# Effect of Process Parameter on the Production of Bioethanol from Corn Cob and Rice Husk

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***Abstract* - Bioethanol was successfully produced from corn cob and rice husk through the process of saccharification and fermentation. The effect of process parameters such as sulphuric acid concentration, yeast concentration and reaction time were investigated. The result of the analysis showed that from the bioethanols produced from corn cob have higher bioethanol yield and better properties compared to standards. The physical and chemical properties close to the standard of bioethanol recorded were: heating value of 5565 kcal/kg, flash point of 15 oC, density of 0.787 kg/m3, viscosity of 1.420 cst and pH of 7.7.**

***keywords* - Bioethanol, Saccharification and Fermentation, lignocellulose, Yield.**

## I. INTRODUCTION

Biomass is the world's largest renewable energy source, accounting for 77.4 percent of worldwide renewable energy supply [1]. World biofuel output increased from 4.8 billion gallons in 2000 to around 16 billion gallons in 2007, but this still falls short of global transportation fuel demand [2]. According to another statistic, global bioethanol output has risen rapidly from around 39 billion to almost 100 billion in just a few years [3].

Bioethanol is a sustainable fuel that can be used to partially replace fossil fuels. Bioethanol output grew from 50 million $m^3$ in 2007 to more over 100 million $m^3$ in 2012. Brazil and the United States account for over 80% of global supplies which mostly use corn or sugarcane [4]. To be viable, waste plant materials must be turned to fuel as a long-term alternative to fossil fuels. As a result, renewable energy resources derived from non-edible agricultural materials such as millet husks are required to replace fossil fuels. This is because plant feedstock fuel emits fewer greenhouse gases than fossil fuels, making it better for the environment and reducing global warming [5, 6]. As a result, the production of biofuels from agricultural leftovers has received increased attention.

Agricultural residues are made up of lignocellulose, making them a desirable feedstock for bioethanol production [7]. Saccharomyces species are commonly used in bio-ethanol fermentation because it ferments glucose to ethanol and is known for its high insensitivity to temperature and substrate concentration, quick fermentation rates, and high ethanol tolerance [8]. Pretreatment and hydrolysis are frequently required in bioethanol fermentation from lignocellulosic materials in order to convert these materials to monomeric sugars before fermentation can begin [9]. Northern Nigeria is commercially known to be producers of energy crops whose residues can be used in promoting the production of second generation biofuels [10]. The chemical composition of these materials consists mainly of polymer sugars (cellulose and hemicellulose) and lignin, these chemical components can be recycled and used for the production of a number of value-added products such as ethanol, food additives, organic acids, enzymes, and others [10, 11].

Bioconversion of lignocelluloses to biofuel from inexpensive non-edible resources is critical for renewable energy. Maize cobs and rice husk are agro waste products which contain a huge amount of sugars that can be used to make a variety of chemicals [7, 12]. Fermentation of sugar or starch-rich feedstock such as sugarcane, sugar beet, sweet sorghum, corn, and cassava is the most prevalent method of manufacturing ethanol [13]. However, because the majority of these crops are food crops, this approach has the potential to raise production costs. To make the fermentation technique more cost-effective and meet the high demand for ethanol, researches are presently focused on two areas: the production of ethanol from less expensive raw materials and the investigation of new microorganisms or yeast strains that are efficient in ethanol production [14. 15, 16].

## II. METHODOLOGY

### *Samples Collection*

Both corn cob (CC) and rice husk (RH) were collected from Bakin-Dogo, Kaduna central market. The collected CC and RH were sun dried for two days before being ground to obtain a uniform particle of 8, 0.45 mm from each of the samples.

### *Pre-treatment*

The ground powder from the two samples were treated with an alkali solution to expose the cellulose and make it available for enzyme hydrolysis [17]. The dry powder was kept in sealed polythene bags at room temperature for further operations.

### *Simultaneous Saccharification and Fermentation (SSF):*

The pretreated CC & RH samples were divided into three portions each. 500 $cm^3$ of 1%, 2% and 3% sulphuric acid were added to the samples and heated for 2 h (not to boiling).
Baker's yeast, *Saccharomyces cerevisae* purchased from a local retailer in Kaduna was cultured on yeast extract agar. Dried yeast samples (1g, 3g and 5g) were measured into three different 10 ml sterile distilled water. The mixtures were shaken rigorously for even distribution of the cells.
Lab-scale batch fermentations were carried out on 500 g of each of the samples containing the hydrolysates. *Saccharomyces cerevisae* was aseptically inoculated and incubated at 25 ℃ under static conditions in an incubation chamber for 24 h. Thereafter, the inoculum was added at a concentration of 1g/l, 3g/l and 5g/l of wet cells. Samples were taken at 24, 48, and 72 h to quantify ethanol production. The parameters considered were: yeast loading (%v/v), concentration of sulphuric acid (%v/v) and reaction time (h).

