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Quality Assessment Of The Bioethanol Derived From Cassava Peel And Fermented Cassava Starch Liquor

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Abstract: ***The bioethanol produced from cassava peel (Manihot esculanta cranz) and its applications to industrial processes was investigated. Two modes of hydrolysis were adopted for the liquefaction of the gelatinized sample of the cassava peel: acid and enzyme hydrolysis. 0.1 – 1 M H_2SO_4 and HCl were used in-turn to hydrolyze the gelatinized sample as well as Alpha-amylase and Gluco-amylase enzymes. Both the acid and enzyme hydrolyzates were subjected to fermentation process using industrial baker's yeast (Saccaromycescerevisea). For the acid hydrolysis, different experimental conditions such as reaction temperature (100 ^{o}c), reaction time (60 min.), and acid concentrations (1.0 M) were examined in order to establish the best conditions for the hydrolysis. The yield of bioethanol obtained using H_2SO_4 was 20.7 % and noticed to be higher than that of HCl which was 15.62 % under the same experimental conditions. However, the yield of bioethanol obtained via enzyme hydrolysis after fermentation was observed to be 21.62 %, which was higher than the yields obtained from acid hydrolysis. The physicochemical properties of the bioethanol derived from the cassava peel indicated that the flash point of the liquid fuel was 40°C, Refractive index as 1.358 and pH of 5.38 All these values conformed to those of the conventional ethanol which showed values for flash point as 38 ^{o}C, Refractive index of 1.360 and pH of 4.68. Functional group of the derived bioethanol shows O-H functional group around 3600-2400cm^{-1}, C-H(1470-1350 cm^{-1}) and C-O(1320-1000cm^{-1}). The viability of the in-house derived-bioethanol for the production of some household products such as aftershave, hand sanitizer and disinfectant was investigated and found suitable as base chemical for the industrial production of these commodities. The quality assessment of these household products showed that cassava derived bioethanol is a promising feedstock for the industrial production of these products and their allied.***

Key words: Bioethanol, Cassava Peel, fermented cassava starch liquor, hydrolysis

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I. INTRODUCTION

In recent years, there has been an increased trend towards efficient utilization of agro-industrial by-products aimed at obtaining value-added bio-products, including biofuels, biochemicals and biomaterials. Bio-processing of agro-industrial residues minimises environmental problems that are often associated with their disposal, thus reduces dependence on petroleum resources when they are used to produce bio-fuels. The exploration of novel and efficient bioprocesses for underused biomass is thus at the forefront of biotechnological research and industrial application (Rattanachomsri *et al.,* 2009; Pandey *et al.,* 2000).

In many countries, Nigeria inclusive, energy consumption is based on imported refined fossil fuel, but there is need for alternative source of energy which can successively compete with fossil fuel, in terms of cost and quantity. Energy obtain from feedstock (such as sorghum, maize, sweet potato, cassava etc) is such a good alternative and it is renewable, if efficiently harnessed (*modusdale,* Biofuel, USA, 2008).

Renewable energy is refers to as a clean energy i.e. energy from a source that is not depleted, this energy from renewable resources is already today a viable alternative to fossil fuel. Biomass encompasses a wide spectrum of plant materials ranging from agricultural, forestry and municipal wastes. Biofuels are produced mainly through hydrolysis, fermentation and distillation. Solid biofuel are plant matter such as wood chips, tubers and other solid woody biomass that can be directly used as fuel, mainly in traditional cooking stoves and lamps (Global forum for Underutilized Species, 2009).

