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PROXIMATE ANALYSIS AND PRODUCTION OF BIO-ETHANOL FROM SWEET POTATO (*Ipomoea batatas*) *WHITE CULTIVARS* OBTAINED FROM SAMARU ZARIA

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ABSTRACT
This study entails the production of bioethanol from the peels of sweet potato of white cultivar variety obtained in Zaria, Kaduna State Nigeria. Fresh cultivar with the proximate composition of 72% moisture content, 9.71% ash content, 24.52% crude fiber, 78.74% total carbohydrate and crude protein of 6.42% were hydrolyzed with 3% sulphuric acid solution at 130^{o}C and 60 minutes in an improvised reactor to generate 54.5ml of hydrolyzate after steam pretreatment step. The fermentable reducing sugar of 10.68% was achieved through glucose standardization with UV-spectrophotometer at 540nm wavelength. The fermentation of the hydrolyzate –yeast/media mixture (155ml) at 30^{o}C for 72hours was achieved by commercial grade saccharomyces cerevisiae to yield 20.5g/54.5ml, which corresponds to 0.8198g/ml specific gravity and 93.6% ethanol concentration. The molecular sieve was eventually adopted in dehydrating the bioethanol to 99.9% (0.8072g/ml) concentration and the final yield of 1.61% per 50g of w. cultivar. FTIR spectrum that declares the ethanolic identity with the stretching vibrations of O-H, C-O and C-H at 3391, 1055 and 2981cm^{-1} respectively with the symmetric stretching vibration of the methyl groups at 2930cm^{-1}.

Keywords: ***Acidic hydrolysis, Bioethanol, Fermentation, Saccharomyces cerevisiae, Samaru, Zaria.***

INTRODUCTION

Ethanol is produced both as a petrochemical, through the hydration of ethylene and, via biological processes, by fermenting sugars with yeast, which is more economical depends on prevailing prices of petroleum and grain feedstocks. Certain species of yeast such as *Saccharomyces cerevisiae* metabolizes sugar, producing ethanol and carbon dioxide (Gumienna *et al.,* 2014).

Producing ethanol from starchy materials such as cereals must first be converted into sugars. Sugars for ethanol fermentation can be obtained from cellulose-containing agricultural by-products, such as corncobs, straw, sawdust, starchy products, sugar cane bagasse, and energy crops into renewable energy resources and fermentable sugar sources (Liu *et al*., 2021)**.** Agricultural-based industries produced a vast number of residues every year. If these residues are released into the environment without proper disposal procedure, serious environmental pollution and harmful effect on Various studies reported that different kinds of waste such as pomegranate peels, lemon peels, and green walnut husks can be used as natural human and animal health remain inevitable. Most of the agro-industrial wastes are untreated and underutilized; therefore, they are either disposal by burning, dumping, or unplanned land filling.

These untreated wastes create different problems associated with climate change by increasing the number of greenhouse gases (Sadh *et al.,* 2018). Hence, it is a worldwide concern to dictates the improvement of alternative cleaner and renewable bio-energy resources as these wastes cause a serious disposal problem. Globally, approximately 147.2 million metric tons of fiber sources are found, whereas 709.2 and 673.3 million metric tons of wheat straw residues and rice straws were estimated, respectively, in the 1990s (Sadh *et al.,* 2018).

As per the composition of these agro-industrial residues is concerned, they have a high nutritional perspective with more consideration for quality control and are also categorized as agro-industrial by-products (Sadh *et al.,* 2018). antimicrobials (Oliveira *et al.,* 2013). Wastes from the organic compounds pose a great risk to the atmosphere, but represent a possible source

for making mushrooms as foodstuffs and other bio-based products like bio-energy and bio-fertilizers (Kim and Han, 2017).

Some of the agricultural residues are used for animal food. However, such wastes contain a high amount of proteins, sugars, and minerals. Due to high nutritional composition, these residues are not described as "wastes" but considered as raw materials for other product formations and developments. The availability of these nutrients in raw materials offers appropriate environments for the growth of microorganisms. These microorganisms can reuse the raw materials with the use of fermentation processes. These agro-industrial residues are used for solid support in solid-state fermentation developments for making different beneficial products.

It also helps with the production of fermentable sugars by reducing the production costs based on food crops. In light of these developments, various studies have been carried out to determine the conversion of agricultural waste into sugar by using different microorganisms (Byadgi and Kalburgi, 2016).

Specifically, the potato processing industry generates lots of waste. One-quarter of the potatoes that go into potato processing plants as input come out as waste. These wastes can be used as a carbon source for yeast during alcohol fermentation to produce bio-ethanol. The potato peel waste contains a sufficient amount of starch, hemicellulose, cellulose, lignin, and fermentable sugars, which make the potato, peel a suitable feedstock for ethanol production (Ojewumi *et al*., 2018).

Fossil fuel is depleting day by day throughout the world. This limitation, combined with the issue of Green House Gas (GHG) emissions, leads to the discovery of environmentally and commercially viable alternative energy sources. On a daily basis, the dumping of a lot of cellulosic agro-based waste materials such as potato peels into the environment from which a valuable product such as ethanol is produced to trim down the energy demand for fossil fuel is being experienced (Shekhar *et al*., 2021).

As transportation fuel, ethanol is a rapidly growing chemical product, with the EU aiming for renewables to provide 3.5 percent of transport fuels by 2030 (Meredith *et al*., 2021). Ethanol is predominantly made from sugar cane in Brazil, corn in the US, and grains in Sweden (Formann *et al*., 2020). Over the last few years, there has been a growing debate on whether ethanol from crops is justified from a resource point of view, with many millions of people starving.

