PRODUCTION OF BIO-ETHANOL USING PINEAPPLE FRUIT WASTE BY FRACTIONAL DISTILLATION PROCESS.

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CERTIFICATION

This is to certify that the project was undertaken by **AILOKPEDE ABDULRAZAQ OMOAREGBUN ENG1504024** of the Department of Production Engineering, Faculty of Engineering, University of Benin.

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DEDICATION

This project work is dedicated to Almighty God who saw me through in my course of Study throughout my stay in school and also my lovely families for their support.

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ABSTRACT

Waste disposal has become one of the major concerns for our Country, Nigeria. Fruit peels are the major solid by-product. The dried fruit peels have a content of cellulose and hemicelluloses, which make it suitable as fermentation substrate when hydrolyzed. This thesis aims at utilizing fruit (pineapple) peels for the production of bio-ethanol by using the yeast *Saccharomyces cerevisiae*, thus, producing a valuable product from the fruit peel wastes. The pineapple waste is collected and weighed. This is then grinded, mixed with about 2 litres of water and then filtered. The filtrate is heated on the stove for 5-6hours in which sugar syrup is obtained.

After this, fermentation process takes place which involve introducing 10ml of the yeast into the mixture and mixing with 100ml of water. The water is first boiled at 100°c for 30 minutes after which it was allowed to cool to around 37°c.

Finally, distillation process is being carried out. The cold mash is put into the combustion chamber and heat is applied from a stove and a copper pipe connected through the condenser Chamber, thermometer, and cork fitted to the collection chamber. Re-distillation is carried out to increase the ethanol content.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Ethanol (C_2H_5OH) or ethyl alcohol is an alcoholic compound that recently has considered a renewable bio-energy source; it is biodegradable clear-colorless liquid, eco-friendly potential fuel to power automotive engines, and a potential petrol substitute for road transport vehicles. Due to increasing population and industrialization, the demand of fuel is increasing day by day. Production of various chemicals and fuels by using low cost processes is important from the economic viewpoint and this is more important for the developing countries such as Egypt. According to Energy Information Agency, ethanol's first use was to power an engine in 1826, and in 1876, Nicolaus Otto, the inventor of the modern four-cycle internal combustion engine, used ethanol to power an early engine. Ethanol also was used as a lighting fuel in the 1850s. The first ethanol blended with gasoline for use as an octane booster occurred in the 1920s and 1930s, and was in high demand during World War II because of fuel shortages. Today's ethanol industry began in the 1970s when petroleum-based fuel became expensive and environmental concerns involving leaded gasoline created a need for an octane. Corn became the predominant feedstock for ethanol production because of its abundance and ease of transformation into alcohol.

The first large scale use of ethanol as a fuel happened during the early 1900s when petroleum supplies in Europe were short. Though ethanol is conventionally produced from petroleum by-products, bio ethanol can alternatively be produced by fermentation technology using renewable raw material. Saccharomyces cerevisiae is the most popular organism used for ethanol production due to its high ethanol yield and high tolerance. Nowadays, crops are the main source used for ethanol production. To achieve significant economic and 1750 Girisha Malhotra et al environmental benefit large amount of food wastes can be utilized to produce ethanol. Utilization of fruit waste for bioethanol production is one of the best options. One example of raw material is pineapple waste that is converted to bioethanol. The wastes contain valuable components such as sucrose, glucose, fructose and other nutrients. Lignocellulose is the major structural component of woody plants and non woody plants. The use of mango peel as a source of pectin and fiber production also has been reported. Grohmann et al. (1994; 1995; 1996; 1998) previously reported ethanol production from orange peel. Ethanol production from banana and pineapple peels were also investigated. Dried orange peels have a high content of pectin, cellulose and hemi cellulose, which make it suitable as fermentation substrate when hydrolyzed.

Insoluble carbohydrates are present in the cell walls of the peels, particularly in the form of pectin, cellulose and hemicellulose.

This research gives an insight about the production of ethanol from waste fruits using fraction distillation process at specific conditions. The processing loss during production must be reduced by employing efficient peeling methods to obtain maximum economic returns and at the same time the disposal problem needs to be addressed by converting the waste into value added products.

1.2 Statement of the problem

Inadequate municipal and industrial solid waste collection and disposal creates a range of environmental problems in our country. A considerable amount of waste ends up in open dumps or drainage system, threatening both surface water and ground water quality and causing flooding, which provides a breeding ground for diseases-carrying pests. Open air burning of waste, spontaneous combustion in landfills and incinerating plants that lack effective treatment for gas emissions are causing air pollution. The situation is exacerbated in slums where households cannot make use of garbage collection containers. Lack of the most basic solid waste services in crowded, low-income neighbors are a major contributor to the high morbidity and mortality among the urban poor. The adverse effects of inadequate solid waste service on productivity and economic development of the city are significant. Solid waste such as fruit peels largely obtained as a byproduct from hotels, restaurants and juice processing houses in our country. These wastes can entail serious environmental problems unless they change or convert in to some useful products or disposed properly.

