DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY
PRODUCTION OF ETHANOL FROM CASSAVA TUBER

BY
OLAKANMI BOLANKE JUMOKE
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BEING A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF LIBRARY AND INFORMATION SCIENCE, INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGY, KWARA STATE POLYTECHNIC, ILORIN, KWARA STATE

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CERTIFICATION

This is to certify that this project was carried out by **OLAKANMI BOLANLE JUMOKE** with matriculation number **ND/23/SLT/PT/0731** and it has been read and approved as meeting the requirement of Department of Science Laboratory Technology, Institute of Applied Sciences (IAS), Kwara State Polytechnic, Ilorin for the Award of National Diploma (ND) in Department of Science Laboratory Technology.

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MR. IBRAHIM, I. A. Date

(Project Supervisor)

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MR. ABDULLAH .Z. LUKMAN Date

(Part-Time Co-ordinator)

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DR. USMAN ABDULKAREEM Date

(Head of Department)

DEDICATION

I dedicated this project work to my Lord, my Creator , the Almighty God who gave me the privilege to finish this work successfully , and to my parents that supported me financially and also with prayers.

ACKNOWLEDGEMENT

In the first premise, I give gratitude to Almighty God, the most beneficent the most merciful for seeing me through from the beginning of my project work to the end. I adore Him for His favour and kindness.

I sincerely thank my project supervisor (Mr. IBRAHIM, I.A) for his tremendous efforts, stress, advice and also adding to my knowledge. Am so much indebted to you sir.

I won't hesitate to appreciate my parents for their prayers, financial support and parental care. I pray that you will live long to reap the fruit of your labour.

My profound gratitude also goes to my relatives; brothers, sisters, uncles, aunties, for their caring and support.

Finally I would like to thank my colleagues that we worked together as a team in the seminar work for their diligent and handwork. May Almighty God grant us all success in our endeavors.

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ABSTRACT

This project involves discovering simple methods of producing ethanol from a selected cassava root using acid hydrolysis, fermentation and distillation and the uses of ethanol to the industries and its environment. This research investigated the feasibility of using cassava roots for energy production and the promising results revealed that at least a selected cassava roots following all the necessary procedures and precaution would yield 65 percents of ethanol. Thus, harvesting cassava for food and as well as ethanol production is deemed feasible. However, this system would require supportive policies to ensure a balance between food security and fuel.

CHAPTER ONE

1.0 INTRODUCTION

Cassava is a perenial woody shrub with an edible root, which grows in tropical and subtropical areas of the world. It is rich in carbohydrates, calcium, vitamin B and C, and essential minerals. It nutrient composition differs according to- variety and age of the harvested crop, and soil conditions, climate and other environmental factors during cultivation.

Practically, cassava is rich in carbohydrade and is an essential crop with up to 32% fresh starch contents. Starch is a storage compound consisting of glucose and amylopeotin. The compactness and complexity of lignocellulose makes it more difficult than starch to enzymatically degrade to fermentable sugars.

The insight for the change to bidmass as a source of fuel is due to the fact that petroleum which has became indispensable to our country Nigeria is no longer sustainable. Based on research, Nigeria is one of the crude oil producing country but not still advisable to fully depend only on it for transportation and other uses, for this simple fact, the research on biomass to produce ethanel as a supplement for petroleum is now on the rise.

National Renewable Energy Laboratory NREL, through research is already developing technologies to convert biomass – plants matter such as tree, grasses, agricultural products such as cassava, and other biological materials to fuel. This biofuels will reduce our nation's dependence on foreign oil, improve our air quality, and support rural economies. The biofuel in this project in a fermented ethanol from plants such as cassava.

Ethanol which is also called "ethyl alcohol" is a volatile, flammable, colorless liquid with structure $CH_3 – CH_2 – OH_1$ often abbrreviated as C_2H_5OH or C_2HcoO.

It is commonly reffered to simply as alcohol or spirits. Ethanol is the principal type of alcohol found in alcoholic beverages, produced by the fermentation of sugars by yeasts. It is a psychoactive drugs, it is used in thermometer as a solvent, as an antisecptic and also as fuel.

However, bio-ethanol is produced by hydrolysis and fermentation of carbohydrate feedstocks such as cassava. This bio-ethanol may be used as fuel as it is or in a mixture with fossil fuels using various proportions.