This study is important as the waste peel of sweet potatoes is a widely available and cheap feedstock for the alternative production of ethanol, which overcomes challenges related to energy security, promotion of rural development through job creation, environmental conservation, and decreasing greenhouse gas emissions.

MATERIALS AND METHODS

List of apparatus/equipment

The following equipment was used during the experiment. Ziplock bags to collect and transport samples to the laboratory, Oven (GALLENKAMP) to dry the sample, blender to crush the dried sample, vacuum filter, analytical balance, digital pH meter (3310, JENWAY), hot plate with thermostats, test tube rack, fermentation, hydrolysis and distillation vessels, measuring cylinders (50, 100, 250 ml), autoclave (Sanoclave), pycnometer/ specific gravity bottle, shaker (EXCELLA E24R), blender, sieve, UV-Spectrophotometer.

List of reagents

The reagents are; Hydrochloric acid (2.5 M), copper sulphate, potassium sulphate, titanium dioxide, ammonia, methyl red, anthrone reagent, sodium hydroxide, sodium carbonate, glucose, benedict's reagent, yeast extracts (Agar), urea, dextrose sugar, yeast (*Saccharomyces cerevisiae*) and distilled water.

Description of the sampling/study area

About 83km north of Kaduna with an approximate latitudinal position of 1103-110N and longitudes of 7036-7045E. It falls within the central high plains of northern Nigeria and stands between 1800 and 2350 feet above sea level with the coordinate of $11^{0}1617^{1}$ N, 7.6479° E. Zaria has a tropical continental climate, which is suggested by its latitudinal and continental location. The surrounding rural areas support a variety of grains and vegetables which provide commodities for retailing in urban Zaria. This includes groundnuts, cassava, maize, guinea corn, millet, rice, beans, yam and a variety of vegetables (Muhammed *et al*., 2021).

Plate1. Geographical map of Samaru, Zaria Kaduna State.

Sample collection and processing

They were washed with warm distilled water to remove all foreign matter, cut into pieces, air dried at room temperature and blended into 710µm powder mesh size.

Figure I. A = Sweet potato varieties,
B= Sweet potato(white cultivar),
C= White cultivar peels,
D= White cultivar peel's powder.

Proximate analysis

Moisture content determination of the peels

This was achieved according to standard method of Ngoma *et al.*,2019.

$$\% \text{ Moisture content} = \frac{(W_1 - W_2)}{(W_1 - W_0)} \times 100$$

Where, W_0, W_1, and W_2 are the weight of the dish, the dish and fresh sample, and the dish with the dried sample respectively.

Ash content determination of the peel

Fresh samples were weighed in triplicates. Dried and powdered samples were incinerated in a muffle furnace at 550°C for 4 h, cooled in desiccators and weighed until the weight is constant (Thiex *et al.,* 2012).

Crude fiber determination of the peel

The fresh sample was weighed into the extraction unit, 150 mL of hot 0.2N H_2SO_4 was added and digested for 30 min. Then, the acid was drained and the sample was washed with hot distilled water for 1 h. The crucible was removed and oven dried overnight at 105°C, cooled, weighed, and heated at 550°C in a muffle furnace overnight and reweighed after cooling (AOAC, 1995).

The percentage of extracted fiber was calculated as:

$$\text{Crude fiber (\%)} = \frac{\text{Weight of digested sample} - \text{Weight of ashed sample}}{\text{Weight of the sample}} \times 100$$

Crude protein determination of the peel

Concentrated H_2SO_4, a mixture of 2.5 g of $CuSO_4$, K_2SO_4 and TiO_2 were added to the fresh sample for digestion in a Kjeldahl digestion flask at 380°C for 6 h until the mixture was clear. The digest was filtered into 500 mL volumetric flask and made up to mark with 100 mL distilled water and connected for distillation. The mixture of 20mL ammonia and 40% NaOH was steam distilled for an hour. 200mL of the distillate was collected in 250 mL conical flask containing 20 mL of 0.2N H_2SO_4 and methyl red indicator. The ammonia-NaOH distillate in the receiving conical flask was reacted with 0.2 N H_2SO_4 and the excess acid in the flask was estimated by back titration against 20 mL of 0.1 N NaOH with color change from red to yellow. A blank distilled was collected in 250 mL conical flask containing 20 mL of 0.2N H_2SO_4 and methyl red indicator. The distillate was titrated against 20 mL of 0.1 N NaOH. Total nitrogen in the sample was calculated using colorimetric methods (Nielson, 2010). Crude protein content was obtained by multiplying the nitrogen content using factor 6.25 (AOAC, 2005).

$$\textbf{Crude protein} = \textbf{N} \times 6.25$$

Total carbohydrate determination

In a hot acidic medium, glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone a green colored product with an absorption maximum of 630 nm. 100 mg of the sample will be weighed into a boiling tube and hydrolysed by keeping it in a boiling water bath for three hours with 5 mL of 2.5 N HCl and cooling it to room temperature. The mixture will then be neutralized with solid sodium carbonate until the effervescence ceases. The volume of the solution will be made up to 100 mL and centrifuged into 0.5 and 1 mL aliquots for analysis. Standards of 0, 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard will be prepared. '0' as blank.

