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Comparative Studies on the Bioethanol Yields of Three Agricultural Waste

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Abstract: Cheaper substrates for bioethanol production has become a necessity in order to scale up the utilization of this energy type. This study was carried out to compare the potentials of three agro-wastes (banana peels, spoilt mango fruit and cassava processing effluent) in the production of bioethanol. The agro-wastes were ground and 1000 g of each weighed into 2 litre flasks for acid pretreatment using 10 mL of 4 % sulphuric acid for 12 hours at 40°C after which they were also pretreated using 5 % amylase enzyme at room temperature for 24 hours. Thereafter, commercial yeast cells, *S. cereviseae* was inoculated for fermentation at temperatures between 28–32°C for 4 days under anaerobic condition. Parameters such as ethanol percentage, moisture content, specific gravity, density, viscosity and refractive index were determined. The result showed that the cassava processing effluent had the highest alcohol yield percentage of 21.15±0.06% and least viscosity of 2.943±0.02mm^2/sec. However, there were no significant differences (P?0.05) between the three agricultural wastes all in other parameters investigated. Cassava processing effluent is therefore a better substrate for bioethanol production among the three substrates studied.

Key words: Cheaper Substrates · Cassava Processing Effluence · Banana Peels · Spoilt Mango Fruit

INTRODUCTION

There is a rising demand for renewable energy sources including bioethanols [1]. Bioethanol can be produced by converting the sugar content of any starchy material into alcohol with the evolution of carbon dioxide (CO_2) under controlled environmental conditions [1]. Sugar, starchy and cellulosic crops are major raw materials that can be used for alcoholic fermentations [2]. Usually bioethanol is synthesized from alcoholic fermentation of sucrose or simple sugars of diverse types of biomass, either from feedstock or non-feedstock sources [3]. In the present time, bioethanol production from cellulosic and lignocellulosic wastes has become solutions to the hitherto environmental, economic and energy problems experienced worldwide [4].

The acceptance and commercialization of biofuel is not in doubt. The United States, Brazil and most Asian countries such as China, Korea, Japan, India and others produce bioethanol due to direct association with cost effect on raw materials, environment-friendly characteristics and fuel-blending purposes [5]. The US Army built the first industrial-scale fuel ethanol plant in the 1940s to fuel army vehicles and for fuel-blending [6]. Brazil consumes and exports large quantities of bioethanol annually.

The fermentation method is a very popular, traditional, well-established natural metabolic process for conversion of lignocellulosic biomass to bioethanol, where an organism transforms complex carbohydrate into simple sugar and sugar into an alcohol or an acid [7]. The prominent raw material candidate of bioethanol

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manufacturing companies ismainly plant-based biomass, such as corn, sweet sorghum, sugarcane bagasse, wheat and crop residue etc. and the feedstock cost was very reasonable such as US$ 7.40/ton (including transportation cost) [8, 9].

Bioethanol can be used as a fuel, either pure or blended with gasoline (gasohol). In the United States, it is used as 10% solution in gasoline (E-10) while in Brazil it is used both blended (24% ethanol, 76% gasoline) and hydrated in flexible-fuel vehicles [10].

It has been stated that the bioethanol production from feed stocks is not suitable as it affects the food reserves. The use of non-edible lignocellulosic biomass requires pretreatment and saccharification before conversion to bioethanol. Similarly, the use of industrial wastes containing carbohydrates is also not economical due to the presence of solid residues and other contaminations [11]. There are huge agro-wastes that can be used in the production of bioethanol around. Fruit residues and spoilt fruits those are disposed as waste could serve as low cost substrates for bioethanol production [12]. In this study, we compared the quantities and qualities of bioethanol produced from three agro-wastes (banana peel, spoilt mango fruits and cassava processing effluent) to establish the one with better potentials for bioethanol production.

MATERIALS AND METHODS

Collection of Biomass: The biomass used, including banana peel and cassava processing effluent were collected from Abakaliki Ebonyi State while Spoilt mango fruits were collected from Enugu since it was out of season.