Ethanol from Cassava and it Preferences

Ethanol is generally produced from cassava by the fermentation of sugar, cellulose or converted starch and has a long history. In Nigeria apart from phamaceutical uses, ethanol is more advisable to be used as a supplement for petroleum for the following reasongs:

- Ethanol is not poisonous.

- ❖ 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 warning).
- ❖ It has a higher octane rating than petro as a fuel. That is, ethanol is an octane booster and anti-knocking agent.
- ❖ It is an excellent raw material for sunthetic chemicals.
- ❖ Ethanol reduces country's dependence on petroleum and it is a source of non-oil revenue for any producing country.
- ❖ Finally, ethanol is capable of reducing the country adverse foreign trade balance.

1.1 OBJECTIVE OF THE STUDY

- ❖ To determine the amount of ethanol in a selected cassava roots.
- ❖ To provide additional information on the mineral contents of cassava roots.
- ❖ To outline the importance of ethanol to the industry and its environment.
- ❖ To provide method involved in the extraction at ethanol from cassava.

1.2 SCOPE OF THE STUDY

The scope of this project is limited to the determination of ethanol in cassava using hydrolysis methods followed by fermentation.

CHAPTER TWO

2.1 LITERATURE REVIEW

In Nigeria, in the early 1990s, only about 700 tonnes of cassava starch was produced per year because Nigeria cassava is considered to be of low quality by Nigerian Industries and none is exported. In the mid-1990s, cassava starch only accounted for 5 percent of the 17,000 tonnes of starch used each year as industrial raw materials in Nigeria (RMRDC 1996).

The bulk of the starch used as industrial raw materials during the mid-1990s was imported corn starch which represented 80 percent of the total. The remaining 15 percent was unspecified types of starch. The quality of industrial starch used in Nigeria in the late 1990s was low. Even if at most of it was made from cassava. The impact on the total demand for cassava would be small.

The scope for increasing the use of cassava starch in Nigerian industries is to a large extent, limited by the ready availability of high quality imported corn starch and Nigeria's meagre research and development investment in preparing cassava starch for inductrial uses. Nigeria private investors do not have the incentive to invest in cassava research and development because of the lack of pateut protection.

Currently, the Nigeria beer industry uses about 200,000 tonnes of sorghum each year to make beer malt (RMRDC, 1996). No attemp has yet been made to prepare beer malt from cassava roots produced in southen Nigeria based, however biochemists at the national root research institute (NRCRI) believe that given the right enzyme, it is possible to prepare beer malt from dried cassava roots. The manager of the golden guinea brewery, umuahia believes that consumer would also accept cassava malt beer judging from their ready acceptance of sorghum beer in the mid-1990s. However, the manager reported that golden guinea would be reluctant to invest in research on making beer malt from cassava roots because patent law is not enforced in Nigeria. Research is needed to develop the technology for making beer malt from dried cassava roots.

The third potential for cassava as an industrial raw materials is a cassava based alcohol industry. Currently, Nigeria imported 90 milion liters of alcohol annually with about 80 million litres being used by the liquor industry. If the 80 million litres were produced from cassava, it would require 500.000 tonnes of dried cassava roots which would increase the demand of cassava, raise farm income, generate on farm and off-farm jobs and save foriegn exchange. However, a cassava-bassed ethanol industry, Nigeria can invest in cassava-bassed ethanol industry, Nigeria would be an important country having an cassava-based ethanol industry in africa, and Nigeria would be able to produce ethanol that would be used as fuels and would be rated high than other Africa cassava producing countries that import petroleum as fuel.

2.2 COMMON NAMES FOR CASSAVA

There are basiscally two types of cassava:

- Bitter cassava
- Sweet cassava

It has a binoorial name manihot esailenta. Other common names are:

- Manioc (Brazil)
- Yuca (Central America)
- Balinghoy (Philippine)
- Mogo (Northern Califonia)
- Mandioca (Brazil)
- Tapioca-root (India and Malaysia)
- And cassava (Africa and southeast Asia)

BIOLOGICAL CLASSIFICATION

- Kingdom: Plantae
- Phylum : Tracheophyta
- Class : Magnoliopsida
- Order : Malpighiales
- Family : Euphorbiaceae
- Species : Manihot esculenta

2.3 CULTIVATION OF CASSAVA

Cassava is typically grown in tropical lowlands and requires at least

8 months of warm weather to mature. It likes full sun and requires temperatures ranging from 77 to 81 degree fahreheit and at least 19.6 inches at rain annually. Cassava will bot tolerate trost 1 so it grows best in green house or with cold frame protection in cooler area.

