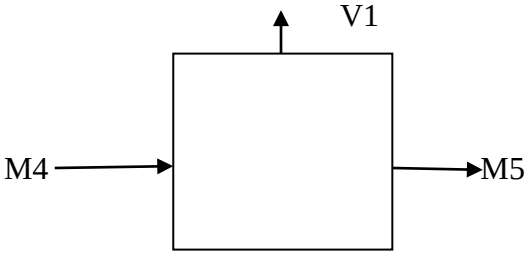
M3 = 839.375g

3. Mass balance on cutter



M3 = M4 = 839.375

4 Mass balances on dryer



M4 = V1 + M5

Where, v1= 58% M4 =0.58 *839.375g = 486.84g

839.375 = 486.84 + M5

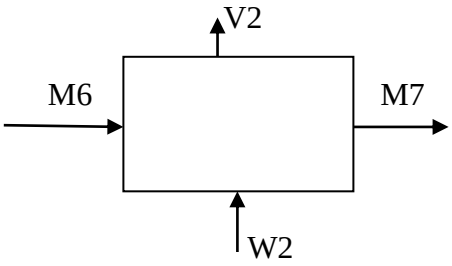
M5= 352.54g

5. Mass balance on miller:



M5= M6 =352.5g

6 Mass balances on cooker



W2+M6 = V2+M7

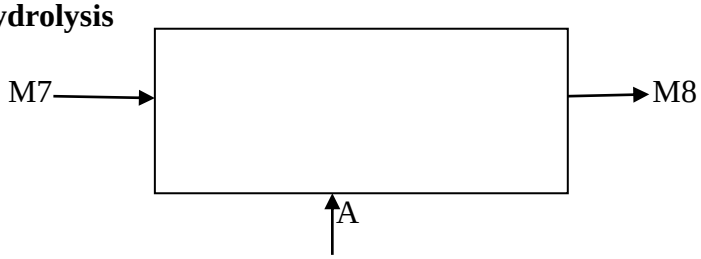
W2= 5*M6 = 5*352.5375= 1762.69g and

V2=13% M6 = 0.13*352.5375= 45.83 g

1762.6875kg + 352.5375Kg = 45.829875kg + M7

M7 = 2069.4g

7. Mass Balance on Acid hydrolysis



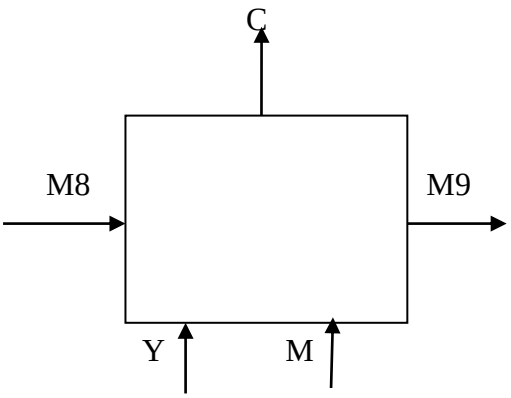
M7+ A = M8

Where, A= 0.7%M7 = 0.007*2069.43= 14.49g

M8 = 14.49g + 2069.43g

M8 = 2083.91kg

8. Mass balance on fermenter



M8 +Y +M = M9+C

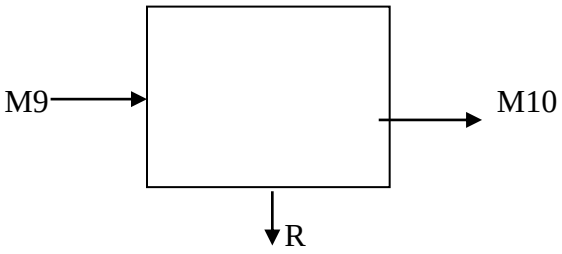
Where, M= 3%M6 = 0.03*352.54 = 10.58g

Y= 15%M6 = 0.15*352.54 = 52.9g

C =5%M8 = 0.05*2083.91= 104.2g

So, 2083.91 g+10.58g+52.875g = 104.2g+M9M9 = 2043.17g

9. Mass Balance on distillation



M9 = R+M10

Where, M10 = 131.5g

2043.1645kg = R+ 131.5g

R = 1911.66g

5.1.2. Over all Total mass Balance

1500 + 1762.6875 +14.485975 + 10.575 + 52.875 = 1911.66 + 131.5 +104.1955 +45.829875+