1.3 Aim of the study

The aim of this thesis was to investigate the possibility of using and transforming fruit peel waste to something valuable product, namely ethanol there by contributing towards alternative energy supply as well as creating an employment opportunity.

1.4 Objective of study

. The overall objectives of this project are:

- ❖ To develop and optimize production of ethanol from waste fruits such as pineapple, banana peels, mango peels etc, using different series subsequent steps i.e pre-treatment, hydrolysis, fermentation and distillation method.
- ❖ To protect the environment from fruit peel wastes and there by generating financial revenue from waste.
- ❖ To determine the optimal acid concentration, temperature and time that give the highest possible efficiency of converting solid fruit peel waste mixture to ethanol.

1.4 Scope of the study

Ethanol has been recognized as an important renewable and sustainable fuel source for modern industries. For example, it can be used as a replacement of gasoline for many internal combustion engines, and it can be mixed with gasoline to any concentration. Most existing car engines can run on blends of up to 15% bio-ethanol with petroleum/gasoline, thus it can significantly reduce the dependence on crude oil. At the same time, food waste, particular fruits and vegetable waste, has become an increasingly alarming issue Nigeria. Therefore, if 493 large amount of food waste can be utilized to produce ethanol, it will lead to significant economic and environmental benefits. Through a fermentor, the waste vegetables and fruits can be fermented into a liquid wash which contains approximately 15% to 20% ethanol by weight [8–10]. To produce usable ethanol, the excess water contents from the liquid wash must be removed through distillation process. The final purity of the ethanol products is limited to 95–96% due to the formation of a low-boiling water-ethanol azeotrope. Many ethanol distillation approaches have been developed to improve the system efficiencies. Griend et al developed an ethanol production system which includes a fermentor that may produce the beer slurry from the corns. Through a series of arrangement of process units, the system achieved great energy, water and downtime savings. Grethlein et al developed a system which employed a heat pump using a vapor stream from within the distillation system as a heat source and a liquid stream from within the distillation system as a heat sink. However, all these improved distilling systems still consume a significant amount of energy to heat the wash and to evaporate the ethanol, which is usually accomplished by burning natural gas in a boiler to produce steam for heating. It is well known that burning any fossil fuel will create more greenhouse gases that are emitted to the atmosphere. One of the approaches to reduce the amount of burned fuel is to apply other applications.

1.6 Significance of the study

Waste from fruit is a challenge to the environment all over the globe, hence there is need to be recycled. Production of ethanol from fruit wastes has being carried out with the singular aim of converting this waste to useful material. Vegetables and fruits biomass is a resource of renewable energy with significant fuel source potential for the production of electricity and steam, fuel for consumption and laboratory solvent.

In contrast with its counterpart; fossil fuels, this process leads to cleaner energy

Unlike petroleum based-fuels, biofuels are generally nontoxic. Furthermore, they are often promoted as a carbon-neutral fuel source. Aside the challenge of constant pollution from these renewable waste, biofuels allow for less dependence on imported petroleum and can allow for more local sustainability for a country or individual if there is abundant land in which to grow fuel crops.

This project does not entail the complete replacement of conventional fuels with biofuels, as recent research shows that the amount of energy produced by biofuels is not enough to replace fossil fuels. Such can possibly be achieved only through conversion of most of the planet's non urban areas to farmlands with the aim of yielding the crops necessary for biofuel production

CHAPTER TWO

LITERATURE REVIEW

2.1 Preamble

Excessive use of fossil fuels has resulted in the global warming and climate change. Therefore, there is a thrust towards replacing fossil fuels with cleaner and renewable fuels such as bioethanol and biodiesel. Moreover, due to the rapid consumption of conventional fossil fuels and their unpredictable change in prices there is an urgent need to develop an alternative renewable source of energy e.g., bioethanol for the national energy securities. Lignocellulosic raw materials which include fruit and vegetable waste, forestry waste, agroresidues, MSW etc. can be used to produce bioethanol. Fruit wastes are a rich source of natural sugars. Huge amount fruits are consumed world over as health supplements and even as functional foods [1]. World fruit production in 2012 was 636,545,000 tons, out of which China produced the maximum (21.2%) followed by India (12.6%) and then Brazil (5.9%). Fruit wastes are rich in cellulose and hemicellulose and have low lignin contents, which are mostly loosely placed there between cellulose and hemicelluloses. This makes these wastes interesting for bioethanol production. Lignocellulosic raw materials are considered renewable source of energy and their use for bioethanol production may also help in CO2 mitigation.

Ethanol production is motivated by the use of renewable energy and, among bio-fuels, it is considered the most appropriate solution for short-term gasoline substitution (Zamboni et al., 2009).