A. BIOETHANOL

Bioethanol is a liquid fuel that can be obtained from plant resources such as cassava, sweet potato, corn, sago, sugary, starch and lignocellulosic biomass through hydrolysis, fermentation, and distillation processes (Musanif, 2008). Any kind of starch containing crops can be used to produce ethanol. Many research works on the bioethanol derived from various starchy materials such as potato (Quintero *et al.,* 1999), cassava (Leng *et al.,* 2008), and wheat (Power and Murphy, 2008), have been investigated and reported

Bioethanol has so many advantages over the conventional fuels. It comes from renewable sources i.e crops which can be grown again. Another benefit of bioethanol over conventional fuel is that through the use of bioethanol, green house gases emission is reduced as the fuel crops absorbed the CO_2 they emitted through growing by the process called photosynthesis. Bioethanol is biodegradable and far less toxic than fossil fuels; it can be produced from biomass waste. Cassava (*Manihot esculanta Cranz*) is the world sixth most important crop and is grown in many countries in Africa, Asian, and Latin American countries.

Cassava is a starch-containing root crop and is one of the most important sources of calories in the tropics. Cassava is also widely employed as a raw material for many industrial applications in animal feeds industries and starch industries and more recently for production of ethanol. Cassava can be cultivated on arid and semiarid land where other crops such as corn do not thrive (Lin *et al.,* 2011). Cassava is a root crop that produces in high yield with little input. According to IFAD/FAO (2000) report, cassava is the fourth most important staple crop in the world after rice, wheat and maize. The present annual global production of cassava is estimated at 160 million tonnes. This huge production also results into the discharge of significant cassava–derived solid wastes and liquid wastes into the environment especially during processing. Cassava peels constitute 10–20% by mass of each tuber. Cassava tuber contains 25–30% dry matter by mass, the major portion of which is made up of carbohydrates in the form of starch and sugars. The tuber also contains 70–75% moisture. The ongoing encouragement of cassava cultivation by Governments in Nigeria, Thailand, China and other countries is gradually raising the profile of the crop as a significant cash crop.

With increased crop production, there is also a corresponding increase in the production of peels and other cassava-derived wastes. This constitutes an enhanced risk of pollution to the environment. Hence, there is an urgent need for productive use of the peels and other by-components of cassava. One area of possibility is to investigate the potential application of cassava peels as feedstock for biofuel such as biogas and bioethanol. Finding such an important use for the peel would make it less burdensome on the environment as pollutant, but rather, contributes towards enhancing energy security in the cassava-producing regions.

Yield as high as 45ton /hec has been reported (Ogbonna and Okoli, 2010). Cassava pulp contains about 50% -70% starch on a dry weight basis and 20-30% fibers, which are composed mainly of cellulose and other non – starch polysaccharides (Rattanachomsri *et al.,* 2009).

II. MATERIALS AND METHODS

a. *SOURCE OF SAMPLE/COLLECTION*

The cassava peel and cassava starch liquor used for this project were obtained from cassava processing plant in Oda farm, a neighbouring town to Akure, Ondo-State, Nigeria.

b. *SAMPLE PREPARATION*

The sample used for the preliminary analysis were peeled, the peels were cut into smaller sizes, washed thoroughly with clean water, rinsed with distilled water, sun-dried and pulverized using a Qlink blender (model QBL/20L40). The pulverized sample was sieved through an analytical sieve of 200μm mesh size to obtain fine flour. 600 g of the fine sample was hydrolyzed using acids (HC and H_2SO_4) at various concentrations and Enzymes (alph-amylase, amylo-glucosidase).The enzymes used are industrial enzymes from novozyme, namely alpha amylase (liquiflow) and amyloglucosidase (sacc-enzyme). Other reagents used were of analytical grade and purchased from Pascal Chemical Company Akure.