Pretreatment: The biomass including banana peels, spoilt mango fruits were first washed with clean tap water and store at 4°C with garri/cassava processing effluent to minimize microbial activities on the substrates. The substrates were milled using blending machine and 1000g of each weighed into 2 litre flask for pretreatment, while 10 mL of 4 % sulphoric acid was used to pretreat each substrate for 12 hours at 40°C. Reduction of pH value to 4.9 was achieved using 3 % lime water ($Ca(OH)_2$).

Enzymatic Hydrolysis: The method of separate hydrolysis and fermentation (SHF), process was adopted in this research in order to create the best conditions (temperature) necessary for hydrolysis and fermentation, since most fermentation microorganisms do not survive at high temperatures required for hydrolysis. The pretreated substrates were treated with 100 mL of 5 % amylase enzyme at room temperature for 24 hours. Flask containing substrates were sealed with paraffin to avoid microbial contamination.

Fermentation: Using simple batch culture method, the flask containing 1000 g of each substrate was inoculated with 200 mL of 10 % commercial strain of yeast cells, (*Saccharomyces cerevisiae).* Fermentation temperature was maintained between 28-32°C using incubator for 4 days under anaerobic condition achieved by using paraffin to seal the flasks.

Distillation: This was done using a distillation heating mantle. The samples were loaded into the heating mantle using a distillation flask with stopper. The samples were heated at 90°C for one hour and distillates collected into conical flasks.

Quality Parameters of the Bioethanol Produced

Determination of the Specific Gravity (S.G): About 100 mL each of the bioethanol produced and equal volume (100 mL) of distilled water were weighed and the specific gravity was determined using the equation below:

$$\text{S.G.} = \frac{\text{Weight of sample}}{\text{Weight of equal volume of water}}$$

Determination of the Percentage Moisture Content of the Bioethanol: The percentage moisture content was deduced by the equation below:

$$\%\ \text{moisture} = \frac{\text{Amount of ethanol}}{\text{Total volume of sample}}$$

Determination of the Density of Bioethanol: About 200 mL of each sample was weighed on digital weighing balance and the density of each sample was deduced using the equation below:

$$\text{Density (km/m}^3\text{)} = \frac{\text{Mass}}{\text{Volume}}$$

Determination of Viscosity: The viscosity of each sample was determined using viscometer. This was evaluated by dropping each on the transparent sensor tube of the meter and the time at which it drops taken.

Determination of Refractive Index: Light was pass through beaker containing each sample and angle of incidence of the light recorded as well as the angle of refraction. The refractive index was estimated using the equation below:

$$\text{Refractive index} = \frac{\text{Change in incidence ray}}{\text{Change in refracted ray}}$$

Statistical Analysis: The data obtained were subjected to Analysis of Variance (ANOVA) at 95% confidence level to compare the mean values of the different samples.

RESULTS

The results of the bioethanol produced are as shown in Figure 1. Cassava processing effluent had the highest ethanol percentage of 21.15±0.06% while banana peels had yielded the least (19.20±0.27%). The lowest percentage moisture content (78.85±0.06 %) was seen in the bioethanol produced from cassava processing effluent while the highest (80.80±0.27 %) was from the one produced from banana peels (Figure 1). Meanwhile, there were no significant differences (P?0.05) in the density (Figure 1) as well as the specific gravity (Figure 2) of the ethanol produced from threeagro-waste.

On the other hand, the viscosity of the bioethanol produced ranged from 3.255±0.11 mm^2/sec in mango to 2.943±0.02 mm^2/sec in cassava processing effluent (Figure 2). However, there were no significant differences (P?0.05) in the refractive index in the bioethanol produced from the three agro-wastes (Figure 2).