Ethanol is a high octane fuel and has replaced lead as an octane enhancer in petrol. By blending ethanol with gasoline we can also oxygenate the fuel mixture so it burns more completely and reduces polluting emissions. Ethanol fuel blends are widely sold in the United States. The most common blend is 10% ethanol and 90% petrol (E10). Vehicle engines require no modifications to run on E10 and vehicle warranties are unaffected also. Only flexible fuel vehicles can run on up to 85% ethanol and 15% petrol blends (E85).

The ethanol, which is produced from the fermentation process, still contains a significant quantity of water, which must be removed. This is achieved by using the fractional distillation process. The distillation process works by boiling the water and ethanol mixture. Since ethanol has a lower boiling point (78.3C) compared to that of water (100C), the ethanol turns into the vapour state before the water and can be condensed and separated.

The principle fuel used as a petrol substitute for road transport vehicles is bioethanol. Bioethanol fuel is mainly produced by the sugar fermentation process, although it can also be manufactured by the chemical process of reacting ethylene with steam.

Bioethanol has a number of advantages over conventional fuels. It comes from a renewable resource i.e. crops and not from a finite resource and the crops it derives from can grow well in the UK (like cereals, sugar beet and maize). Another benefit over fossil fuels is the greenhouse gas emissions. The road transport network accounts for 22% of all greenhouse gas emissions and through the use of bioethanol, some of these emissions will be reduced as the fuel crops absorb the CO2 they emit through growing. Also, blending bioethanol with petrol will help extend the life of the UK's diminishing oil supplies and ensure greater fuel security, avoiding heavy reliance on oil producing nations. By encouraging bioethanol's use, the rural economy would also receive a boost from growing the necessary crops. Bioethanol is also biodegradable and far less toxic than fossil fuels. In addition, by using bioethanol in older engines can help reduce the amount of carbon monoxide produced by the vehicle thus improving air quality. Another advantage of bioethanol is the ease with which it can be easily integrated into the existing road transport fuel system. In quantities up to 5%, bioethanol can be blended with conventional fuel without the need of engine modifications.

Bioethanol is produced using familiar methods, such as fermentation, and it can be distributed using the same petrol forecourts and transportation systems as before.

2.2 History

The fermentation of sugar into ethanol is one of the earliest biotechnologies employed by humanity. The intoxicating effects of ethanol consumption have been known since ancient times. Ethanol has been used by humans since prehistory as the intoxicating ingredient of alcoholic beverages. Dried residue on 9,000-year-old pottery found in China imply that Neolithic people consumed alcoholic beverages.

Although distillation was well known by the early Greeks and Arabs, the first recorded production of alcohol from distilled wine was by the School of Salerno alchemists in the 12th century. The first to mention absolute alcohol, in contrast with alcohol-water mixtures, was Raymond Lull.

In 1796, Johann Tobias Lowitz obtained pure ethanol by mixing partially purified ethanol (the alcohol-water azeotrope) with an excess of anhydrous alkali and then distilling the mixture over low heat. Antoine Lavoisier described ethanol as a compound of carbon, hydrogen, and oxygen, and in 1807 Nicolas-Théodore de Saussure determined ethanol's chemical formula. Fifty years later, Archibald Scott Couper published the structural formula of ethanol. It is one of the first structural formulas determined.

Ethanol was first prepared synthetically in 1825 by Michael Faraday. He found that sulfuric acid could absorb large volumes of coal gas. He gave the resulting solution to Henry Hennell, a British chemist, who found in 1826 that it contained "sulphovinic acid" (ethyl hydrogen sulfate). In 1828, Hennell and the French chemist Georges-Simon Sérullas independently discovered that sulphovinic acid could be decomposed into ethanol. Thus, in 1825 Faraday had unwittingly discovered that ethanol could be produced from ethylene (a component of coal gas) by acid-catalyzed hydration, a process similar to current industrial ethanol synthesis.

Aso a niger produces enzymes such as amylase, amyloglucosidase, cellulases,lactase, invertase and pectinases. Maximum saccharification was achieved by hydrolysing banana-waste cellulose with a cellulase enzyme from Trichoderma reesei QM 9414. A yield of 1·38% and 0·78% (v/v) and 44·5% and 61·1% ethanol (mg g^{-1}reducing sugars) was achieved from cellulose and acid hydrolysed (2·5% at 15 psi for 15 min) banana peels, respectively. Grohmann et al. (1998) observed that E. Chrysanthemi EC16 contains the PET operon from Zymomonas mobilis on the plasmid pLOI555 which increases the organism's ethanol production and decreases the final concentration of co-product (Beall and Ingram 1993). Escherichia chrysanthemi EC16 fermentations of sugar beet pulp produced 1.97 % (w/v) ethanol, less than the 2.55 % (w/v) ethanol produced by E.Coli KO11 on the same substrate. In a study by Jayant Mishra et al. (2012), ethanol production from fruit peels of pineapple, orange and sweet lime was investigated. Total amount of sugar in pineapple, sweet lime and orange was 0.5, 1 and 0.8% respectively. In the solid state fermentation, pineapple agro residue gives a maximum yield around 2.16% with yeast. With a change of strain to C. albicans, pineapple still gives a high yield of 1.08% for group A in 50 ml capacity. Pineapple gives a maximum yield of 1.87% with S. cerevisae. Lavarack B. P. et al. (2002) tried dilute acid hydrolysis of bagasse for conversion of hemicellulose to xylose, glucose, Arabi nose, acid soluble lignin and furfural.

