BIO-ETHANOL VIA ACIDIC HYDROLYSIS AND FERMENTATION OF SWEET POTATO PEELS (HANNAH SPECIES) BY POLARIMETRIC AND FOURIER TRANSFORM-INFRARED ESTIMATION TECHNIQUES.

Olabimtan Olabode.H[1], Ashade Noah.O[2], Abdulkarim Yahaya.M[3], Mahmoud Abdulkarim.A[4], Suleman Stephen.M[5]

[1]1Department of Industrial and Environmental Pollution, National Research Institute for Chemical Technology Zaria, Kaduna State, Nigeria
[2]Research and Development, Outstation Coordination Department, National Research Institute for Chemical Technology Zaria Kaduna State, Nigeria
[3]Textile Technology Department, National Research Institute for Chemical Technology Zaria Kaduna State, Nigeria
[4]Scientific and Industrial Research Department, National Research Institute for Chemical Technology Zaria Kaduna State, Nigeria
[5]Chemistry Department, Nigeria Army University, Biu Borno State, Nigeria

Abstract

Nigeria has abundant agricultural resources that are perceived as wastes but could serve as the agent of Eco-friendly value addition such as biofuel when chemically and biologically modified. Sweet potato peels (SPP) of Hannah specie which was characterized for total carbohydrate (starch) of 24.75mg/g undergoes an acidic (Conc.H2SO4) hydrolysis into a fermentable sugar content (dextrose equivalent) and fermentation with Saccharomyces cerevisiae (pH=5, Temperature=25oC and Time=120 hours) generating 54.8% ethanol after distillation and dehydration of the fermented broth. Polarimetric method and FT-IR spectroscopy were adopted in the quantification of the sugar content as 12.61% with a specific rotation of 37.6o (R2=0.996) after hydrolysis and 54.8% ethanol with a specific rotation of 12.71o (R2=0.990) after distillation and water dehydration and quality examination of the achieved ethanol.

Keyword: Bio-ethanol, SPP, acidic hydrolysis, Saccharomyces cerevisiae, polarimetry, and FT-IR

1.INTRODUCTION

Petroleum derivatives are as of now the primary source of energy, giving an expected 79% of the world energy applications [1]. The advancements and demands on petroleum-based fuels which have significantly affected the environment and the health of the organism within, make it compulsory in devising another source of these energies [2]. Additionally, because of the present use, the availability of this petroleum-based source of energy will not be able to stand a large scale demand [3]. Biofuels are a potential sustainable power source that can supplant energy sources that are not renewable, especially because of the much lower ozone-depleting agents (Greenhouse gases). They are generated from regular biomass sources that are topographically more uniformly dispersed than petroleum derivatives, which take into account a sustainable and secure form of energy [4, 5]. Thus, there is a rising interest on biofuels by researchers, with an encouraging number of articles being distributed. Bioethanol at present is the common analog of biofuel, relating to about 73% of the 135.3 billion liters of biofuel delivered in 2016[6]. The United States (USA) is the greatest manufacturer with 59%, and Brazil, which is accountable for 27% of the worldwide production [7]. Bioethanol is adopted as an unadulterated fuel additive and `co-mixture with gases. The utilization of bioethanol in flash start engines has numerous points of interest than to that petroleum source. [8].