Make up the volume to 1 mL in all the tubes, including the sample tubes, by adding distilled water. 4 mL of anthrone reagent will be added to each and heated for eight minutes in a boiling water bath. They are rapidly cool as the green to dark green color is estimated at 630 nm in a spectrophotometer. A standard graph by plotting concentration of the standard on the X-axis versus absorbance on the Y-axis will be designed as the amount of carbohydrate present in the sample tube is directly extrapolated from the graph (Pons A *et al*, 1981).

$$\text{Amount of carbohydrate per100 mg of the sample} = \frac{\text{mg of glucose}}{\text{Volume of test sample}} \times 100$$

Steam pretreatment of the peel

The fresh sample was soaked in 500 mL distilled water in conical flask for 24 hours. The conical flasks were capped with aluminum foil and the lingo-cellulosic peel was rapidly heated at 120°C by high-pressure steam without the addition of any chemicals in an autoclave. The biomass/steam mixture was held for 15 minutes to promote hemicellulose hydrolysis, and terminated by explosive decompression. After finishing the given pretreatment time, the sample in the autoclave was allowed to cool and the soluble portion was separated from the non-soluble portion. The non-soluble portion was hydrolyzed in the next steps and the soluble solution was placed in another conical flask.

Acid hydrolysis

Dilute acid is used to hydrolyze the biomass to sucrose (Torget *et al.,* 2000).

The sweet potato peels (white cultivar) were actively hydrolyzed in the reactor at a temperature of 130°C for 60 minutes. After hydrolysis, the solid part was separated from the liquid in the hydrolysate by vacuum filtration to remove the non-fermentable lignin portion. After the solid part was separated, it was again washed with distilled water.

The washing was performed to extract all soluble sugars from the peels.

The hydrolysate was neutralized with 10 M NaOH until the pH became in the range of 4.9-5.2. Then the soluble component was mixed with the previously filtered solution from the pretreatment step for the hydrolysate separation where the sugar solution was obtained in a separate vessel.

Determination of the reducing sugar content of the hydroxylate

Benedict's solution is designed to detect the presence of reducing sugars. In hot alkaline solutions, reducing sugars reduce the blue copper (II) ions to brick red copper (I) oxide precipitate. As the reaction proceeds, the color of the reaction mixture changes progressively from blue to green, yellow, orange, and red.

When the conditions are carefully controlled, the coloration developed and the amount of precipitate formed depends upon the amount of reducing sugars present. Hence, in most conditions, a sufficiently good estimation of the concentration of glucose-equivalent reducing sugars present in a sample can be obtained (Alexander *et al*, 2011). From the prepared concentrations of 11, 9.5, 8, 6.5, 5, 3.5, 2, 0.5, and 0%, 1ml of each of the standard glucose solutions is added into labeled test tubes, each containing 5 mL of Benedict's solution, and

mixed by shaking. The labeled test tubes were heated in a 90°C water bath for 5 minutes. The test tubes were removed from the water bath and filtered samples using filter paper to remove any red precipitate formed when reducing sugar in the samples reacted with Benedict's reagent.

$$\text{Conc. of unknown sample} = \frac{(\text{absorbance}) - (\text{y-intercept})}{\text{Slope}}$$

pH adjustment of the hydrolysate

The pH has to be adjusted to prevent the micro-organism from inactivity in a highly acidic or basic state. A pH of around 4.9 -5.2 is maintained (Lorenzo *et al.*, 2018).

First, the pH meter was calibrated by using a buffer solution. The hydrolyzate solution is acidic, so it needs a highly basic solution to bring the pH into the range of 4.9-5.2.

A sodium hydroxide solution (10 M) was added dropwise to the other flask with constant stirring until the pH reached a range of 4.9-5.2. If the pH goes beyond 4.9-5.2, concentrated sulfuric or hydrochloric acid will be added dropwise to maintain the pH in the range.

Fermentation of the hydrolyzate

This is conducted under anaerobic conditions at of 30°C and 200 rpm stirring conditions for 3 days. Before conducting fermentation, the preparation of media for the yeast is a must. To prepare the media, favorable conditions for yeast growth must be established to supply the required amount of nutrients. For this, the following nutrients were mixed in their desired proportion (Uzman, 2001). To the 100 ml media prepared as above, 0.5 g of yeast, *Saccharomyces cerevisiae* (Arif instant) was added in a 250 ml conical flask. The conical flask was properly covered with aluminum foil. The conical flask was then placed in a shaking incubator for 48 hours at a temperature of 30°C, 200 rpm, and then stored under 4°C before fermentation (Uzman, 2001).

Fermentation

The fermentation step was initiated by the addition of the media in the proportion of 10:1 by volume. The shaker incubator (fermenter) was set for 72 hours at 30°C (Uzman, 2001).

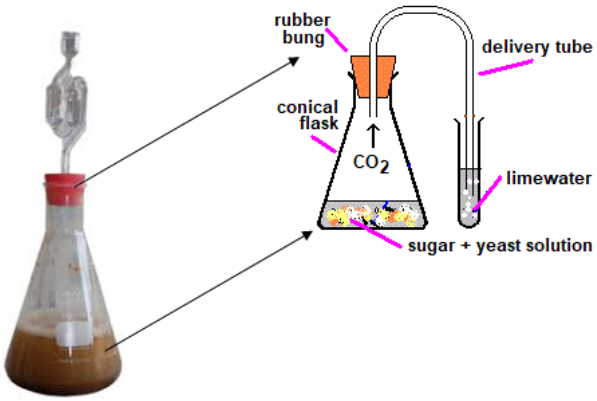

Figure 2. Fermentation setup

Distillation of the fermented hydrolyzate

Ethanol turns into a vapor state before the water and can be condensed and separated (Mangwanda *et al.,* 2021). Water and ethanol form an azeotrope; a 95% ethanol-5% water combination boils at 78.15°C. Pure ethanol has a boiling point of 78.3°C and water has a boiling point of 100°C.Therefore, the pure ethanol is distilled from the fermentation mixture. The carefully decanted amount of the fermented mixture was measured without disturbing it into a round-bottomed flask with some boiling chips.

Determination of the specific gravity of the hydrous bioethanol distillate

The 25 ml Pycnometer was cleaned and dried first and then weighed (W_0), then after the bottle was filled with ethanol, a stopper was inserted and reweighed to give (W_1) (Aleme *et al.,* 2009). The ethanol was substituted with water after washing and drying the bottle and weighed to give (W_2).