In modern times, ethanol intended for industrial use is also produced from ethylene. Ethanol has widespread use as a solvent of substances intended for human contact or consumption, including scents, flavorings, colorings, and medicines. In chemistry, it is both an essential solvent and a feedstock for the synthesis of other products. It has a long history as a fuel for heat and light, and more recently as a fuel for internal combustion engines.

Bioethanol is the most widely used biofuel in transportation sector and have a long history as alternative fuels. In 1984, Germany and France started to use bioethanol as a fuel in internal combustion engines (ICEs) [3]. Utilization of bioethanol by Brazil was initiated since 1925. In Europe and United States, bioethanol was widely used until the early 1900s.

2.3 Previous research of bio- ethanol

The world's reliance on fossil fuels for transport is unsustainable. In addition, fossil fuels are the main reason for global warming, a process that practically all climate scientists say we have to deal with not soon, not tomorrow, but now. One of the most promising alternate source of energy is bioethanol. Bioenergy represents the utilization of biomass as starting material for the production of sustainable fuels and chemicals (Fukuda et al., 2009). Ethanol has long been considered as a suitable alternative to fossil fuels either as a sole fuel in cars with dedicated engines or as an additive in fuel blends with no engine modification requirement when mixed up to 30%. Today, bioethanol is the most dominant biofuel and its global production showed an upward trend over the last 25 years with a sharp increase from 2000 (Talebnia et al., 2010). Sugar and starch based materials such as sugarcane and grains are 2 groups of raw materials currently used as the main resources for ethanol production. The 3rd group is lignocellulosic materials representing the most viable option for production of ethanol. Growing demand for human food, as it is for energy and considering the priority for starving human society could make the first 2 groups of raw materials potentially less competitive and perhaps expensive feed stocks in the near future compared to lignocellulosic materials (Taherzadeh and Karimi, 2007). The bio-fuels to be considered as relevant technologies by both developing and industrialized countries are due to a number of factors, including energy security reasons, environmental concerns, foreign exchange savings and socioeconomic issues related to the rural sector. Increasing use of biofuels for energy generation purposes is of particular interest nowadays because they allow mitigation of greenhouse gases, provide means of energy independence and may even offer new employment possibilities (Wierzbicka et al., 2005). Biofuels are non-toxic, biodegradable and free of sulphur and carcinogenic compounds like benzene (Sastry et al., 2006). Biofuels are being investigated as potential substitutes for current high pollutant fuels obtained from conventional sources (Nwafor, 2004). Biofuels are liquid or gaseous fuels made from plant matter and residues, such as agricultural crops, municipal wastes and agricultural and forestry by-products.

Present study deals with bioethanol production from different rotten fruits which are wasted in markets and go downs. Five rotten fruits such as sapota, papaya, apple, berry and grapes were selected for bioethanol production as they are good source of carbohydrate naturally. Qualitative estimation of bioethanol was done by method of Jones reagent test and estimation of bioethanol production done by specific gravity method. Bacteria were isolated from respective 5 rotten fruits named as A, B, G, P, S and inoculated in fruit samples to study the bioethanol production. Microscopic observation of bacteria shows that bacteria A was coccus, bacteria B was coccus, bacteria G was bacillus, bacteria P was coccus and bacteria S was bacillus. All 5 bacteria were motile, bearing endospore, acid fast negative and bacteria A was gram negative and other bacteria B, G, P and S were gram positive.

In rotten fruit apple produced 6.15% of bioethanol on 3rd day, in 4th day production of bioethanol was 7.22, 5.88 and 4.81%, respectively for 5th and 6th day. Maximum amount of bioethanol was produced on 4th day (Table 2.1). Vendruscolo et al. (2008) used apple pomace as versetile substrate for bioethanol production. Neelakandan and Usharani (2009) also study bioethanol production from cashew apple juice using Saccharomyces cerevisiae. Rotten berry produced 4.81% of bioethanol on 3rd day, 5.08% on 4th day, 7.00% on 5th and 3.18% on 6th day of incubation (Table 2.2). After the fermentation of rotten grapes sample percentage of bioethanol production was 5.36, 8.04, 7.76 and 7.49% on 3rd-6th day of incubation, respectively. The maximum production of bioethanol was obtained on 4th day of incubation (Table 2.3). Korkie et al. (2002) worked on grape pomace for ethanol production. Rotten papaya obtained the 2.64% of bioethanol on 3rd day, 3.18% on 4th day, 6.41% on 5th day and 2.37% on 6th day.