Ethanol has a higher oxygen content, which induces better ignition and lowers exhaust emanations, and a higher octane number, which permits the engine to work at a higher pressure proportion [9]. Likewise, utilizing vegetable biomass as feedstock for bioethanol generation takes into account reusing the CO2 discharged during burning, decreasing the CO2 generations [10].Bioethanol serves as a starting feedstock in the production of chemicals like diethyl ether, ethylene, propylene, acetaldehyde, and ethyl acetic acid derivation, pharmaceuticals, and beauty care products [11]. Presently, industrial bioethanol is on the part of the original product being formulated from agricultural by-products as feedstock; sugarcane in Brazil, corn in the US, sugar beet and wheat in the European Union (EU) [11]. The principal shortcoming with original bioethanol is the challenge over the use of arable land for cultivation of crops for biofuel feedstocks; with an implication of high cost. [11]. Bioethanol can be generated from leftover biomass such as municipal, industrial and forest wastes. These feedstocks don't raise worries about nutritional management, have a low and stable cost, and don't request additional land. Among these feedstocks are sweet potato strips of Hannah species.Sweet potatoes (Solanum tuberosum L.) are major agricultural harvests for human use after wheat (Triticum L.), rice (Oryza L.) and maize (Zea mays subsp. mays L.), with 376 million tons delivered in 2013[13]. In developed nations up to 69.5% in 2012 of absolute potatoes are processed in (U.S)[14]. Potatoes are normally stripped during processing and waste generations with regards to this can differ from 15 to 40%, base on the stripping technique [15]. Yearly, immense amounts of waste PPW (potato peel waste) as a result of industrial processing into various applications. Scraped spot stripping is of the mill for chips generation, though steam stripping is utilized for dried out and solidified potato [16]. Steam peelers are smaller and generate less waste. Therefore, steam stripping is sensible when high amounts of the peel must be stripped in restricted space with the presence of a darker ring that doesn't mess up the product. Dark-colored ring occurs due to tissue damage and chemically catalyzed phenolic oxidation response [17]. It is accounted for; that compound stripping with NaOH could displace steam stripping to maintain a strategic distance from heat-ring [18]. Otherwise scraped spot stripping is encouraged.SPP is nutritionally not encouraged for non-ruminants naturally without any more treatment since it is strongly fibrous but as cheap sources of feed with the huge amount of starch, nonstarch polysaccharides, lignin, polyphenols, protein and a limited quantity of lipids [19, 20]. This makes it a modest and important base material for the extraction of significant natural products like biopolymers, dietary fiber, antioxidant and fermentation by-products [21].Fermentation is commonly characterized by the transformation of starches to acids or alcohols. The transformation of corn sugar (glucose) to ethanol by yeast under anaerobic conditions is the procedure that is used to make the inexhaustible transportation fuel (bioethanol) [22].

A fermentor is controlled by immunizing a multifarious sugar medium with a microorganism. This microorganism is, for the most part, permitted to duplicate under oxygen-consuming conditions before the fermentor is changed to anaerobic conditions to deliver optional metabolites such as ethanol.In a nutshell, when starchy biomaterials are to be utilized for ethanol generation by a microorganism (yeast), they are first to transform into sugars by various methods. Acids are employed in the hydrolysis of starch to fermentable sugars. The generation of ethanol relies upon pretreated yields of saccharification [23]. Saccharification from starch-containing biomass requires a straightforward innovation, such as acidic hydrolysis but with cellulosic biomass, the source needs an increasingly complex procedure with microorganisms [23]. Sweet potato is one of the biomass which has been identified to be a wellspring of biofuel, like bioethanol. There are sources of agricultural products like cassava and sweet sorghum containing starch that is ordinarily used for ethanol production. [24]. Hence, the goal of this research is to evaluate and employs the potential of sweet potato peels (Hannah species) as a renewable and value addition feedstock in the production of ethanol.

2.MATERIALS AND METHOD

2.1. Sourcing of the raw materials

About 5 kg of sweet potato peels were obtained from the potato chips seller at palladan in Zaria, Kaduna State Nigeria. Chemicals used in this study are saccharomyces cerevisiae, 2% ammonium sulfate, 2% peptone, 0.1M sodium hydroxide, absolute ethanol, distilled water, and calcium hydroxide.

2.2. Selected proximate characteristics of sweet potato peels

Total carbohydrate [25], total ash [26], starch contents [27], fat content [28], protein content [29], moisture content [30] and polyphenol [31] were determined.

2.3. Preparation of the biomass sample (SPP)

The sweet potato peels were thoroughly washed with clean water and macerated into smaller pieces. Then dried in an oven at 80℃ till constant weight. Once dried, the peels were ground with a blender and sealed in the sealed bag or poly bag and stored in room conditions.

2.4. Hydrolysis of SPP powder (starch)

Pretreatment and hydrolysis of sweet potato peel were conducted as the protocol described in [32] with a small modification. 100 grams of the peel powder was weighed into a clean 1L conical flask with 500 ml of distilled water. The powder solution was wrapped with aluminum foil in a crucible while sterilized in an autoclave at 121℃ for 1 hour and allowed to cool. It was then centrifuged at 1500rpm for 5 minutes. Afterward, 350 ml of 1% concentrated sulfuric acid was added to the resulting mixture and autoclaving at 121℃ for 45 min. [33]

2.5. Polarimetric determination of the reducing sugar (Dextrose equivalent)

In principle, the optical activity property of the glucose solution rotates the polarization direction of the polarized light when passing through the glucose solution. The amount of rotation is defined as a rotation angle. The rotation angle depends on the nature of the solution, the concentration of the solution, the length of solution that is exceeded by light, the wavelength of source light, and the temperature of the solution. The angle of rotation (α) can be mathematically expressed as

$$\alpha = \alpha_t^D \frac{LC}{100}$$

Where L is the length of solution that is exceeded by light and C is the concentration of the solution.
The specific rotations of the standard dextrose solutions [5%,10%,15%,20%,25%,30%,35%,40%,45% and 50%(w/v)] with the blank reading (distilled water)were determined with Model D7 polarimeter.