All glass wares were properly washed, rinsed with distilled water and dried in the oven to avoid contamination. 30 Litres black drum used for fermentation was purchased from Isikan market Akure, Ondo State. The GC-MS used for this analysis was GCMS-QP2010 plus SHIMADZU, Japan. The spectrophotometer model is FTIR-(8400s.) SHIMADZU, Japan.

c. *DETERMINATION OF SIMPLE SUGAR CONTENT OF CASSAVA BIOMASS HYDROLYZATE (GLUCOSE)*

The simple sugar content of the sample was determined using the analytical procedure as described by (Lane and Eynon, 1995).

d. *PROCEDURE*

PREPARATION OF SUGAR SOLUTION: A prepared solution of the sugar- containing food was done, by weighing about 4-5 g of the sample into a beaker and adding about 100mL of warm water. The content was stirred until all the soluble matter were dissolved , filtered through glass wool

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into a 250mL volumetric flask and made up to mark with distilled water. The prepared solution was used for the titrations.

e. ESTIMATION OF THE TOTAL SUGAR CONTENT OF THE HYDROLYZATE

The non-reducing sugar content of the hydrolyzate was converted into reducing sugar by pipetting 100ml of the hydrolyzate into a 250mL conical flask, 10mL of 0.1M HCl was added and boiled for 5min. The solution was allowed to cool and neutralised with 10% NaOH. The solution was tested with phenolphthalein solution to ascertain neutrality. The neutralized solution was poured into a 250 mL volumetric flask and made up to mark. The solution was titrated against Fehlings's solution. The non- reducing sugar (e.g sucrose was estimated as the difference between the total sugars content and the reducing sugar content).

The titration was done by filling the burette with the prepared sugar solution. 10ml of the mixture of Fehling's solutions (A and B) mixed in ratio 1:1 was measured inside a 250mL conical flask containing 50mL of the hydrolyzate, into which 4 drops of 1% methylene blue was added and the whole solution was boiled for 10mins. While the solution was boiling, the sugar solution was introduced from the burette into the conical flask and continued the boiling until the blue-black color of the mixture in the conical flask ceased. The concentration of sugars in the hydrolyzate was calculated using the following factors; 1mL fehling solution is equal to 4.9 mg glucose, 5.25 mg fructose, 4.75 mg sucrose.

Therefore;

$$\% \text{ Total Sugar (glucose)} = \frac{4.95 \times 250 \times 2.5}{T \times W \times 10}$$

Where T = Titre of hydrolysed sugar solution, and
W = weight of the sample used (g)

$$\% \text{ Reducing Sugar (glucose)} = \frac{4.95 \times 250}{T \times W \times 10}$$

% Non-Reducing sugar (glucose) = % Total Sugar (glucose) — % Reducing Sugar (glucose)

f. ASSAY OF ENZYME ACTIVITY

Alpha amylase activity assay was done using analytical procedure as described by Demoraes et al, (1999). 0.3 mL enzyme solution was added into the test tube containing g 0.5 mL of 0.5% soluble starch w/v buffered with 0.2 mL of 0.1 M sodium acetate buffer at pH of 5.6.

The solution was incubated at 40˚C for 30mins. The reducing sugar was measure using the DNSA (dinitrosalicyclic acid) method as outline by Miller. The reaction was cooled, followed by addition of 1mL of DNSA, boiled for 5min on a water bath. The solution was then cooled on ice, and the absorbance was read at 540nm using visible spectrophotometer.

Amyloglucosidase assay of the enzyme was done using analytical procedure as describe by (Cereia et al., 200). 0.2 mL of 1% µmol starch in 0.1 M sodium acetate buffer at pH of 5.5 was added to 0.2 mL of the enzyme solution. The solution was incubated at 60˚C for 10mins. The glucose released was measured using the DNSA (dinitrosalicyclic acid) method as outlined by Miller (1959). The reaction mixture was cooled, followed by addition of 0.5 mL of DNSA; it was then boiled at 100˚C for 5min, and cooled on ice. The absorbance was read at 540nm using visible Spectrophotometer.

g. METHOD

h. HYDROLYSIS OF GELATINIZED SAMPLE USING ENZYMES

The gelatinized sample was subjected to a two–stage enzymes hydrolysis procedure; liquefaction and saccharification. The first stage involved the application of alpha- amylase, a liquefying agent which liquefies the starch of the substrate. 0.2 mL of the enzyme was added to the gelatinized substrate and then heated to 90˚C, after which 0.4 mL of the same enzyme was added and allowed to cool down to 55˚C. The substrate was placed on a shaker for 1hour at pH of 5.5 and 2 mL of the substrate was taken and iodine solution was added to it to check if the starch has been completely broken down into simple sugar.