Table 2.1: Amount of bioethanol produced by apple

Incubation period	Amount of bioethanol (%)
3rd	6.15
4th	7.22
5th	5.88
6th	4.81

Table 2.2: Amount of bioethanol produced by berry

Incubation period	Amount of bioethanol (%)
3rd	4.81
4^{th}	5.08
5^{th}	7.00
6^{th}	3.18

Table 2.3: Amount of bioethanol produced by grapes

Incubation period	Amount of bioethanol (%)
3rd	5.36
4th	8.04
5th	7.76
6th	7.49

Table 2.4: Amount of bioethanol produced by papaya

Incubation period	Amount of bioethanol (%)
3rd	2.64
4th	3.18
5th	6.41
6th	2.37

Table 2.5: Amount of bioethanol produced by sapota

Incubation period	Amount of bioethanol (%)
3rd	6.68
4th	7.49
5th	8.40
6th	8.04

Production of bioethanol was maximum on day of 5 (Table 2.4). Akin-Osanaiye et al. (2008) produced bioethanol form Carica papaya waste. Sharma et al. (2007) explained optimization of fermentation parameters for production of ethanol from kinnow waste and banana peels. Rotten sapota produced 6.68% of bioethanol on 3rd day, 7.49% of bioethanol on 4th day, 9.40% of bioethanol on 5th day and 8.04% of bioethanol on 6th day (Table 2.5). Result shows that highest production of bioethanol was obtained on 5th day of incubation. Tiwari et al. (2010) studied effect of temperature variations in bioethanol production process. Tiwari et al. (2011) also explained bioethanol production from some carbohydrate sources by gram positive bactetia. Tiwari et al. (2012) worked on Jatropha oil cake for bioethanol production. Pandey et al. (2013) used Azolla a lignocellulosic waste for bioethanol production.

In current time the importance of alternative energy source has become even more necessary not only due to the continuous deletion of limited fossil fuel stock but also for the safe and better environment. Rotten fruits may serve as a good substrate as they contain sufficient amount of carbohydrates naturally which can be used for production of bioethanol.

CHAPTER 3

METHODOLOGY

3.1 Setup

The setup consists of the raw materials such as the fruits, reagents, a temperature scale to measure and keep track of the temperature of the fermented materials in the heating chamber. A cooling chamber consisting of ice/cold water to cool the vapour as it passes through the cylinder, and finally an outlet where the ethanol is to come out from.

3.2 Setup Geometry

Calculation for Distillation Chamber

During fermentation of the pineapple fruit peels, we assume 5litres (5000grams in mass) of water will be used to produce 2litres (1578gram in mass) of ethanol.

Total volume of liquid= volume of water + volume of ethanol

= 5 litres + 2 litres = 7 litres

Volume of the Middle product in the mixture (X_L)

$$X_L = \frac{volume\ of\ water}{total\ volume} = \frac{5}{7} = 0.714$$

Volume of the top product in the mixture (X_v)

$$X_v = \frac{volume\ of\ ethanol \times 100}{total\ volume} = \frac{2}{7} = 0.286$$

Moles of liquid = $\frac{mass\ of\ water\ in\ gram}{molar\ mass\ of\ water} = \frac{5000grams}{18grams} = 277.18mol$

Moles of vapour= $\frac{mass\ of\ ethanol\ in\ gram}{molar\ mass\ of\ ethanol} = \frac{1578grams}{46grams} = 34.3mol$

Liquid flow rate (N_L)

$N_L = \frac{mole\ of\ liquid \times 10lb}{hr} = \frac{277.78 \times 10lb}{hr} = 2777.8lbmol/hr$

Vapour flow rate (N_V)

$N_V = \frac{mole\ of\ vapour \times 3.156lb}{hr} = \frac{34.3 \times 3.156lb}{hr} = 108.25lbmol/hr$

Feed flow rate (N_F)

$N_F = N_L + N_V = 2777.8 + 108.25 = 2886.05$lbmol/hr

Volume of the bottom product in the mixture (X_f)

$X_F = \frac{(XL)(NL)+(Xv)(Nv)}{Nf} = \frac{(0.714)(2777.8)+(0.286)(108,25)}{2886.05} = 0.697$

Molar weight of the liquid (M_{wl})

M_{wl} = (X_L) (molar mass of water) + (X_v) (molar mass of ethanol)

= (0.714) (18) + (0.286) (46) =26.008

Molar weight of the vapour (M_{wv})

M_{wv} = (X_f) (molar mass of water) + (X_v) (molar mass of ethanol)

= (0.6979) (18) + (0.286) (46) =25.4

Density of liquid (D_L)