Cassava growers plants cuttings from the stems of recently harvested plants. They typically cut 8 inches from the bottom of the stem then slice 10-inches cutting from the next 30 inches. Cuttings are best planted as soon as possible, although they can be stored successfully in a cool, shaded place for up to 3 months.

The lower half of the cuttings are planted every 3 feet in rows that are 3 feet apart. If the soil is dry, the cuttings are planted vertically.

Cassava plant like water and need regular inigation if it is not

raining. Two months after planting, urea-46-0-0 fertilizer is applied in a band ce inches from the base of the plants. It the soil contains large amounts of nitrogen, continuing to add more will make the plant grow more and the edible roots grow less. In the developing world, only commercial growers typically fertilizer cassava using a balanced fertilizer most of the farmers use organic manure.

2.4 HARVESTING OF CASSAVA

Cassava is usually not harvested until at least eight months after planting. Growere dig up a sample cassava to chech it size. To harvest, the stem is cut, leaving a stub as a handle to pull the cassava roots out of the ground. Harvested roots are stored in a shades place and deteriorate rapidly.

2..5 CHARACTERISTICS OF CASSAVA

The following are the characteristics of cassava:

1. High whitness
2. Odorless
3. Tasteless
4. High paste viscosity
5. Clarity and stability

Also cassava plant can be differentiated into five major types (A-E) based on the following characteristics.

1. Absence or presence of branches
2. Branching angle
3. Hight at first branching
4. Number of modes at which first branching occurs.

Plant types A and B have a higher yield potential leaf number, and leaf area index (size of leaf per unit of gound area) than other types.

Plant types D and E require closer plant spacing than type A, B and C to achieve similar level of leaf area index and yield.

2.6 NUTRITIONAL AND CHEMICAL COMPOSITION OF CASSAVA ROOTS

The composition of the parenchyma edible portion of the tuber is as follows:

The composition of the parenehyme and peel differ. The most important contents are proteins, crude fibre and sugars. In addition the peel contains more cyanides parendyma of low cyanide cultivars contain between 30 and 100mg cyanides per kg, while bitter cultivars may contain up to 1350mg per kg.

2.7 SOURCES OF ETHANOL

The table below shows different sources of ethanol.

Table 2: sources of ethanol

Plant	Plant portion	Ethanol product
Cassava	tuber	4,500
Sweet Potatoes	Tuber	7,800

Sugar cane	stalk/mocasses	5,000-6,000
Maize	grain	3,000-4,000
Sorghum	grain	3,000-4,000
Sweet Sorghum	stalk	5,500-6,000
Sago	stalk	4,000-5,000
Coconut	milk	8,000-10,000

The reliability of this figures must be checked. If coconuts can produce this high level of ethnanot yield per hectare, crop's potential in southern Africa should be considered based on viability studies.

2.8 IMPORTANCE OF ETHANOL AND ITS USES TO THE INDUSTRY AND ITS ENVIRONMENT

- Ethanol fuel is renewable and bunns clearer than gasoline
- Ethanol fuel emits harmless emissions such as carbon monoxide
- Addition farmland use would help our farmers and the econoly
- Very little petroleum is used in ethanol production reducing our country depending on foreign oil

USES OF ETHANOL

Ethanol is used in many different products ranging from perfumes to explosives. The most important or popular uses of ethanol alone is in the automotive fuel industry. These are cars that run off 100% ethanol or fuel mixtures containing part gasolines and part ethanol also known as gashol. It is mixable in all proportions with water and most organic solvents.

Ethanol in the presence of an acid catalyst makes an ethyl ester. The two most used ethyl esters are ethyl acetate and ethyl acrylate. These are used to make up such products as paints coating, adhesives and the most popular household product is nail polich remover. In Brasil, all the fuel for cars has at least a 24% ethanol content. You can even get 100% ethanol if your engine is designed to run on the alcohol. Ethanol is used worldwide and known mostly for getting people intoxicated. Many social gathering around the world involve ethanol in the form of beer, wine and liquor.