486.8375 + 512.5 + 148.125

3340.647875g = 3340.647875g

5.2. ENERGY BALANCE

The amount of heat energy gained or lost by a substance can also be calculated for mass of substance:

$Q = M \times Cp \times (Tf - Ti)$

Q = amount of heat energy gained or lost by substance

M = mass of substance

Cp = specific heat capacity (J K-1 kg-1)

Tf = final temperature

Ti = initial temperature

Basic data

Standard temperature of drying of cassava chips = (60-70) = 65^{o}C = 338^{o}k

Standard temperature of cooking = 90 – 95^{o}c = 366^{o}k

Standard temperature of mixing = 70^{o}C = 343^{o}k

Ambient temperature = 25^{o}c = 298^{o}k

Specific heat capacity of cassava = 1125J/kg^{o}k

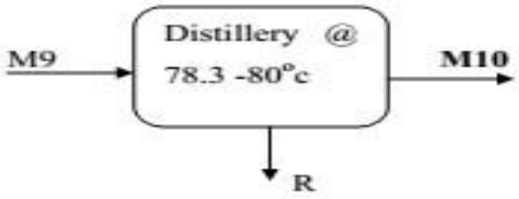
Specific heat capacity of vapor = 1880 J/kg^{o}k

Specific heat capacity of water = 4200 J/kg^{o}k

Specific heat capacity of ethanol = 2440 J/kg^{o}k

Specific heat capacity of steam = 4180J/kg^{o}k

Energy Balance on distillation



Qm9 = m9 x Cp x (Tf - Ti)

= 2043.1645 *2440*(79-25)

= 269207.3545 kJ/ hr

Qm10 = m10 x Cp x (Tf - Ti)

= 131.5 *2440*54

= 17326.440 kJ/ hr

Q R = R x Cp x (Tf - Ti)

= 1911.66 *1125*54

= 251880.3216 kJ/ hr

37771.875+207292.050 + 925.6538 = 17326.440 + 251880.3216 +5389.593.3+21907.6875

245989.5788 kJ/ hr = 245989.5788 kJ/ hr

CHAPTER SIX: ECONOMIC ANALYSIS

6.1 ESTIMATE THE TOTAL CAPITAL REQUIREMENT

Equipment purchasing cost

Estimating equipment cost by scaling cost of equipment of A= cost of equipment of B*(capacity of equipment A/capacity of equipment B) $^{0.6}$

Boiler

Standard capacity = 45359.24kg/hr

The cost of the boiler = $1199900

Our plant boiler equipment capacity = 1762.6875kg

Equipment cost of A=equipment cost of B*(capacity A/capacity B) $^{0.6}$

=$1199900(1762.6875/45359.24)$^{0.6}$

= $170941.1932 *18.7 = 3196600.31284birr

NO	Purchasing equipment	Quantity		Unit price(birr (2013GC)	Total price(birr)
1	Pumps	5		100,900	504,500
2	Neutralizer (mixer)	1		1,360,000	1,360,000
3	holding tanks	2		800,000	1,600,000
4	Condenser	1		180,000	180,000
5	Waste treatment plant	1		1,000,000	1,000,000
6	Boiler	1		3196600	3196600
7	Root cleaning unit	1		300,000	300,000
8	Washer	3		48620	145860
9	Knife cutter Machine	2		74800	149600
10	Fermentation unit	3		205700	617100
11	Tank heater	1		9490	9490
12	Bottling machine	1		135986	135986
13	Hydrometer	3		16	48
14	Bottles	500000		3.366	1683000
15	Conveyer	40meter		187	7480
16	Distillation column	3		476850	1430550
17	Peeler	2		74800	149600
		Total material cost(PEC)			12,469,814

Table 5 Equipment purchasing cost [12].

6.2 Estimation of Fixed Capital Investment

Fixed capital investment = direct cost + indirect cost

PEC = (15-40 % FCI) = 20%FCI

FCI = PEC/0.2 = 12,469,814/0.2 =62,349,070 birr

Our plant works 24hr/day, 6 days per week, 317day per year and 3 shifts.