D_L= (X_L) (Density of water) + (X_v) (density of ethanol)

= (0.6979) (18) + (0.286) (46) =0.9396g/ml

Density of vapour (D_v)

Using ideal gas law

Pv =NRT, where

p=pressure of gas = 1 atm

R= Gas constant =82.05 mL atm mol^{-1} K^{-1}

T= Absolute temperature=378°k

$$D_v = \frac{pressure\ of\ gas \times Mwv}{gas\ constant \times absolute\ temperature} = \frac{1 \times 25.4}{82.06 \times 378} = 8.189 \times 10^{-4} g/ml$$

To calculate k^{DRUM} (via equation)

Mass flow of vapour (W_v) = $M_{wv} \times N_V$

$W_v = 25.4\times 108.25 = 2749.55$lb/hr

Mass flow of liquid (W_L) = $M_{wL} \times N_L$

$W_v = 26.008\times 2777.8 = 72245.02$lb/hr

To calculate flv

$$Flv = \frac{Wl}{Wv}\sqrt{Dv/Dl}$$

$$Flv = \frac{72245.02}{2749.55}\sqrt{\frac{0.0008189}{0.9316}} = 0.7757$$

Use equation for k^{drum}

$$K^{drum} = e^{A + B(Inflv)+C(Inflv)^2+D(Inflv)^3+E(Inflv)^4}$$

A= -1.8774

B=-0.8146

C= -0.1871

D= -0.0145

E=-0.001

$K^{drum}= e^{-1.6823}= 0.186$

Permissible velocity (V_{perm})

$$V_{perm} = K^{drum} \sqrt{\frac{Dl-Dv}{Dv}}$$

$$= 0.186 \sqrt{\frac{0.9396-0.0008189}{0.0008189}} = 6.298 \text{ft/sec}$$

Cross sectional area (A)

$$A = \frac{Nv \times Mwv}{Vperm(3600 \times Dv)} =$$

$$\frac{108.25 \times 25.4}{6.298(3600 \times 0.0008189)} \; multiply\ by \; \frac{454}{28316.85} \; to\ convert\ to\ ft\text{^}2$$

$=2.37ft^2$

$$\text{Diameter} = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4\times 2.37}{\pi}} = 1.74\text{Ft} = 20.88\text{inches}$$

Length =1.3 x Diameter =1.3 x 20.88inches =27.12inches

With these calculations put in mind, we were able to obtain and draw the orthographic as well as the angle projections for the designed ethanol production system as shown below.