The concentration of the glucose (hydrolyzed solution) level generated by the hydrolysis was extrapolated from the plot of optical rotation (R) against the concentration (C) of the dextrose solution [34].

2.6. Polarimetric determination of Ethanol content

Specific rotations of standard ethanol compositions [10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%] were also determined with the same polarimeter model, conditions and method.

2.7. Fermentation

The highest amount of sugar through acid hydrolysis process was fermented with 10% (w/v) of
Saccharomyces cerevisiae yeast, as many as 148 ml [35]. 12.61% sugar concentration (800ml) of the hydrolyzed mixture in 1L conical flask was adjusted to a pH of 5 with 170ml of 0.1M sodium hydroxide, and then added with 1% (w/v) peptone and 4% (w/v) ammonium sulfate as a nutrient. The flask was sealed and incubated at room temperature (25oC) for 120 hours. The production of ethanol was detected at 120 hours (5days) fermentation period.

2.8. Distillation and Dehydration

The fermentation broth in a fractional distillation flask was allowed to boil and vaporized within the temperature range of 78oC. After the distillation process, the ethanol fraction was dehydrated by adding CaO at the ratio 1:4. Then allowed to stand for 24 hours before evaporation in a water bath and re-distilling [37]. The total ethanol content was qualitatively determined with FT-IR and quantitatively with the polarimetric method.

3.RESULTS AND DISCUSSION

Table I. Selected proximate characteristics of sweet potato peels

Parameter	Value
Total carbohydrate	24.75(mg/g)
Total ash	1.34%
Fat content	0.29%
Protein content	2.45%
Moisture content	53.5%
Polyphenols	4331.4(mg/kg)
Crude Fiber	0.36%

Table II. Standard concentration and optical rotations of dextrose (glucose) solutions

Working temperature= 26^{0}C
Length of the sample tube (l) =20cm
Optical (zero) reading with distilled water=65.90°

Standard dextrose concentration (w/v %)	Rotation before correction(R°)	Actual Rotation (R)
5	80.0	14.1
10	84.5	18.6
15	88.7	22.8
20	92.5	26.6
25	98.2	32.3
30	100.2	34.3
35	106.3	40.4
40	111.5	45.6
45	115.4	49.6
50	121.0	55.1

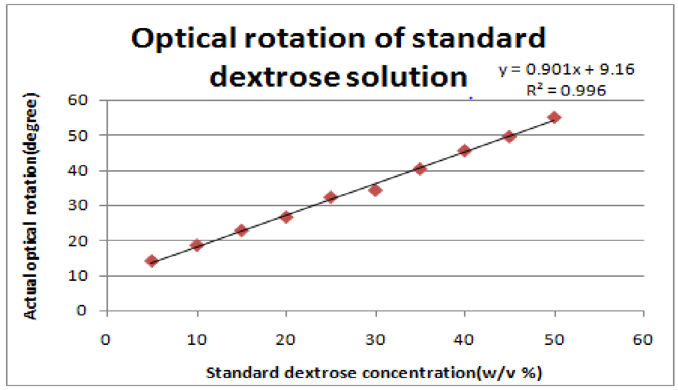

Figure l. Plot of the actual rotations and standard dextrose solutions

Table III. Standard concentration and optical rotations of standard ethanol percent concentration

Working temperature= 26°C
Length of the sample tube (l) =20cm
Optical (zero) reading with distilled water=65.90°

Ethanol (v/v) %	Rotation before correction(R_o)	Actual Rotation (R)
10	68.9	3
20	72.2	6.3
30	74.4	8.5
40	75.7	9.8
50	78.3	12.4
60	79.5	13.6
70	81.4	15.5
80	83.9	18
90	86.3	20.4
100	87.5	21.6