The second stage involves application of amyloglucosidase (AMG) a saccharifying agent to convert the liquefied starch into simple sugar. After the holding time of 1h, 0.6 mL of saccenyzme was added to the substrate maintained at 55˚C and further shaken for 1hr at pH of 5.5. 2mL of the substrate was taken and iodine solution was added to check if the starches have been completely broken down into simple sugar, and later cooled to 33˚C at pH 4.5.

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i. HYDROLYSIS OF GELATINIZED SAMPLE USING ACIDS

Hydrolysis was done using 600g of the sample boil with 20% (v/v) H_2S0_4 and 20% (v/v) HCl differently under a reduced pressure. The pressure was 15ounce by square inch, for 60min. The hydrolysed sample was cooled and neutralised with Calcium hydroxide $Ca(OH)_2$ between a pH of (6.5-7.4). 10% of the yeast was introduced for the fermentation process.

A. FERMENTATION OF THE HYDROLYSED SAMPLE

The liquefied sample was fermented with 50g Industrial beakers yeast (saccharomyces cerevivsea) along with 20g of glucose and 60g of urea. Fermentation process was allowed to take place for 6days at a temperature of 33^0C, respectively. Ethanol was collected every day for six (6) days by distillation process at temperature of 70-80^0C the fermentation broth was distilled using a simple distillation set-up and then further purified using another distillation set-up consisting of a Liebig condenser and fractionating column. The concentration of glucose (Reducing sugar, Total sugar, and Non-reducing sugar) from the hydrolysis process was determined by using volumetric determination of sugar by copper reduction (Lane and Eynon method AOAC, 1990).

B. PHYSICAL AND FUEL PROPERTIES OF THE BIOETHANOL PRODUCTS

a. DETERMINATION OF SPECIFIC GRAVITY (S.G)

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The dry specific bottle was weighed (W_1) then the bottle was filed with distilled water and weighed as (W_2), the bottle was empty and dried, and then filled with bioethanol sample (W_3). Therefore, the Specific gravity of the bioethanol was calculated as follows;

$$S.G = \frac{W_3 - W_1}{W_2 - W_3}$$

b. DETERMINATION OF REFRACTIVE INDEX

The method adopted for the determination of the refractive index was as described by Joslyn 1970, using a refractometer. The prism was wiped with tissue paper, moistened with ethanol, and a drop of bioethanol sample was placed on the previously cleaned surface of the prism and clamped. The telescope was viewed why the control knob was adjusted to enable accurate reading on the scale. The value obtained was noted and recorded. The determination was replicated for other samples.

c. DETERMINATION OF ABSOLUTE/DYNAMIC VISCOSITY

This was done with Oswald viscometer as described by AOAC, 1990 The bioethanol sample was continuously introduced into the open right arm of the viscometer until the left arm bulb was filled up to the upper meniscus. The flow time for the liquid to flow through the capillary was then noted. This step was replicated for bioethanol from cassava peels and fermented liquor of cassava starch, the standard and water. The calculation was as follows:

$$\text{Viscosity in centipoises} = \frac{FT\ of\ Alcohol \times S.G \times 0.8007}{FT\ of\ Water}$$

Where;
FT = flow time
S.G = specific gravity
Viscosity of water at 30°C is 0.8007 centipoise (cP)

d. CALORIFIC VALUE DETERMINATION

The calorific value of the sample was determined using an improvised bomb calorimeter adopting the method described by Oxford University Cambridge National Science level 2, 2012.