The expression for specific gravity (Sp.gr) is:

$$\text{Specific gravity} = \frac{W_1 - W_0}{W_2 - W_0}$$

Where: W_0- weight (g) of empty bottle, W_1- weight (g) of bottle + sample (ethanol)
W_2 - weight (g) of bottle + water

Percentage yield determination of the dehydrated bioethanol distillate

Bio-ethanol yield was determined accordingly (Nazli, 2020).

$$\text{Percent yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100\%$$

Chromic acid oxidation test on the anhydrous bioethanol distillate

Chromic acid will oxidize primary alcohol first to an aldehyde and then to a carboxylic acid and it will oxidize secondary alcohol to a ketone. Tertiary alcohols do not react as the OH bearing carbon must have a hydrogen atom attached. Recall, that carbon is oxidized when it loses hydrogen or gains a more electronegative atom. Since the carbon atom is being oxidized in primary and secondary, the orange chromium Cr^{6+} ion is being reduced to the blue-green Cr^{3+} ion (Ghosh *et al.*, 2013).

Then, 3-4 drops of the test alcohol were added directly to each test tube and then, with 3-4 drops of the test alcohol. Afterward, 2 drops of the chromic acid test reagent (Bordwell-Wellman Reagent) were added to each tube with vigorous shaking.

FT-IR analysis of the anhydrous bioethanol distillate

The identification of different covalent bonds that are present in the compound can establish the functional groups that are present. FT/IR-4700 model was adopted.

RESULTS AND DISCUSSION

Proximate analysis

The amount of moisture, ash, crude fiber, total carbohydrate and the crude protein are the indicators of organic macromolecules in an organic biomass.

In this context, the results clearly indicate that the biomass material is significantly rich in sugar with significant amounts of water content, crude fiber, ash, and crude protein content respectively.

Table 1: Proximate analysis of the sweet potato (white cultivar) peel.

Parameter	Value
Moisture content (%)	72.00
Ash content (%)	9.71
Crude fiber (%)	24.25
Total carbohydrate (%)	78.40
Crude protein (%)	6.67

Benedict's reagent starts out as a blue solution. As it is heated in the presence of reducing sugars, it turns yellow to orange. The "hotter" the final color of the reagent, the higher the concentration of reducing sugar. In general, blue to blue-green or yellow-green is negative, yellowish to bright yellow is a moderate positive, and bright orange is a very strong positive.

In addition, the result Interpretation of Benedict's test is professed to be 0.1 to 0.5 percent sugar in solution if the color upon boiling is changed into green, 0.5 to 1 percent sugar if it changes color to yellow, 1 to 1.5 percent sugar when change to orange,

1.5 to 2.0 percent sugar when change to red and 2 percent sugar when the colour change to brick red (Alejandro *et al.*, 2020).

Table 2: Qualitative determination of reducing sugar using Benedict's reagent

Test	Observation	Inference
Drops of Benedicts reagent Was added to the acidic Hydrolysate drop wisely	Brick-reddish precipitate	Presence of reducing sugar

Standard glucose calibration

These curves then help determine the concentration of the unknown solution. The absorbencies of the prepared standards at the wavelength of 540nm for glucose were recorded accordingly (Maarebia *et al.*, 2020).

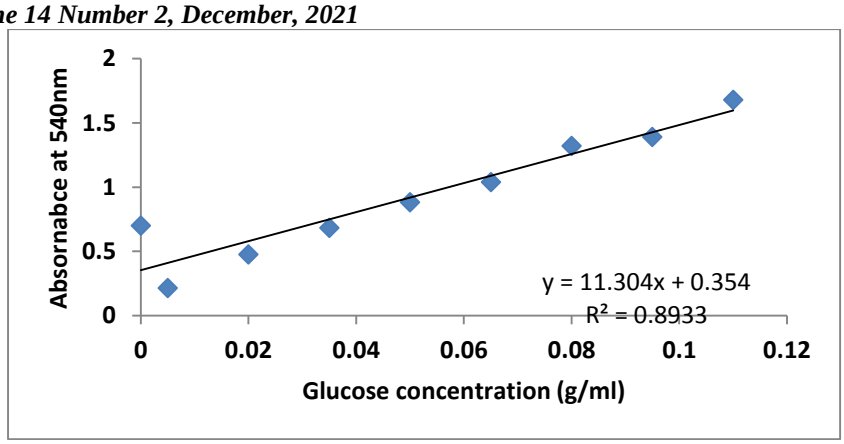

Figure 3. The plot of the standard glucose solution

The starch content of a biomass determines the final ethanol production, since the sweet potato peel is mainly composed of starch and moisture (Kuan-Chen Cheng *et al*, 2015). The total reducing sugar of 10.68% (0.0981g/ml) at the wavelength of 540nm with 54.5ml hydrolysate (50g feedstock) prior to fermentation was achieved.

Table 3: Total reducing sugar of the sweet potato peel (white cultivar)hydrolysate.

Parameter	Value
Absorbance at 540(nm)	1.4610
Sample weight (g)	50
Hydrolyzate volume (ml)	54.5
Reducing sugar per ml (g)	0.0980
Total reducing sugar (g/54.5ml)	5.3410

Specific gravity calculates the volume occupied by a product whose weight is known, or to calculate the weight of a product from its volume. It may be used to determine the composition of binary mixtures of pure chemicals according to ASTM D891-18 compared to a standard, usually water, at a specified temperature (Yu et al., 2020), (Liu and Li, 2012).