## III. RESULTS AND DISCUSSION

In a fermentation container, there should be a distinct visible liquid layer on top of the yeast layer, the majority of the alcohol produced following appropriate fermentation is contained in this layer [18].

**Distillation Process**

After fermentation, distillation has been carried out using fractional distillation apparatus. The fermented 150mL of top fermented broth was transferred into round bottom flask and placed on a heating mantle fixed to a distillation column enclosed with running tap water as cooling medium. Another flask was fixed to the other end of distillation column to collect the distillate at 78°C (standard temperature for ethanol production).

**Determination of Quantity of Ethanol Produced**: The distillate collected from the different samples were measured using a measuring cylinder and expressed as quantity of ethanol produced in g/l by multiplying the volume of the distillate by the density of ethanol (0.8033 g/cm3 )[19].

**Determination of percentage sugar content**: Refractometer was used to determine the percentage of total sugar content of the cassava hydrolysate after hydrolysis. This was carried out by placing a drop of cassava hydrolysate on the graduated hand refractometer glass slide and expressing the brix reading in percentage. The brix (%) was determined using a hand refractometer [20].

**pH Test**:

pH meter was first calibrated and was inserted separately into each of the filtrate. The readings was then taken as described [19].

**Determination of specific gravity of the filtrate**:

The specific gravity of the filtrate was determined from the results of refractive index [20].

**Effect of Process Parameters on Bioethanol Yield**

Three (3) parameters - yeast loading (%v/v), concentration of sulphuric acid (%v/v) and reaction time (h) were considered for these research work. Their effects on bioethanol yield on CC and RH are discussed in Fig. 1-3.

In Fig. 1, both the yield of bioethanol for CC and RH increases from 4.1 to 7.2% and 3.4 – 6.1% respectively as the concentration of sulphuric acid increases from 1 to 3%. Thus, increase in sulphuric acid concentration favour bioethanol yield. This is similar to the effect of yeast loading on yield of bioethanol. The bioethanol yield for both CC and RH increases from 4.2 – 6.2 g/l and 5.4 – 8.2 g/l respectively. These values recorded are higher than that of effect of sulphuric acid.
Fig. 3 is a case of reaction time on percentage yield. For all the three cases considered, the yield for CC is higher than that of RH. It was also observed that percentage bioethanol yield increases from 5.4 to 8.2 % for CC and 4.2 to 6.2 % for RH for a time range of 24 - 72 h.