10mL of distilled water was weighed into a boiling tube and clamped. The temperature of the water inside the boilimg tube was noted prior the determination 10mL of the derived bio ethanol was poured inside q pre- weighed spirit lamp, the weight of the spirit lamp and the bioethanol was equally noted before the experiment. The spirit lamp was ignited, and placed directly under the boiling tube. The set up was lagged to avoid heat loss The bioethanol was allowed to burn until the temperature of the water rise to 30°C then the flame was extinguished and the spirit lamp was removed. The final temperature of the water was taken quickly to avoid heat loss. The spirit burner and bioethanol were weighed after the experiment, and the change in temperature was recorded.

Then the heat of combustion of ethanol was calculated using: $Q = mc\Delta T$

Where Q is the quantity of heat, m is the mass of water, c is specific heat capacity of water which is 4.18/°C and ΔT change in temperature.

e. DETERMINATION OF FLASH POINT

A test tube was filled with the 10 mL of the bioethanol sample with the aid of a clamp attached to a retort Stand and placed on a hot plate. A thermometer was hung and dipped inside the sample, but not allowed touching the bottom of the test tube. The sample was heated and a flame was introduced to the surfaces of the tube evolving the ethanol vapour until a flash was observed; the temperature at this point was noted and recorded.

f. DETERMINATION OF ALCOHOL PERCENTAGE BY VOLUME

The alcohol content by volume of ethanol used a standard and bioethanol product was done using hydrometer (Alco meter), as described by A.O.A.C 1990.

Procedure

200mL of the bioethanol produced from cassava biomass was poured into a trough Cylinder, an alcohol meter (Densitometer) was inserted and allowed to settle until all bubbles were gone. The bioethanol in the trough thoroughly settled, the alcohol reading was recorded from the graduated densitometer.

g. EVALUATION OF PROOF SPIRIT

The proof spirit was evaluated from the percentages gotten from alcohol percentage by volume using a standard Table recommended by David Pearson, (1976)

h. FLAME TEST

Twenty millilitres (20mL) of the bioethanol was poured into a 50mL capacity spirit lamp assembled with a wick, in order to test for combustibility of the fuel; this step was repeated using conventional ethanol as standard**.**

C. APPLICATION OF THE BIOETHANOL PRODUCTS

a. PRODUCTION OF HAND SANITIZER

About 250 mL of essential oil (vanilla) was weighed into 300ml conical flask and 2 mL of vitamin E oil were mixed with it, 150mL of ethanol was added to the mixture and stirred thoroughly and then 200mL of aloe Vera gel was added.

b. PRODUCTION OF ANTISEPTIC

About 65.2 g of Texapone and 250 mL of Pine oil were mixed. This produced a milky coloured solution which was kept separate. 450 ml distilled water and 120 mL Chloroxylenol was added mixed thoroughly until a homogenous solution was obtained. Followed by the addition

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of 2 Litres bioethanol. The resulting mixture which turned milky earlier was added to the mixture for proper blending. Finally, colouring agent, fragrance and preservatives was added as desired.

c. PRODUCTION OF AFTERSHAVE

About 8 litres of bioethanol was mixed with one litre distilled water, a tea spoon of menthol was dissolved in little quantity of bioethanol, then mixed and poured into a production keg. To the mixture, 25 mL of glycerine was added, followed by the addition of perfume and colouring agent, and then mixed thoroughly to obtain homogenized solution.

III. RESULT AND DISCUSSIONS

A. TOTAL SIMPLE SUGAR CONTENT

Table 1 shows the levels of sugar content recorded as 52.9 % and 32.9% for Cassava Peel and Cassava fermented liquor respectively. The result indicates that cassava peel has higher sugar content than that fermented liquor, but lower than 61.68 % reported by (Sunee et al., 2004) and higher than 37.1% reported by Jirasak et al (2006). The two by-products have a good level of fermentable sugar which indicates that they could serve as alternative source of raw materials for bioethanol production.