Table 4: Specific gravity of the hydrous bio-ethanol distillate

Description	Symbol	Weight(g)		
		1st Run	2nd Run	3rd Run
Empty pycnometer (EP)	Wo	50.0000	50.0000	50.0000
EP + Ethanol	W1	70.4950	70.4960	70.4950
EP+ Water	W2	75.0000	75.0000	75.0000
Specific gravity (g/ml)		0.8198	0.8198	0.8198
Average specific gravity (g/ml)			0.8198	

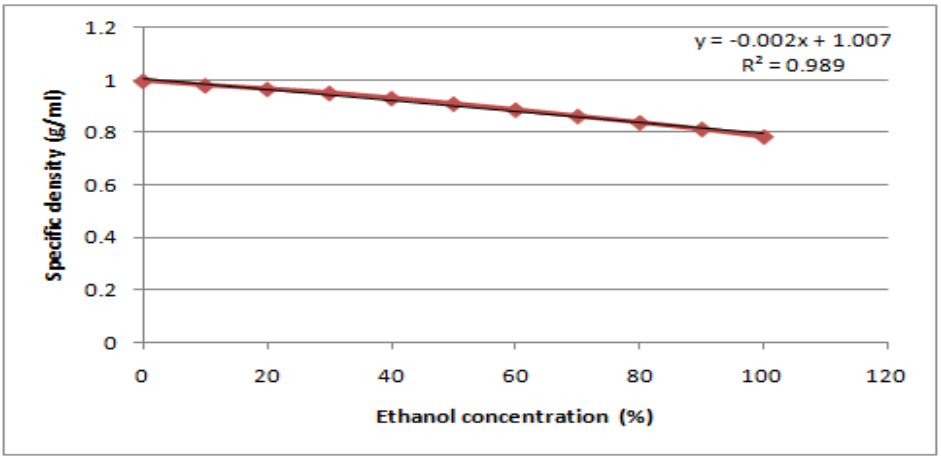

Figure 4. Specific gravity of ethanol-water mixture at various temperatures

Ethanol's specific gravity is 0.79, which is lighter than water, but since it is water-soluble, it will thoroughly mix with water. The initial specific gravity of the bio-ethanol at 0.8198g/ml (93.6%) was dehydrated to 0.8072g/ml (99.9%) bio-ethanol with the percentage yield of 68.8%.

Table 5: Specific gravity and concentration of anhydrous ethanol

3A Molecular sieve(g)	Specific gravity (g/ml)	Ethanol (%)
10	0.8166	95.2
10	0.8122	97.4
10	0.8084	99.3
10	0.8080	99.5
10	0.8076	99.7
10	0.8072	99.9
10	0.8072	99.9

The percentage yield of the bio-ethanol final distillate (37.5ml) from the acidic hydrolyzed (54.5ml) and fermented SPP was estimated to be 68.8 % from the basic initial weight of 50g of the SPP.

Also, chromic acid oxidation test oxidizes aldehydes and alcohols and reduce the chromic acid, resulting in a color change. It is able to identify aldehydes, primary alcohol, and secondary alcohol. It cannot, however, identify tertiary alcohols (Lou,1990).

Table 6: Chromic acid oxidation test

Test	Observation	Inference
Four drops of the anhydrous bioethanol distillate was added to 2ml of acetone and 2 drops of Bordwell-wellman reagent in a test tube with vigorous shaking for few seconds.	Appearance of blue-green precipitate	A positive test that confirms the presence of primary alcohol

Additionally, when run like a liquid film, the region 3500-3200 cm^{-1} with a very intense broadband indicates the O-H stretch of alcohols, while the region 1260-1050 cm^{-1} confirms the C–O stretch. The bands at around 2880 and 2930 cm^{-1} were assigned as the symmetric stretching modes of the $–CH_2$ and $–CH_3$ groups, respectively. This assures that the product obtained from the peels is exactly ethanol due to the confirmation of these regions as shown below (Nitin Mahendra Chauhan *et al.*, 2021).

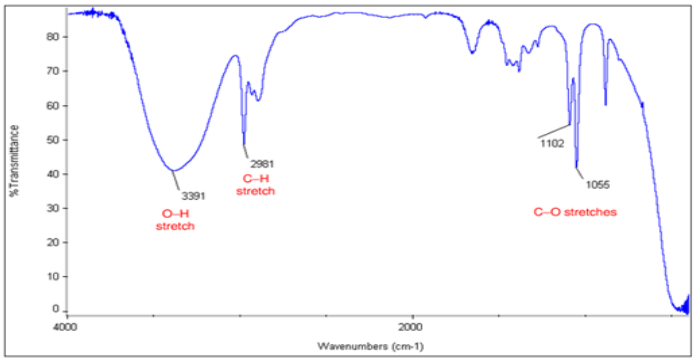

Figure 5. FT-IR spectrum of the bio-ethanol distillate

Primarily, the purpose of pretreatment is to remove lignin, reduce cellulose crystallinity, and increase the porosity of the materials (Bernal-Lugo *et al.*, 2019). Pretreatment must meet the following requirements: improve the formation of sugar, avoid the degradation or loss of carbohydrates, avoid the formation of by-product inhibitors, and must be cost-effective (Torget *et al.,* 2000).

The proximate analysis conducted on the sweet potato peels (white cultivar) were in terms of the amount of moisture, ash, crude fiber, total carbohydrate and the crude protein. These are indices of the quantitative analysis of organic macromolecules in an organic biomass.