Ethanol is also used as a preservative for biological speciments medically, ethanol is a soporific, that is sleep-producing, although it is less toxic than other alcohols.

Uses of Ethanol as Fuel

Ethanol is used as a fuel for internal canbustion engines, either alone or in combination woth other fuels, ethanol has been given much attention mostly because of its possible environmental advantages over fossil fuel.

Anhydrous ethanol, that is ethanol with water can be blended with gasoline in varying quantities to reduce the comsumption of petroleum feuls, as well as to reduce air pollution.

In addition, flexible-fuels vehicles can run on any mixture of hydrated ethanol and gasoline, as long as there is at least 20% ethanol and gasoline, as long as there is at least 20% ethanol.

Ethanol is increasingly used as an oxygenate additive for standard gasoline, as a replacement for methyl t-butyl ether (MTBE), the latter chemical being responsible for considerable groundwater and soil contaimination.

Finally, ethanol can also be used to power fuel cells and to produce biodiesel.

<u>Uses of Ethanol as a solvent</u>

- ❖ Ethanol can be use as a solvent for both polar and non-polar substances, it is a very polar molecule due to it hydroxyl (OH) group, with the high electronegativity of oxygen allowing hydrogen bonding to take place with other molecules.
- ❖ Ethanol attracts polar and ionic molecules "the ethyl (C_2H_5) group in ethanol is non-polar".

Thus ethanol can dissolve both pollar and non-polar substances. In industrial and consumer products, ethanol is the second most important solvent after water.

2.9 PROPERTIES OF ETHANOL

Ethanol, C_2H_50H (also called ethyl alcohol) is the second member ofthe aliphatic alcohol series. It is a clear colourless liquid with a pleasant smell. Except for alcoholic beverages, nearly all the ethanol used industrially is a mixture of 95% ethanol and 5% water, which is known simply as 95% alcohol.

PHYSICAL PROPERTIES OF ETHANOL

Ethanol is a colourless liquid with a pleasant smell. It is miscible with water and organic solvents and is very hydroscopic.

- It has a melting point of about – 1150^0c
- It boiling point is 18^0c, and also have a specific gravity of 0.79.

CHAPTER THREE

3.0 MATERIALS, METHODS AND METHODOLOGY

3.1 MATERIALS

1. Pot
2. Bucket
3. Thermometer
4. Beakers
5. Knife
6. Mortar and pestle
7. Stove
8. Siever
9. Weighing balance
10. Round-bottomed bottle (for distillation)

3.2 REAGENTS

1. Baker yeast (saccharomyces cerevisiac)
2. Dilute tetraoxosulphate (vi) acid "H_2S0_4"

3.3 METHODOLOGY

SAMPLE PREPARATION

The cassava tuber was obtained from a farmer at Akuo in Ilorin, kwara State. The cassava roots were raised with water to remove sand after which it was peeled using knife. After peeling, the cassava was cut into smaller pieces and was soaked in water for 2½ hours to remove the cyanogenic content.

The chips were pounded with morta and pestle with water and the starch milk was obtained by straining the chips. Water was added again in excess and then filtered to completely wash down the starch contents.The starch milk obtained served as the starch sample.

PROCEDURE;

Hydrolysis: The starch sample was treated with 40ml of dilute tetraoxosulphate (vi) acid (H_2S0_4) and was poured into a pot applying heat as a catalyst, a stove was used as the heat source. The sample was allowed to boiled for 30 minutes maintaining a temperature of about 120^0c using a thermometer time-by-time to ensure the temperature is maintained.

Fermentation: After the 30 minutes, the sample was allowed to cool for 15 hours after which baker's yeast was then added and was allow to ferment under aerobic condition, the glucose was assumed to be converted to crude ethanol as the concentration reduce for about 6 to 7 days.

Distillation: After fementation process, the crude ethanol containing ethanol, water, yeast and other impurities was allowed to pass through fractional distillation method since the mixture have different boiling point of 78^0c and100^0c for ethanol and water respectively.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

Figures 3 and 4 shows the effect of the amount of yeast used on the yield of ethanol produced from cassava tubers.