B. RESULTS OF THE ENZYME ASSAY ACTIVITIES

Table 1 shows, the enzyme assay activity which was done to know the strength of the enzymes used in the analysis and the volume required for hydrolysis. One enzyme unit is equivalent to the amount of enzyme that releases one µmol of glucose per minutes under assay condition. Result shows that the activity of alpha amylase under the assay condition used was 0.007 U/min while the activity of amyloglucosidase was 0.024 U/min.

C. TOTAL SUGAR ANALYSIS FOR ACID HYDROLYSIS

Table 1 shows the increase in sugar acid hydrolysis as the acid concentration increases, irrespective of the acid type. However, the sugar produced using H_2SO_4 was 52.9 % which gave a higher percentage when compared to 32.9% observed with HCl, but lower than 61.68 % reported by (Sunee *et al.*, 2004) and higher than 37.1% reported by Jirasak *et al.,* (2006).

D. TOTAL SUGAR ANALYSIS FOR ACID AND ENZYME HYDROLYSIS

Table 2 compared the result of the sugar content produced in the hydrolysate of cassava peels and fermented Liquor using Acids (HCl and H_2SO_4) and Enzyme respectively, this shows that levels of sugar content 51.30 % for the enzyme was higher than 33.92% that was noted in the cassava fermented liquor

	Cassava Peel		**Cassava fermented liquor**	**Alpha-amylase**		**Amyloglucosidase**
Total Sugar content of the Cassava biomass prior hydrolysis (%)	52.9		32.5	-		-
Total Sugar content of the cassava biomass after Enzyme Hydrolysis	51.30		33.92			
Total Sugar content in the cassava biomass at different acid Hydrolyzate (HCl)	0.1M	0.5M	1.0M	-	-	-
	19.9	25.8	29.5			
Total Sugar content of in cassava biomass acid Hydrolyzate (H_2SO_4)	29.1	33.9	52.9	-	-	-
Assay of Enzyme Activities:				6.99		24.82

Table 2: Total Sugar content of the cassava biomass before and after hydrolysis and Enzyme activities Assay

Table 3 shows the correlation between the Physico-chemical properties of the conventional ethanol and the derived-bioethanol. The flash point of the bioethanol derived from cassava peels hydrolysed with HCl and H_2SO_4 were 44ºC and 46ºC respectively, while the flash point of the bioethanol obtained from enzyme hydrolyzed cassava peel and fermented starch liquor were 40 ºC and 44 ºC respectively. These values were quite comparable with the standard ethanol with flash point value of 38 ºC.. The specific gravities of the bioethanol derived from the hydrolyzates of cassava peel treated with HCl and H_2SO_4 were 0.963 and, 0.955 respectively while the specific gravities of the bioethanol derived from the enzyme –hydrolysed cassava peels and the fermented starch liquor were 0.924 and 0.965 respectively. All these values were found comparable with the specific gravity of the standard ethanol which is 0.7974. Refractive index of the bioethanol obtained from HCl and H_2SO_4 cassava peel hydrolysed sample were 1.345 and 1.358 respectively, while the refractive index of the enzyme hydrolysed cassava peel and fermented starch liquor were 1.358, and 1.356 respectively.. All these values compared favourably with the 1.3600 and 1.3607 reported for standard ethanol by Shetty *et al.,* 2007, The pH values of the bioethanol obtained from the acid and enzymes hydrolysed samples were 3.75, 3.60, 5.38 and 3.68respectively, these values were found comparable with the pH of standard ethanol, which ranges 4.68 and 4.45 as reported by reported by Rojanaridpiched *et al.*, 2003; Sriroth *et al.*, 2007 which shows that they are acidic in nature. The results obtained shows that bioethanol from these feedstock would be very good and suitable for bioethanol production. Other properties such as density, appearances, colour and flavour conforms favourably to the standard values obtained from conventional ethanol.