The total carbohydrate of 78.40%, 72% moisture content, 24.25% crude fiber, 9.71% ash content, and 6.27% crude protein clearly indicate that the biomass material is ultimately rich in sugar with a significant amounts of water content, crude fiber, ash, and crude protein content respectively. The analysis also as demonstrated by ojewumi *et al*., 2018 declares that sweet potato peel contained sufficient amounts of starch and total carbohydrates to guarantee use for bio-ethanol production. Results from Solomon *et al,* 2015, Adegunloye and Oparinde (2017), and Alam *et al*.,2016, show significant differences to the results achieved with this work. These comparative differences might be due to the varieties and the environmental variations.

Total reduced sugars are fermentable sugars that are obtained by hydrolysis of sugar, and then fermented into ethanol, which is the traditional conversion process that is still widely used today (Hossain *et al*. 2014).

This biomass contains a sufficient amount of total reducing sugar (TRS), which can be extracted and further treated with microbial pathways to produce bio-ethanol.

The extraction of TRS from potato peels by hydrolysis in dilute sulphuric acid was investigated.

To obtain maximum conversion of starch into fermentable at the stated conditions to achieve 10.68% (5.341g/54.5ml) at the wavelength of 540nm with the 50g of the sweet potato white cultivar peels.

However, Bhattacharyya *et al*., 2013 reported that sonication of hydrolyzed potato peel samples under 0.76% acid concentration and 76.80% amplitude gives the best results with the outcome that was about 30% better in TRS than the results without a sonicated sample.

Specific gravity remains an important property of fluids, being related to the density and viscosity of fluids. Knowledge of the specific gravity will allow determination of a fluid's characteristics compared to a standard, usually water, at a specified temperature
(Tavana *et al*., 2009).

Alcohol in water is less dense than sugar in water and so this will result in a change in the specific gravity. Ethanol's specific gravity is 0.79, which indicates it is lighter than water, but since it is water-soluble, it will thoroughly mix with water.

During fermentation the sugars in the liquid are converted by the yeast into alcohol and carbon dioxide. As the alcohol in water is less dense than sugar in water and so this will result in a change in the specific gravity as it will retain a specific gravity closer to that of water.

The initial specific gravity of the sweet potato peel bio-ethanol at 0.8198g/ml (93.6%) was effectively dehydrated to 0.8072g/ml (99.9%) bio-ethanol. According to Mundy (1996), the same relationship of inverse proportionality between the specific gravities and the percentage concentrations were observed.

Percent yield is important because many chemical reactions generate byproducts, meaning not all the reactants in the equation actually react (Syed *et al*., 2012).

This is important in the manufacturing of products because a low percent yield would indicate incomplete and poor reactions. It is an important consideration in industrial chemistry as it is calculated to compare the actual yield (quantity) of the product obtained with what could have been obtained in theory, if all of the reactants were converted with no loss or waste. 68.8 % bio-ethanol yield was achieved after dehydration with the molecular sieve.

The maximum ethanol yield obtained by Ojewunmi *et al*, 2018 was 6.39g/L at pH 5.0, temperature of 32.5ºC and inoculums size of 6% (v/v) after 48 hours of fermentation.

The positive outcome of blue green precipitate confirmed the activity and presence of primary alcohol according to lou,1990. Similarly, Ghosh *et al*., 2013 was able to achieved fast rate of oxidation with Triton-X-100 catalyst and Sodium dodecyl sulfate (SDS)-Cetyl pyridinium chloride (CPC) co-catalyst with the oxidation of ethanol in aqueous acid media.

The developed FTIR spectrum at the specified absorptions is characteristics of ethanol as established by Nitin Mahendra Chauhan *et al*., 2021.

The IR absorptions responsible with the O-H stretch, C-O stretch, and C-H stretching vibrations are obvious around the intense band of 3391cm^{-1}, 1260-1050 cm^{-1} and 3500-3200 cm^{-1} respectively. The bands at around 2880 and 2930 cm^{-1} were assigned as the symmetric stretching modes of the $–CH_2$ and $–CH_3$ groups, respectively.

These confirm the nature of product to be alcoholic according to Nitin Mahendra Chauhan *et al*., 2021. Similar range of results were reported by Elibol-Can *et al*., 2011 and (Ruzene and Gonçalves, 2007).

CONCLUSIONS

This study successfully examines the bio-ethanol yield with the selected agricultural waste biomass through acidic hydrolysis and anaerobic fermentation.

The method could be adopted as a cost-effective alternative in the pursuit of ethanol fuel production protocol on a commercial scale. The peels of sweet potato (white cultivar) could therefore serve as cheap source of glucose framework that can be fermented locally for bio-ethanol production.

REFERENCES

Adegunloye, D.V., & Oparinde, T.C. (2017). Effects of Fermentation on the Proximate Composition of Irish (Solanum tuberosum) and Sweet Potato (Ipomoea batatas) Peels. *Ai Magazine*, 07, 565-574

Alam, Mohammad K., Ziaul H. Rana, and Sheikh N. Islam (2016). "Comparison of the Proximate Composition, Total Carotenoids and Total Polyphenol Content of Nine Orange-Fleshed Sweet Potato Varieties Grown in Bangladesh" *Foods* 5, no. 3: 64. https://doi.org/10.3390/foods5030064

Alejandro Hernández-López*****, Daniel A. Sánchez Félix, Zenaida Zuñiga Sierra, Itzel García Bravo, Tzvetanka D. Dinkova, and Alma X. Avila- Alejandre (2020). Quantification of Reducing Sugars Based on the Qualitative Technique of Benedict. *ACS Omega* 2020, 5, 50, 32403–32410.https://doi.org/10.1021/acsomega.0c04467

Aleme HG, Costa LM, & Barbeira PJ, (2009). Determination of ethanol and specific gravity in gasoline by distillation curves and multivariate analysis. *Talanta*; 78(4-5):1422-8. doi: 10.1016/j.talanta.2009.02.042. Epub 2009 Mar 4. PMID: 19362211.