Construction period one year

Source of finance =20% of equity

80% of loan and Bank interest =5%

The finance analysis of our ethanol plant project is based on the current raw material cost tabulated and the diagrammatic relationship of different cost shown below;

Direct cost	Range,%	Selected percentage	Estimated cost
PEC	15-40FCI	20	12,469,814
Purchased equipment installation, insulation and painting	25-55PEC	40	4987925.6
Instrumentation and control	6-30PEC	18	2244566.52
Piping (installed)	10-80PEC	45	5611416.3
Electrical (installed)	10-40PEC	25	3117453.5
Building(including services)	10-70PEC	40	24939628
Service facility and yard improvement	40-100PEC	70	8728869.8
Land	4-8PEC	6	748188.84

Total Direct Cost = 62,847,862.56			
Engineering and supervision	5-30 DC	17.5	10,988,375.95
Construction expenses and contractor fee	6-30DC	18	11,312,615.26
Contingency	5-15 FCI	10	6,234,907
Total indirect Cost = 28,535,898.21			
Cassava root	7608000kg	5/kg	38040000
Yeast	402273kg	102.44/kg	41208282.94
NaOH	2000L	52.36/L	104720
H_2SO_4	110209L	56/L	6182724.9
Total material cost = 85535727.84birr			

Table 6 .Direct and indirect costs [13].

FCI = DC +IDC

= (62,847,862.56 + 28,535,898.21) birr

Fixed capital investment = 91,383,760.77birr

The total capital investment can be calculated as follows:

Fixed Capital Investment (80-90% of the total capital investment), assumed value is 85% of TCI