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Properties	Sample (standard) Convectional ethanol	Sample CPAH (HCL)	Sample CPAH (H_2SO_4)	Sample CPEH	Sample EHCFL
Chemical formula	C_2H_5OH	C_2H_5OH	C_2H_5OH	C_2H_5OH	C_2H_5OH
Molecular formula	46.7	46.7	46.7	46.7	46.7
Boiling Point in	78	78	78	78	78
Specific gravity at 30 °C	0.7974	0.963	0.955	0.924	0.965
Alcohol by volume (%)	98	28.33	32.5	51.3	33.92
Refractive Index	1.3600	1.345	1.355	1.358	1.356
Flash point °C	38	46	44	40	44
pH	4.68	3.75	3.60	5.38	3.68
Density at 30 °C (Kgm^3)	797	963	955	924	965
Appearance Color and Flavour	Free and clear Spirit flavour	Free and clear Spirit flavour	Free and clear Spirit flavour	Free and clear Spirit flavour	Free and clear Spirit flavour

Key:CPAH= Cassava Peel Acid Hydrolysed,
CPEH= Cassava Peel Enzyme Hydrolyzed,
EHFCL= Enzyme hydrolyzed fermented cassava Liquor

Table 3: Comparison of the Physico-chemical properties of conventional ethanol and the derived cassava biomass-bioethanol

ETHANOL YIELDS OF THE FERMENTED HYDROLYZATES

The yield of the distilled ethanol obtained from Cassava peels was 139 mL/kg and was closed to 145 L/ton reported by Adelekan (2011). Similarly, the yield of the ethanol obtained from the fermented liquor of cassava after distillation was 140 mL/L, which showed that both samples are promising raw material for ethanol production.

VARIATION OF BRIX LEVEL WITH THE ACID CONCENTRATION AT DIFFERENT OF CONCENTRATION ACID AND TEMPERATURES

CONCENTRATION (M)	TIME (min)	TEMP (◦c)	BRIX LEVEL(sugar@20◦c)
0.1	15	60	1.1
0.1	15	80	1.4
0.1	15	100	1.6
0.1	30	60	1.9
0.1	30	80	2.2
0.1	30	100	2.6
0.1	60	60	2.9
0.1	60	80	3.0
0.1	60	100	3.2

Table 4: Variation of Brix level with 0.1M HCl at different Temperature and Time

Concentration	Time	Temperature	Brix level
0.5	15	60	1.5
0.5	15	80	1.7
0.5	15	100	2.4
0.5	30	60	2.6
0.5	30	80	3.1
0.5	30	100	3.3
0.5	60	60	3.5
0.5	60	80	3.8
0.5	80	100	3.9

Table 5: Variation of Brix level with 0.5M HCl at different Temperature and Time

Concentration	Time	Temperature	Brix level
1.0	15	60	1.4
1.0	15	80	1.7
1.0	15	100	2.0
1.0	30	60	3.2
1.0	30	80	3.7
1.0	30	100	3.9
1.0	60	60	4.2
1.0	60	80	4.5
1.0	60	100	4.9

Table 6: Variation of Brix level with 1.0M HCl at different Temperature and Time

Concentration	Time	Temperature	Brix level
0.1	15	60	1.8
0.1	15	80	2.1
0.1	15	100	2.5
0.1	30	60	2.9
0.1	30	80	3.3
0.1	30	100	3.6
0.1	60	60	4.0
0.1	60	80	4.3
0.1	60	100	4.6

Table 7: Variation of Brix level with 0.1M H_2SO_4 at different Temperature and Time

Concentration	Time	Temperature	Brix level
0.5	15	60	2.5
0.5	15	80	2.8
0.5	15	100	3.0
0.5	30	60	3.2
0.5	30	80	3.5
0.5	30	100	4.0
0.5	60	60	4.6
0.5	60	80	5.0
0.5	60	100	5.3