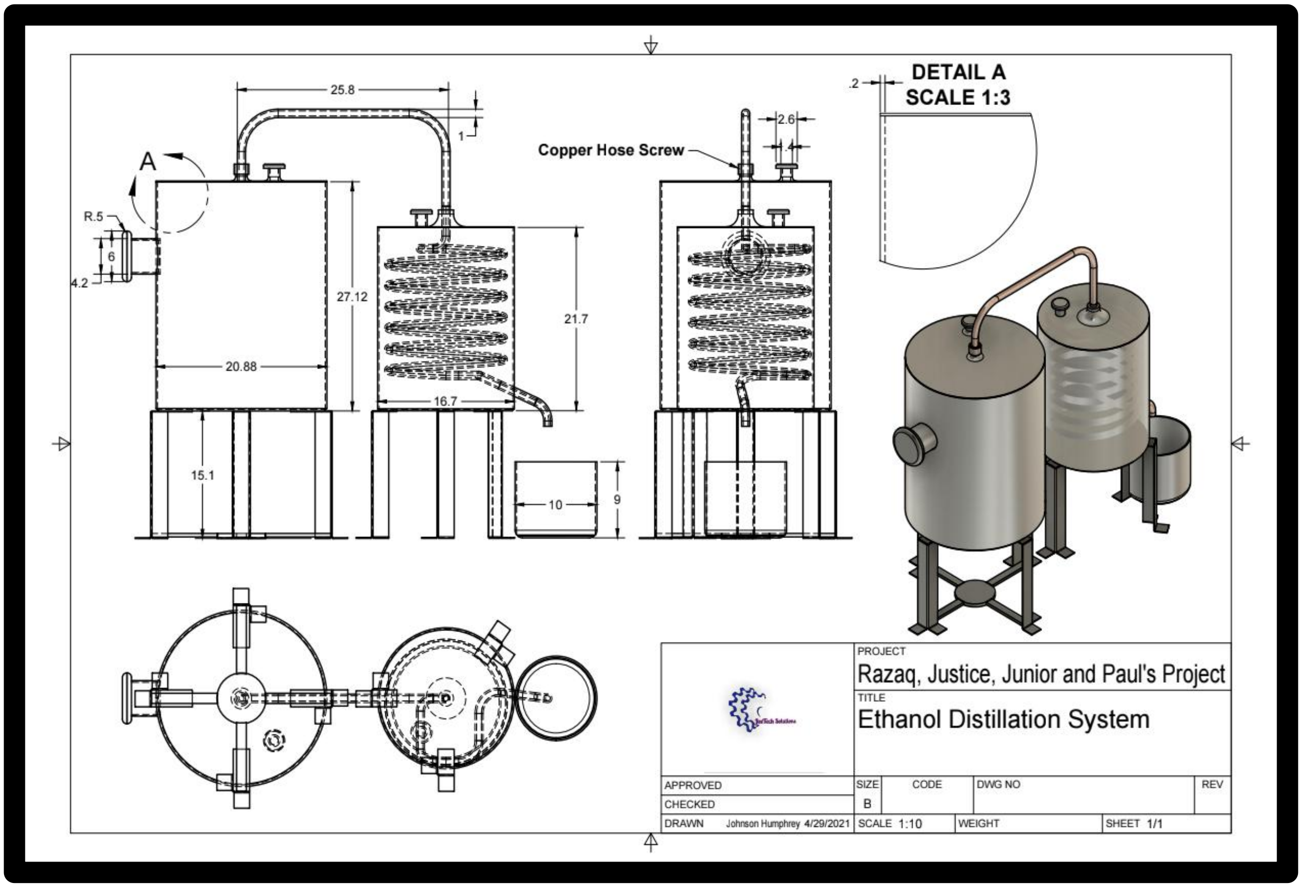

Fig 3.1 Orthographic and isometric projection of ethanol distillation system.

While the fully rendered setup is illustrated below

Fig 3.2 Ethanol distillation system

3.3 Ethanol Production Process

Ethanol can be gotten from a wide range of products. As for fruits, study shows that unripe fruits contain 0% Ethanol, ripe hanging fruits contain 0.6% Ethanol, ripe fallen fruits contain 0.9% Ethanol and over-ripe fallen fruits contain 4.5% of Ethanol (by weight) on an average.

Comparison of different fruits for ethanol production is beyond the scope of this project. However, tests and research by various individuals show that upon fermentation, red apples, pineapples, and bananas yield a decent amount of ethanol.

Due to cost restraints for red apples as well as its lack of availability, we considered the use of Pineapples.

3.4 MATERIALS

This section on materials and methods will be highlighting the materials which were employed in the cause of the research and also the process and method used in the production of ethanol from Pineapple waste which is the essence of this work.

If the raw material contains sugar not starch, the batch does not have to be treated with enzymes. The pineapple is ready to be fermented to alcohol by the yeast without pretreatment. The batch may be cooked briefly to sterilize it before adding the yeast.

3.4.1 Materials Used

The materials used for the production of bioethanol from Pineapple wastes are:

Pineapple wastes

Syrup from the Pineapple waste

Stove for heatingg

Angle bars

Round bottom flask

Condenser

Copper pipes

Measuring cylinder

EBaker's yeast

Funnel

Plastic container

Weigh

Sieve

Hydrometer

Thermometer

3.5 PRE HEATING

The pineapple waste is collected and weighed. This is then grinded, mixed with about 1 litres of water and then filtered so as to allow the solid wastes to distinguish themselves from the liquid. The filtrate is heated on the stove for 5-6hours in which sugar syrup is obtained

3.6 BATCHING

The Pineapple waste is collected and weighed to be 2.5kg. After which it is grated and mixed with 1 litre of water and then sieved.

The filtrate is heated on the stove for 5-6 hours in which sugar syrup is obtained. The sugar content of the syrup was determined using a scale wine hydrometer to be 50g of sugar in 100ml of solution. Upon weighing the sugar syrup was 2.1kg.

The sugar syrup is diluted before the yeast is introduced because any sugar content above 20g per 100ml will kill the yeast. This is why sugar is used as a preservative.

It was made up of three batches with each batch contains three samples

Batch	Yeast content (g)	Sugar content (g)
1A	0	5
1B	1	10
1C	2	20

Table 3.6 Batch samples

3.7 FERMENTATION

Fermentation is a metabolic process which yields chemical changes in organic substances such as food and fruits through the action of enzymes.

10ml of the yeast mixture was introduced into the mixture and mixed with 100ml of water. The water was first boiled at 100°c for 30 minutes after which it was allowed to cool to around 37°c. The water is measured and poured into the mixture in a container; 10ml of the sugar solution and yeast are added.

The mixture is mixed from the outside with a Turner(spoon) and soon, it starts to bubble. The mixture is left for about 3-4 days at room temperature, which ranges from 28°c (82°F) to 34°c (93°F).

At intervals, the mixture gets manually agitated to ensure proper mixing and fermentation of the yeast with the sugar.

During fermentation heat is produced, it should be stirred and when carbon dioxide is being produced it means it is making alcohol. Study has shown that it should contain about 10% of alcohol after 96 hours.