TCI = 91,383,760.77birr / 0.85

= 107,510, 306.8 birr

Working Capital Investment (10-20% of the TCI), assumed value is 15% of TCI

WCI = 73351847birr * 0.15

= 11002777birr

Estimation of Total Production Cost

Total production cost = Manufacturing cost + General expenses

Manufacturing cost = direct production cost + indirect production cost

Manufacturing cost

Direct production cost

1. Raw Material Cost=10-50%TPC take30% TPC = RMC/ 0.3TPC = 85535727.84 /0.3 = 275601753birr/yr

2. Operating labor (OL) = 10-20% of TPC take 15%

0.15 *TPC = 42767863.92birr/year

3. Direct supervisor and clerical labor 10-25% take 20%of OL

= 0.2 *42767863.92birr /year = 8553572.78birr/year

4. Utilities = 10-20%TPC take 15% of TPC

= 0.15*285119092.8birr/yr = 4217863.8birr/yr

5. Maintenance and repair =2-10%FCI take 6% of FCI

= 0.06 *91,383,760.77birr /year = 5483025.6 birr/year

6. Operating supplies =0.5-1%FCI take 0.75 % of FCI

= 0.0075*91,383,760.77birr /year = 685378.2birr/year

7. Laboratory charges =10-20%OL take 15% of OL

= 0.15*42767863.92birr/year = 6415179.6 birr/year

8. Patent and royalties = 0-6%TPC take 3% of TPC

= 0.03*285119092.8birr/yr = 8553572.784 birr/year

DPC = 85535727.84 + 42767863.92 + 8553572.78 + 4217863.8 + 5483025.6 + 685378.2

+ 6415179.6 + 8553572.784 = 162,212,184.524 birr/year

Indirect production cost = fixed charge + plant over head cost

A. Fixed charge

1. Deprecation = 13% of FCI

= 0.13*91,383,760.77birr = 11879888.9 birr/year

2. Local tax =1-4%FCI take 4% of FCI

= 0.04*91,383,760.77birr = 3655350.43 birr/year

3. Insurance = 0.4-1% FCI take 1% of FCI

= 0.01*91,383,760.77birr = 913837.6077birr/year

B. plant over head cost = 50-70%OL take 60% of OL

= 0.6*42767863.92birr/year = 25660718.35birr/year

IDC= A+B

= 11879888.9 + 3655350.43 + 913837.6077+ 25660718.35

= 42109795.2877 birr/year

Manufacturing cost = DPC +IDC

= 42109795.2877 + 162,212,184.524 = 204321979.8117 birr/year

General expense

Administration cost = 2-6% TPC take 4% of TPC

= 0.04*285119092.8birr/yr = 11404763.7birr/year

Distribution cost = 2-20% TPC take 11% of TPC

= 0.11*285119092.8birr/yr = 31363100.21 birr/year

Research and development cost = 5% of TPC

= 0.05*285119092.8birr/yr = 14255954.64birr/year

Interest = 0 – 10% TPC take 5% of TPC

= 0.05*285119092.8birr/yr = 14255954.64birr/year

General expense = Ad C + Dist.C +R&D +I

= 11404763.7 +31363100.21 6+14255954.64 +14255954.64 = 71279773.196 birr/year

Total production cost = Manufacturing cost + General expenses

TPC = (204321979.8117 + 71279773.196) birr/year = 275,601,753birr/yr

Profitability evaluation

Annual Gross earning = sales – TPC

Sales,

Product = 1000.452ton/year

Density of ethanol @ 25^{o}c = 0.789 kg/L

Mass of ethanol = density of ethanol *volume of ethanol

Volumetric flow rate = mass flow rate/density

M = D* V

V =M/D = 1000452kg/yr/0.789 kg/L

V= 1,268,000L/yr

Cost of ethanol = $14200/ton = 265540birr/ton

1000452kg /yr = X

X=Sales=285,660,024 birr/year and Residual in distillation unit = 1911.66kg/hr =

14,543,909.28kg/year for cattle feed or fertilizer

Cost of cattle feed (2birr/kg) = 29087818.56birr /year

Total sales = 29087818.56birr/year + 285,660,024 birr/year = 314747842.56birr/year

Annual Gross earning = 314747842.56birr/year – 275,601,753 birr/yr

= 39146089.56birr/year

Net profit = Annual Gross earning – Annual income tax

Annual Income tax = 20% of sales

= 0.2*39146089.56birr/year = 7829217.912 birr/year

Net profit = 39,146,089.56 birr/year – 7,829,217.912 birr/year

NP = 31,316,871.648 birr

TPC = 60% of TCI

TCI = TPC/0.6 = 275,601,753/0.6 = 45933625.5birr

Rate of Return on Investment (ROI)

ROI = (Net profit/total capital investment)*100%

= (31,316,871.648 / 45,933,625.5)*100%

ROI = 48%

Payback period

Payback period= Fixed capital investment/ (annual profit +depreciation)

Payback period = 91,383,760.77/ (31,316,871.648 +11879888.9)

= 91,383,760.77/43,196,760.548

= 2.11 years

The project's initial investment will be fully recovered within 2.11 years.

CHAPTER SEVEN: SITE SELECTION

For our project ethanol production processing site selected is around wolaita because all of the following is considered and makes the project profitably. The location of the plant can have a crucial effect on the profitability of the project, and the scope for future expansion.

7.1 FACTORS CONSIDERED WHILE SELECTING A PLANT SITE ARE:-

- Transportation
- Sources and costs of raw materials
- Prospective market for products
- Corporation long range planning
- Water source - quality and quantity
- Climatic condition
- Pollution requirements (Waste disposal)
- Utilities - cost, quantity and reliability, fuel - costs, and availability
- Amount of site preparation necessary(site conditions)
- Construction costs
- Operating labor
- Taxes
- Living conditions
- Corrosion
- Expansion possibilities
- Other factors.

Three factors are usually considered the most important. These are the location of the Markets, raw materials and the type of transportation to be used. Wolaita has all the above criteria.

7.2. ENVIRONMENTAL IMPACT CONSIDERATION

During ethanol production much number of chemicals is accidentally released into the environment. Occupationally-related losses among workers in the chemical hydrolysis process are higher than deaths for workers from all other industries combined. Explosions, fires and blowouts have multiple environmental and public health impacts. Operational discharges of water and mud (sludge or dirt) have constant effects on marine communities, mammals, birds and humans.

Key Points on environmental impact consideration

During chemical hydrolysis; CO_2, by-products and chemicals used in the acid hydrolysis process cause chemical, thermal, and noise pollution. Regulations on labor, safety, emission standards and environmental protection are often not enough in developing nations and in poor communities in developed nation.

Air Pollution

Gas flaring at the point of fermentation is a source of air pollution. This reaction is temperature dependent; thus, warming increases the formation of photochemical pollution and may reverse gains made in attaining ground level ozone standards. However, studies show that even acceptable levels of many of the Pollutants result in significant negative health effects.

Acid rain

The estimated recovery of acidified soils appears to be a longer, more expanded process than originally projected, as the depletion of minerals (calcium and magnesium) persists even after correction of soil acidity. Calcium and magnesium deficiencies in soils harm plants and animals. Acidification leaches lead, copper and aluminum into drinking water. Eutrophication (excessive nitrogen and phosphorus) contributes to harmful algal blooms in land waters and coastal "red tides" that contaminate sea food, and leads to biologically unproductive "dead zones".