Alexander V. Gusakov, Elena G. Kondratyeva, Arkady P. Sinitsyn, (2011). "Comparison of Two Methods for Assaying Reducing Sugars in the Determination of Carbohydrase Activities", *International journal ofAnalyticalChemistry*. vol. 2011, ArticleI D 283658, 4 pages, 2011. https://doi.org/10.1155/2011/283658

AOAC (1995) Official Methods of Analysis: Official Method for Crude Fiber. Method No. 920.85. *Association of Official Analytical Chemists,Washington DC. AOAC, 2000.*

AOAC, (2005). Determination of Moisture, Ash, Protein and Fat. Official Method of *Analysis of the Association of Analytical Chemists. 18th Edition, AOAC, Washington DC.*

ASTM D891-18 (2018).Standard Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals*. ASTM International, West Conshohocken, PA*. www.astm.org

Bernal-Lugo, I., Jacinto-Hernandez, C., Gimeno, M., Montiel, C. C., Rivero-Cruz, F., & Velasco, O., (2019). "Highly efficient single-step pretreatment to remove lignin and hemi-cellulose from softwood," *BioRes.* 14(2), 3567-3577.

Bhattacharyya, S., Chakraborty, S., Datta, S., Drioli, E., & Bhattacharjee, C., (2013). Production of total reducing sugar (TRS) from acid hydrolyzed potato peels by sonication and its optimization. *Environmental Technology*, 34(9), 1077–1084. doi:10.1080/09593330.2012.733965

Byadgi, S. A., & Kalburgi, P. B., (2016). Production of Bio-ethanol from Waste Newspaper. *Procedia Environmental Sciences*, 35, 555–562. doi: 10.1016/j.proenv.2016.07.040.

Elibol-Can, B., Jakubowska-Dogru, E., Severcan, M., & Severcan, F. (2011). The Effects of Short-Term Chronic Ethanol Intoxication and Ethanol withdrawal on the Molecular Composition of the Rat Hippocampus by FT- IR Spectroscopy. Alcoholism: *Clinical and Experimental Research,* 35(11), 2050-2062. doi: 10.1111/j.1530-0277.2011. 01556.

Ghosh, A., Saha, R., Mukhejee, K., Ghosh, S., Bhattacharyya, S., Laskar, S., & Saha, B. (2013). Selection of Suitable Combination of Nonfunctional Micellar Catalyst and Heteroaromatic Nitrogen Base as Promoter for Chromic Acid Oxidation of Ethanol to Acetaldehyde in Aqueous Medium at Room Temperature. *International Journal of Chemical Kinetics*, 45(3), 175-186. doi: 10.1002/kin.20754

Hossain, M. A., Rana, M. M., Kimura, Y., & Roslan, H. A. (2014). Changes in biochemical characteristics and activities of ripening associated enzymes in mango fruit during the storage at different temperatures. *BioMed research international*, 2014, 232969. https://doi.org/10.1155/2014/232969

Kim, S., & Han, J. (2017). Enhancement of energy efficiency and economics of process designs for catalytic co-production of bioenergy and bio-based products from lignocellulosic biomass.

International Journal of Energy Research, 41(11), 1553-1562. doi: 10.1002/er.3731

Kuan-Chen Cheng, Yuwen Ting, Chi-Te Liu, Kai-Yin Lo & Teu-Ching Shi. (2015). Conceptual Design of an Industrial-scale Plant for Ethanol Production from By-products of Sweet Potato Processing. *Int J Biotech & Bioeng*. 1:1, 1-8. DOI: 10.25141/24753432-2015-1.0001

Liu, Y., Zheng, X., Tao, S., Hu, L., Zhang, X., & Lin, X. (2021). Process optimization for deep eutectic solvent pretreatment and enzymatic hydrolysis of sugar cane bagasse for cellulosic ethanol fermentation. *Renewable Energy*, 177, 259-267. doi: 10.1016/j.renene.2021.05.131

Liu, J., & Li, G. (2012). Frequency and Temperature Characteristics of an Ultrasonic Method for Measuring the Specific Gravity of Lead-Acid Battery Electrolyte. *Japanese Journal of Applied Physics*, 51, 026601. doi: 10.1143/jjap.51.026601

Lorenzo, J. M., Munekata, P. E., Dominguez, R., Pateiro, M., Saraiva, J. A., & Franco, D. (2018). Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. *Innovative Technologies for Food Preservation*, 53–107. https://doi.org/10.1016/B978-0-12-811031-7.00003-0

LOU, J. (1990). ChemInform Abstract: Chromic Acid Adsorbed on Kieselguhr: A New Reagent for the Oxidation of Primary Alcohols (I) to Aldehydes (II). *Cheminform*, 21(12). doi: 10.1002/chin.199012081

Maarebia, R., Nurvitasari, E., & Sumanik, N. (2020). Measurement of standard glucose solution using silver nanoparticle. Journal of Physics: Conference Series,1569, 042047. doi: 10.1088/1742-6596/1569/4/042047

Mangwanda, Tinashe, Johnson, Joel B, Mani, Janice S, Jackson, Steve, Chandra, Shaneel, McKeown, Tyryn White, Simon Naiker & Mani. (2021). "Processes, Challenges and Optimization of Rum Production from Molasses—A Contemporary Review" *Fermentation* 7, no. 1: 21. https://doi.org/10.3390/fermentation7010021

Modupe, E. O., Akwayo, I. J., Olugbenga, S. T., Oyinlola, M. O., Ayodeji, A.A., Emmanuel, O. O & Esther, A. O. (2018). "Bio- Conversion of Sweet Potato Peel Waste to Bio-Ethanol Using Saccharomyces Cerevisiae". *International Journal of Pharmaceutical and Phytopharmacological Research,* 8(3), pp.46-54.