If it does not, either something was wrong in the batching or the fermentation is not complete. All sugar in the batch should be gone when fermentation is complete.

3.8 DISTILLATION PROCESS

The cold mash is put into the combustion chamber and heat is applied from a stove and a copper pipe connected through the condenser Chamber, thermometer, and cork fitted to the collection chamber.

The mixture contains water and alcohol, which is heated. Alcohol evaporates first because its boiling point (78°c) is lower than water which boils at 100°c. The alcohol vapour rises in the column, condenses and is collected as liquid in a collection chamber. The distillation process is timed and recorded; when it gets to 100°c mark at which it remains constant for some time it is dismantled for another batch to be distilled.

The first distillate contains a high water-ethanol combination called an Azeotrope. To further increase the ethanol content we have to re-distill as the case may be.

CHAPTER 4

RESULT PRESENTATIONS

4.1 Results And Analysis

This chapter deals with the result of the experiment carried out, the tables and from the fermentation and distillations of the batches.

4.2 Results of distillation

Table 4.2.1 showing the quantity of Sugar syrup obtained

0g of Yeast (1A)		1g of yeast (1B)		2g of yeast (1C)	
Time(mins)	Temp(°c)	Time(mins)	Temp(°c)	Time(mins)	Temp(°c)
4.15	32	2.35	30	1.15	28
4.25	46	2.45	40	1.25	48
4.35	68	2.55	48	1.35	68
4.45	96	3.05	80	1.45	94
4.55	98	3.15	98	1.55	96

5.05	98	3.25	98	2.05	98
5.15	100	3. 36	100	2.15	98
5.25	100	3.45	100	2.25	100

Table 4. 2.2 Showing the quantity of liquid obtained after fermentation and first distillation

Batch	**Qty before fermentation**	**Qty after fermentation**	**Qty of ethanol after 1st distillation**	**Qty of liquid left in solution**
1A	**200ml**	**190ml**	**72ml**	**105ml**
1B	**200ml**	**193ml**	**70ml**	**105ml**
1C	**200ml**	**195ml**	**58ml**	**126ml**

4.3 ANALYSIS AND DISCUSSION ON FIRST DISTILLATION

The tables above give us the table of values (time I.E 1hour 10mins for distillation of each sample and the corresponding temperatures) and presentation of the values in the first distillation of the 3 batches.

In the table it can be observed that during distillation the temperature of the samples in batch 1A got to the 100°c mark much quicker. This suggests that the quantity of the ethanol present is low.

In the table it is observed that during the distillation of the samples in batch 1B, that the temperature of the samples got to the 100°c mark at different times. From the table there is the inference that there is more ethanol present in batch 1B than batch 1A. On more careful observation it is discovered that batch 1B contains more ethanol than the other samples in this batch because of the length of time it took to get to the 100°c mark.

In the table, it is observed during distillation of the samples that it took longer time for these samples in batch 1C to reach the 100°c mark than the samples in batches (1A) and (1B). It was further observed that sample 1C took a longer time to reach the 100°c mark, indicating that it contains more ethanol than the rest and suggests that the yeast fermented more of the sugar in the sampleTable 2 gives the quantity (ml) of the initial batches with sugar and yeast combination which is allowed to ferment, the quantity of the filtrate after fermentation, the quantity of the distillate after first distillation after 1hours 10minutes and the quantity remaining after distillation

CHAPTER 5

CONCLUSIONS

In conclusion of the 600ml of batch prepared 578ml filtrate was obtained after fermentation indicating a 96.33%. Of the 600ml, 200ml was obtained at first distillation showing a 33.33 of the fermented material.

The work is not an end in itself. This result indicates that a huge amount of waste is necessary to produce bioethanol and improvements can be made to make it profitable and viable in Nigeria for local use..

This work has researched into the possibility of converting Pineapple wastes into bioethanol. In today's world bioethanol is being used as fuel for automotives and is more environmentally friendly than fossil fuel currently used. It also helps reduce wastes which are deposited in drains and inside city centres causing flooding, and other environmental problems. Considering that Pineapple is cultivated in Nigeria especially in the rain forest region, the wastes and possibly wastes from other sugar containing fruits can be used to empower and benefit the economy.

RECOMMENDATION

Further researches have to be done to improve the production of high quality and quantity of ethanol. Alternative extraction methods of ethanol such as enzymatic extraction have to be done in order to investigate the variation that could be arise on the quality and quantity of the ethanol yield as a result of using different extraction methods. Most of the solid wastes including fruit peel waste in our country have no or very low conversion to different usable products and as such among the major problems of health especially for cities such as Nigeria. Hence, it recommended that government or other investor's to recover this very valuable product as well as to contribute to the country in reducing the highly rising quantity of wastes. To conclude the recommendation, there is an urgent need for proper collection, documentation and assessment of fruit peel yields of orange, mango and banana as well as their seasonal variation in our country.

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