Climate Change

Land surfaces and the deep ocean are warming, altering Earth's ice cover, accelerating the hydrological (water) cycle and changing global weather patterns. Droughts are becoming more severe and persistent, adding to the depletion of fresh water supplies in water-stressed areas, and increasing the vulnerability of agricultural resources. The transition to clean and efficient energy technologies will depend on nationally and internationally coordinated policies and incentives. Understanding the health and environmental consequences of oil use may help decision makers assess the true costs of our dependence on this non-renewable resource. Generally environmental protection is everyone's responsibility. It is part of our value system and displays commitment to our project. Waste minimization at source is of prime consideration in research, process design and plant operations. Technologies and methods, which substitute non-hazardous materials and utilize sources reduction approaches will be given top priority in addressing all environmental issues. Ethanol has many benefits and energy is necessary for all our activities. But each stage in its life cycle carries hazards for humans, wildlife and the environmental systems on which we and other species depend. During ethanol production, wastewater is released from the distillation section. This wastewater contains same amount of NaOH and acid is losses. This wastewater if directly released to the environment, it has negative effect on human's health, wildlife and the environmental systems. So, it has to be treated to avoid this additional compound before disposal. Effluent treatments are for direct discharge to surface water because the products do not have a negative impact on the environment.

CHAPTER EIGHT: CONCLUSION AND RECOMMENDATION

8.1 CONCLUSION

Cassava is not only a traditional subsistence food crop in many developing countries, it is also considered as an industrial crop, serving as a significant raw material base for processed products. Important ones are starches for application in food, paper, textile, glue, cosmetics, pharmaceutical, building and biomaterial. Consequently, the demand of cassava has been rising continuously and thereby contributes to agricultural transformation and economic growth in developing countries. Recently, in some countries, cassava is also used as the energy crop for producing ethanol, an environmentally friendly, renewable alternative fuel for automobile uses. The promise of using cassava for ethanol use is supported by many reasons including distinct plant agronomic traits for high tolerance to drought and soil infertility, low input requirement relatively to other commercial crop, and potential improvement of root yields. In addition, roots are rich in starch and contain low impurities. Although, fresh roots contain high moisture contents and are unpreserved, simple conversion to dried chip can be achieved by farmers at a low cost. Chips as corn analog are less costly to transport, store and process. Improved waste treatment and utilization is also significant in order to minimize overall production cost. With those development, the use of cassava as an energy crop raises more concerns for fuel security. It is critical to agricultural countries that mainly import fossil oil fuel and have lost their economic growth. To overcome that concern, the development of sufficient feedstock supply is considered as the first priority. Use of cassava roots in to fuel ethanol contributes in solving societies needs by generating income, providing a new and cheap alternative source of energy, avoiding excess waste disposal on water bodies and the environment, avoiding having to use more biodiesel for bio-fuel. There are identified numbers of feedstock in ethanol production that have value-added potential in specialty energy demands. This study is done on the production of ethanol from cassava root for bio-fuel purposes and parameter test based on varying PH but other parameters are constant. The most basic bio-fuel sources of starch include cassava root, sugar molasses, corn and maize. The best source of starch was found to be cassava root.

The optimized conditions were found by analyzing the cassava flour in the process of fermentation under various parameters like temperature, pH, and fermentation time, to obtain maximum yield of ethanol. The optimized conditions of cassava flour are of temperature 30^0c, pH 4.5 and the time 72 h which gives maximum ethanol yield. The fermentation was carried out under anaerobic condition

8.2 RECOMMENDATION

Renewable fuel ethanol is environmentally friendly alternative fuel source replacing expensive and depleting fossil fuel source including petroleum, coal, and natural gas. Preliminary investigation has made recommendation for sugar molasses, corn and other starch crops that use chemical hydrolysis such as water that are used to starches degradation. This research had conducted the experiment at limited resource. So, we recommend for interested researchers to fill the gap and deepen the research by considering different type of yeast strain, range of temperature, PH and others.

Varied methodologies of ethanol producing and raw material composition recommendation have been created to bring a solution for the energy problems faced in Ethiopia. Chemical engineers' team is required to be established to standardize the process of cassava for ethanol production and search economical source of cassava as well as quantifying ethanol combustion rates in comparison to biodiesel and measure differences in emissions between the two fuels sources. Lastly the most important things to note is that each individual of the team should play a role in creating awareness in cassava harvesting and developing proposed expansion phase of this ethanol producing technology including financial assistance link tasks.

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