Fermentation was initially carried out separately to determine the amount of yeast to be used. From figure 3, generally, the yield of ethanol produce increase with fermentation time and later decreased. It shows that increasing the amount of yeast (3g-6g) affects the yield of ethanol produced.

Comparing the fermentation time in figure 3 and 4 it was observed that increasing the quality of yeast reduces the fermentation time, when 3g of yeast was used the fermentation time was 120 hours; this was the time the smell of ethanol was noticed. While 6g of yeast required just 72 hours to produce over 25% of ethanol. Although increasing the yeast more than this quality reduces the fermentation time and increases the quality of ethanol produce, but the resultant solution produce will be more cloudier due to much yeast. Hence 5g of yeast to 6g will be preferred; this gave higher yield of ethanol at shorter fermentation time for the starch sample and was used as basic for the production of ethanol from cassava for the studies carried out in this work. After distillation of the crude ethanol, 21ml of anhydrous ethanol was produce from 2kg of cassava tuber.

STARCH CONVERSION

Hydrolysis breaks the glycosidic bond converting sucrose to glucose viz:

$_{(Starch)}(C_6H_{10}O_5)n + H_20$ ...hydrolysis.......> $C_{12}H_{22}O_{11}$(sucrose)

$C_{12}H_{22}O_{11} + H_2O$ ..Amylase....> $C_6H_{12}O_6$(glucose)

$_{(Glucose)}C_6H_{12}O_6$ + zymase....> $2C_2H_5OH_{(ethanol)} + 2CO_{2(carbon\ dioxide)}$

The fermentation was carried out for 7 days. The rate of glucose consumption was found to be somehow slow and almost constant after the 7days. An increment of glucose was defected on dialy basis but started to decrease in the third day, this may be cause due to the fact that the process of hydrolysis was still on, which continue to convert higher molecular starch to glucose by the action of dilute tetraoxosulphate (vi) acid.

After the third day, a smell of ethanol was noticed very strongly due to glucose consumption by the yeast and converted to ethanol releasing carbon dioxide CO_2.

At the 7th day, the concentration of glucose was totally defected. This condition is rather slow in terms of ethanol production capacity. The reason for the slow conversion may be caused by the high glucose concentration in the fermentation environment which can reduce the action of the yeast. However, the boiling point of the ethanol obtained was found to be 78°C.

CHAPTER FIVE

5.0 CONCLUSION AND RECONMENDATION

5.1 CONCLUSION

The cassava tuber that was used in this research weight 2kg which produces 21ml of anhydrous ethanol after distillation.

This project demonstrated a potential for exploitation of cellulosic and starch ethanol from cassava, taking into account that the simultaneous need for energy and food need to be met without compromising the environment, they provide a viable option, holding great potential for acquiring a sustainable system.

The use of cassava ethanol as a second-generation bio-fuel provides a starting-point for improvements in cultivation and adoption of cassava as well as improving food security.

In addition, this may mitigate the human effects on climate change by producing efficient, clean, and renewable energy.

To achieve a sustainable food and energy system, it is important that investments be made in developing, improving, incuring and making technologies available for feedstock preparation, hydrolysis, fermentation and distillation.

Comprehensive guiding policies on exploitation of the bio-fuel sector are urgently needed for this purpose. Policies would ensure the use of both edible and nonedible components of the plant rather than a competition between food and energy, thus facilitating dual plant utilization. In particular, seed availability in communities where the stems provide the bulk of cassava seeds, care should be taken not to generate a shortage of adequate planting material.

This is particularly crucial in cassava-farming communities with poor households, mainly comprising women and children.

5.2 RECOMMENDATIONS

- ✓ Federal Government should encourage the farmers in the production of starch feedstock especially cassava, as it already has advantages in production, such as high yield per hectar, tolerance to drought and degraded soils, and great flexibility in planting and harvesting.
- ✓ Government policies should geared toward promoting cassava starch production to ensure the production of ethanol as it can be used as gasoline and petrol additive, thereby reducing the environment pollutions.
- ✓ There are needs to research more on how to develop essential technology for beer malt from dried cassava roots

- ✓ Since ethanol producing industry is non-existent in Africa, I suggest that Nigeria should establish a well equipped industry where ethanol can be produce, this will also reduces the rate of unemployment.

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