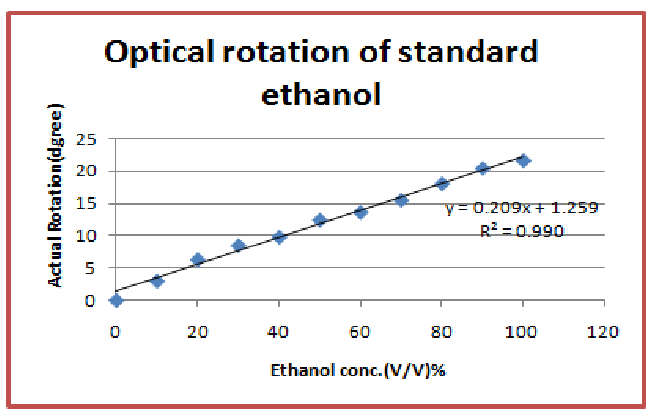

Figure ll. Plot of the actual rotations with standard ethanol percentage

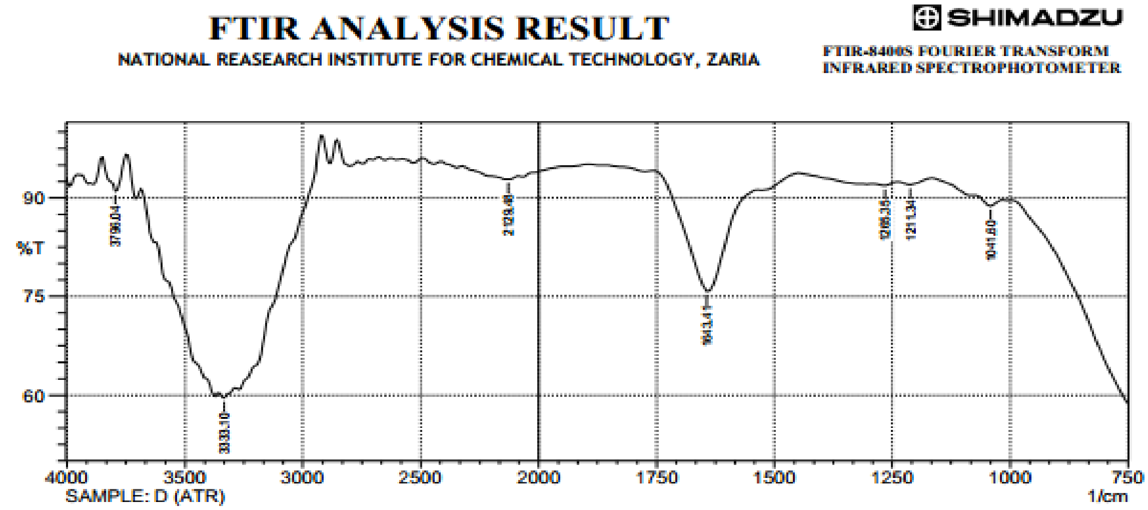

Figure lll. FT-IR spectrum of ethanol fraction after 5 days fermentation period.

Table I presented the selected Physico-chemical properties of this species (Hannah) of sweet potato peel, where the starch (carbohydrate) content is quite significant (24.75mg/g) to be hydrolyzed. The liquid potion after hydrolysis and centrifugation (800ml) was observed with a specific rotation of 37.6o, which approximately corresponds to a glucose concentration of 12.61% as estimated from the standard concentrations of dextrose solution in table II and figure I. Fermentation of 500ml hydrolyzed solution was with 10% Saccharomyces cerevisiae at a controlled pH of 5, 25ºC and 120 hours period. Distillation of the fermented broth resulted in 59% (ml) ethanol and 41% water (ml). Meanwhile, the ethanol fraction was further dehydrated with calcium oxide and redistilled to 54.8% ethanol by the polarimetric method with a specific rotation of 12.71º

(Table III and Figure II). The FTIR spectrum of the ethanol explicitly reveals a broad peak at 3333.1cm-1, an indication of the H-bonded hydroxyl group, at 1643.41cm-1 the characteristics of H-bonded alcohol and another pronounced peak at 1265.35cm-1, an alkane derivative as

R-CH3.

4.CONCLUSION

This research has revealed a simple technique for transforming wastes into useful end products.

Agricultural wastes such as sweet potato peels have been processed biochemically into a valuable product (ethanol). 12.61% per 100g of the SPP (Hannah species) was finally estimated to yield 54.8% ethanol. In contrast with conventional industrial processes of ethanol production, it is concluded that this pathway of ethanol (bioethanol) production retains an economic, environmental friendliness, quality, and low-cost advantages.

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