DISCUSSION

The use of bioethanol is orchestrated by the rising demand for renewable energy sources and have induced the development of new technologies to produce biofuels (European Commission, 2006). Among them, microbial biotechnologies have been largely developed, allowing the development and production of several different

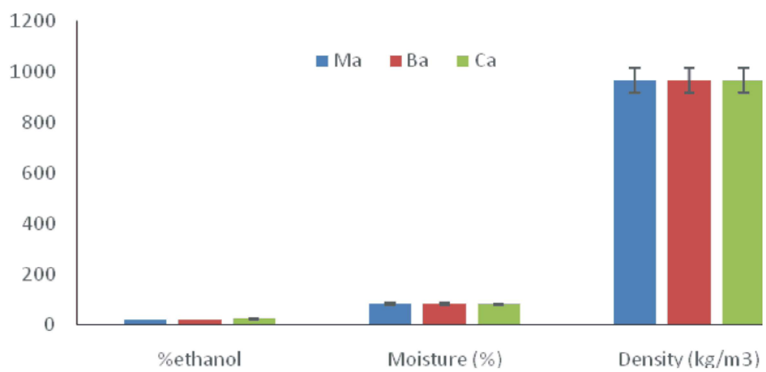

Fig. 1: Ethanol percentage, moisture content and density of the bioethanol produced from the three agro- wastes

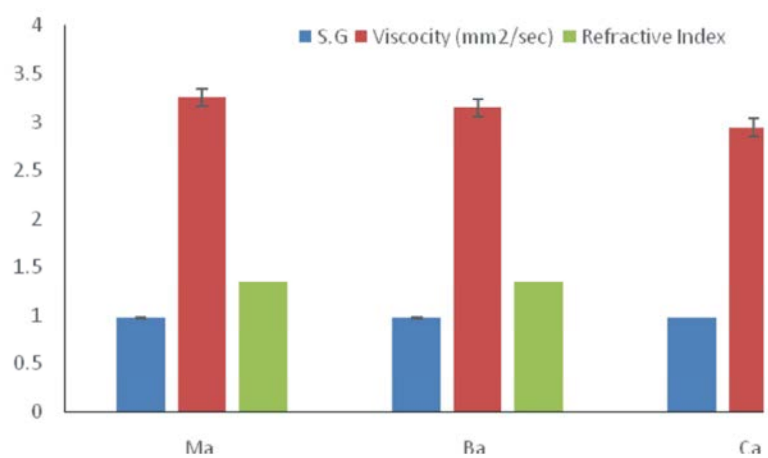

Fig. 2: Specific gravity, viscosity and refractive index of bioethanol produced from the three agro- wastes

biofuels using effluents and wastes as substrates hence, the costs of the processes are reduced, improving their commercial competitiveness and simultaneously reducing the environmental load for wastes disposal [13]. Hence, this study was able to convert the abundant agro-waste to useful product that is in everyday use.

The result obtained from the fermentation of banana peels using commercial yeast strain compared well with the ethanol concentrations reported in a similar research carried out by Sunand Cheng [14]. Thesetwo also confirm that pretreatment of substrates increases the ethanol yield. The results alsocorrespondto the report that the fermentation of enzymatic hydrolyzed of diluted acid pretreated mixed fruit pulps by yeast (*S. cerevisiae*) showed maximum percentage ethanol [15]. The overall results suggest that cassava waste yields significantly higher bioethanol than banana wastes and spoilt mangoes.

Meanwhile, the specific gravity of the bioethanol producedfrom the cassava processing effluent distillate was slightly lower than other substrates, indicating that bioethanol from cassava distillates was lighter than other substrates studied. This is in line with the report of Zoppellari and Bardi [16] who reported similar specific gravity in their research on sweet potato distillate. On the other hand, the bioethanol from spoilt mango fruits recorded slightly higher density, viscosity and refractive index when compared to the other two samples.

Even though all the agro-wastes studied yielded bioethanol possessing closer values one to another, it could be inferred that cassava processing effluent proved a better candidate for bioethanol production compared to both spoilt mangoes and banana peels. There is therefore need to harness these abundant agro-wastes for bioethanol production than allowing them constitute environmental nuisance.

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