Table 8: Variation of Brix level with 0.5M H_2SO_4 at different Temperature and Time

Concentration	Time	Temperature	Brix level
1.0	15	60	4.1
1.0	15	80	4.5
1.0	15	100	4.8
1.0	30	60	5.6
1.0	30	80	5.9
1.0	30	100	6.3
1.0	60	60	6.5
1.0	60	80	7.4
1.0	60	80	7.8

Table 9a: Variation of Brix level with 1.0M HCl at different Temperature and Time

As presented in Table 4 to 9a, comparing the brix levels obtained for acid hydrolysis using HCl and H_2SO_4, it was observed that the brix level increased with acid concentration regardless of the acid type and experimental conditions. However, the brix level observed in the hydrolyzate of H_2SO_4 was higher than that of HCl.

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Table 9: Summary of FTIR for Cassava Peel and fermented Liquor

SAMPLE	PEAK (cm^{-1})	FUNCTIONAL GROUPS
STANDARD ETHANOL	3437.26,	O-H(Alcohol)
	2976.26	C-H(Alkane)
	1041.59	C-O (Alcohol)
CPEH	3437.26	O-H(Alcohol)
	1441.84	C-H(Alkane)
	1043.52	C-O(Alcohol)
CPAH	3415.08	O-H(Alcohol)
	29974.33	C-H(Alkane)
	1055.10	C-O(Alcohol)
CPEH	3436.30	O-H(Alcohol)
	1644.37	C-H(Alkane)
	1058.96	C-O(Alcohol)
CPFL	3420.67	O-H(Alcohol)
	1645.33	C-H(Alkane)
	1057.03	C-O(Alcohol)

Table 9

CHARACTERIZATION OF CONVENTIONAL AND THE DERIVED BIOETHANOL (CPAH (HCL), CPAH (H_2SO_4), CPEH AND EHFL) WITH INFRARED SPECTROSCOPY, (FTIR)

Table 9 shows the summary of FTIR spectral of the Conventional ethanol, CPAH (HCl), CPAH (H_2SO_4), CPEH and EHFL with their functional groups and wave numbers respectively. Characterization of the Conventional Ethanol and the derived Bioethanol was also done using Gas Chromatography Mass Spectrometer (GC-MS)

In these spectra, the compound identified proved that samples from the standard ethanol and the bioethanol produced was ethyl alcohol, the instrument equally confirmed the structure of this compounds. Plates below indicates the various products produced from Bioethanol which include; disinfectant, aftershave and hand sanitizer respectively. There was no difference in some selected properties of the disinfectant produced from conventional ethanol and that of bioethanol, likewise, the aftershave from conventional ethanol and the Bioethanol, this indicates that bioethanol produced can be used in the industries for production of Antiseptics such as after shave, hand sanitizer and disinfectant

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DERIVED BIOETHANOL PRODUCTS

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IV. CONCLUSION

This study has revealed the feasibility of obtaining good quality and high yields of bioethanol from cassava peels and fermented liquor of cassava starch. These materials are considered virtually as waste by- products of cassava tubers. The enhanced yields of bioethanol obtained through hydrolysis with H_2SO_4 showed the acid is a better liquefying agent for the biomass than HCl. However, enzyme hydrolysis showed a higher yield of the bioethanol than either of the two acids. The results of the GC-MS and the FTIR confirmed the presence of both structural and functional group of ethanol in the cassava peel and fermented cassava liquor. The Physico-Chemical properties of the bioethanol produced from these samples compared favourably with those of the conventional ethanol. Hence, this close comparison makes the derived bioethanol a suitable based solvent for many of the household products such as disinfectant, aftershave and hand sanitizer that were produced. The study concluded that the use of agricultural waste such as cassava peel and fermented liquor is cost effective, eco-friendly and readily available to substitute the conventional ethanol that is largely petroleum sourced.

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