Muhammed Yahaya, A., Salahudeen, H., & Zubairu, D. (2021). Building a resilient infrastructure: challenges of rural transportation in Soba Local Government Area, Kaduna State, Nigeria. *Journal of Governance and Accountability Studies*, 1(1), 69-82. doi: 10.35912/jgas. v1i1.370

*Mundy, A. (1996). Collaborative determination of specific gravity by density meter.Journal of The Institute of Brewing, 102, 69-72.*https://www.semanticscholar.org/paper/COLLABORATIVE DETERMINATION-OF-SPECIFIC-GRAVITY-BY-Mundy/2ebe65b9c8d0c48e7c4b207e29fb9715f54d02de

Nancy Thiex, Lawrence Novotny, Andy Crawford, (2012). Determination of Ash in Animal Feed: AOAC *Official Method* 942.05 Revisited, *Journal of AOAC INTERNATIONAL*, Volume 95, Issue 5, Pages 1392–1397, https://doi.org/10.5740/jaoacint.12-129

Nazli, R. (2020). Evaluation of different sweet sorghum cultivars for bioethanol yield potential and bagasse combustion characteristics in a semiarid Mediterranean environment. *Biomass and Bioenergy*, 139, 105624.doi: 10.1016/j.biombioe.2020.105624

Ngoma, K., Mashau, M. E., & Silungwe, H, (2019). Physicochemical and Functional Properties of Chemically Pretreated Ndou Sweet Potato Flour. *International Journal of Food Science*.1–9. doi:10.1155/2019/4158213

Nitin, M. C., Sunil, T. H., Buzuayehu, M., Abreham, A.M. (2021)."Bioethanol Production from Stalk Residues of Chiquere and Gebabe Varieties of Sweet Sorghum", *International Journal of Microbiology*, vol. 2021, Article ID6696254, 16 pages, 2021. https://doi.org/10.1155/2021/6696254

Oliveira, D. A., Salvador, A. A., Smânia, A., Smânia, E. F. A., Maraschin, M., & Ferreira,S. R. S., (2013). Antimicrobial activity and composition profile of grape (*Vitis vinifera*) pomace extracts obtained by supercritical fluids.*Journal of Biotechnology*, 164(3), 423–432. doi:10.1016/j.jbiotec.2012.09.014

Pons A, Roca P, Aguiló C, Garcia FJ, Alemany M & Palou A, (1981). A method for the simultaneous determination of total carbohydrate and glycerol in biological samples with the anthrone reagent. *J Biochem Biophys Methods*. 4(3-4):227-31. Doi: 10.1016/0165-022x (81)90060-9. PMID: 7240650.

Ruzene, D., & Gonçalves, A. (2007). Ethanol/water pulp enzymatic pretreatment: Chemical and FTIR-PCA analyses. *Chemical Papers*, 61(6). doi:10.2478/s11696-007-0064-x

Sadh, P.K., Duhan, S. & Duhan, (2018). J.S. Agro-industrial wastes and their utilization using solid state fermentation: a review. *Bioresour. Bioprocess*. 5,1. https://doi.org/10.1186/s40643-017-0187-z

Sasan,T., Hossein,T., Mojtaba,H and Ebrahim, N.(2009).Specific Gravity of Pleural Fluid Determined by Refractometer to Discriminate Exudates and Transudates.*ResearchJournal of Medical Sciences,3:91-94.* https://medwelljournals.com/abstract/?doi=rjmsci.2009.91.94

Sattari, M., & Mahdavian, L. (2019). Thermodynamic properties of the bubble growth process in a pool boiling of water-ethanol mixture two-component system.*Open Chemistry*, 17(1), 88-95. doi: 10.1515/chem-2019-0010

Shekhar, C., Jaiswal, A., Ji, G., & Prakash, R. (2021). Ethanol extract of waste potato peels for corrosion inhibition of low carbon steel in chloride medium. *Materials Today: Proceedings,* 44, 2267-2272. doi: 10.1016/j.matpr.2020.12.368

Solomon, S. G.; Okomoda, V. T.; Oloche, J. A., 2015. Evaluation of sweet potato (Ipomea batatas) peel as a replacement for maize meal in the diet of Clarias gariepinus fingerling. *J. FisheriesSciences.com,* 9 (4): 63-68

Syed Imran A. Shah, Larry W. Kostiuk, Suzanne M. Kresta, (2012). "The Effects of Mixing, Reaction Rates, and Stoichiometry on Yield for Mixing Sensitive Reactions—Part I: Model Development", *International Journal of Chemical Engineering*, vol. 2012, Article ID 750162, 16 pages. https://doi.org/10.1155/2012/750162

Torget, R. W., Kim, J. S., & Lee, Y. Y., (2000). Fundamental Aspects of Dilute Acid Hydrolysis/Fractionation Kinetics of Hardwood Carbohydrates. *Cellulose Hydrolysis. Industrial & Engineering Chemistry Research*, 39(8), 2817– 2825. Doi: 10.1021/ie990915q

Uzman, A. (2001). Molecular Cell Biology (4th edition): Harvey Lodish, Arnold Berk, S.Lawrence Zipursky, Paul Matsudaira, David Baltimore & James Darnell; Freeman & Co., New York, NY, 2000, 1084 pp., list price $102.25, ISBN 0-7167-3136-3. *Biochemistry and Molecular Biology Education*, 29, 126-128.

Yu, H., Yi, Y., & Puppala, A. (2020). Effects of Oven Temperature and Addition of Ethanol on Measurement of Water Content and Specific Gravity of Cement-Stabilized Soft Clay. *Geotechnical Testing Journal*, *44*(5), 20200039. doi:10.1520/gtj20200039