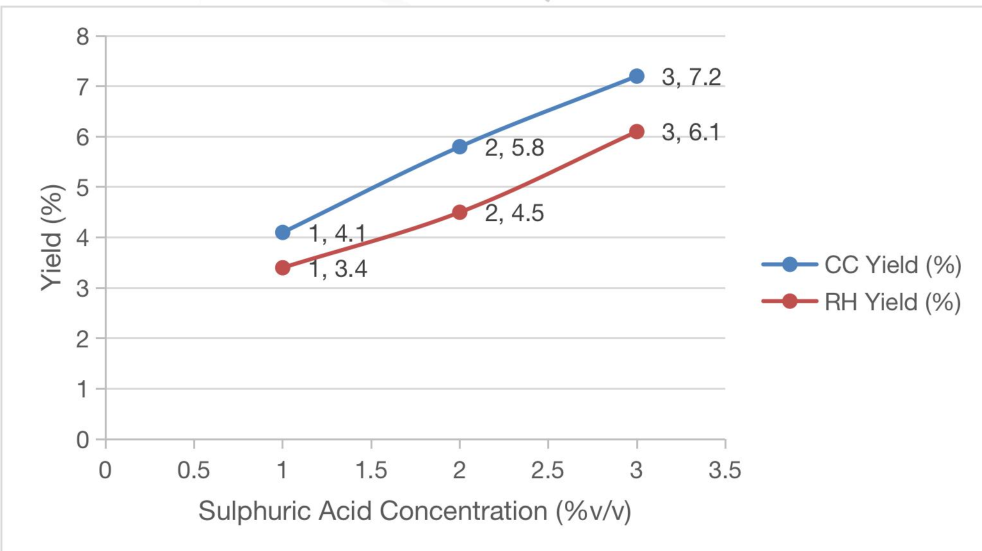


**Fig. 1: Effect of Sulphuric Acid Concentration (% v/v) on Bioethanol Yield**

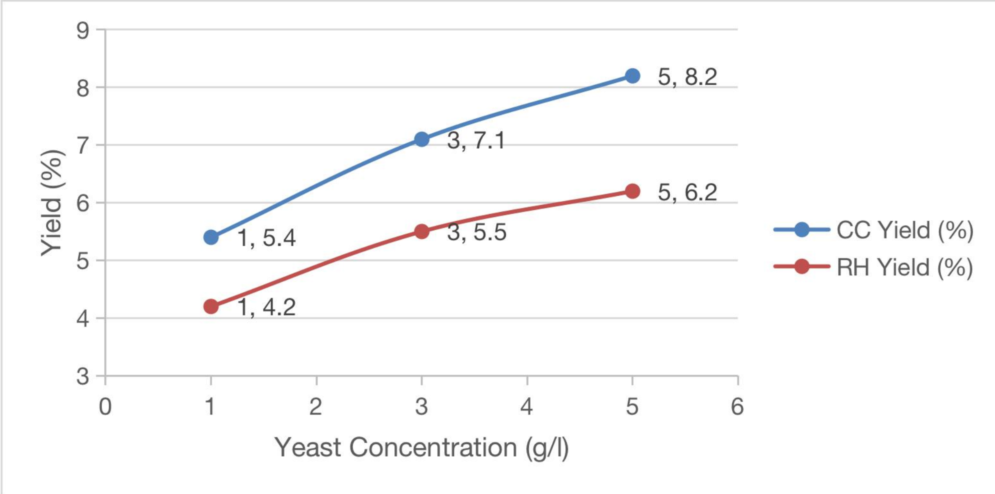


**Fig. 2: Effect of Yeast Concentration (g/l) on Bioethanol Yield**

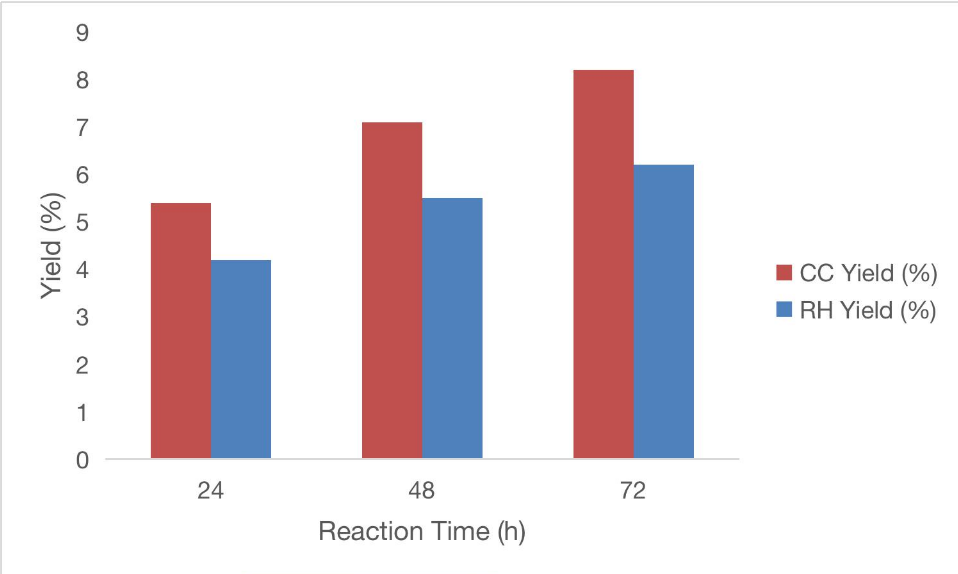


**Fig. 3 Effect of Reaction Time on Bioethanol Yield**

Table 1: Physicochemical Properties of Bioethanol produced from Rice Husk and Corn Cob

| Properties | Rice Husk (RH) | Corn Cob (CC) | Standard [21] |
|---|---|---|---|
| Density (g/cm$^3$) | 0.785 | 0.787 | 0.789 |
| Flash Point (°C) | 19 | 15 | 12 |
| Boiling Point (°C) | 88.9 | 79.5 | 78 |
| Refractive Index | 1.336 | 1.3310 | - |
| Viscosity (cst) | 1.341 | 1.420 | 1.525 |
| Solubility in Water | Soluble | Soluble | Soluble |
| pH | 7.3 | 7.7 | 6.5-9.0 |
| Heating Value (kcal/kg) | 5024 | 5565 | 6380 |

Table 1 shows the physical and chemical properties of produced bioethanol from corn cob and rice husk. The heating value of bioethanol produced from corn cob (5565 kcal/kg) is higher than that produced from rice husk (5024 kcal/kg). The densities of bioethanol produced from CC (0.787g/cm$^3$) and RH (0.785g/cm$^3$) are closed to that of the standard. Other properties measured are flash point (CC-15 and RH-19), boiling point (CC-79.5 °C and RH-88.9 °C), and viscosity (CC-1.420cst and RH-1.341cst).

## IV. CONCLUSION

Based on the research conducted on the production of bioethanol from corn cob and rice hush, the following conclusions can be made:

1. Increase in sulphuric acid concentration from 1% to 3% v/v lead to an increase in percentage bioethanol yield for both corn cob and rice husk. The yield for CC at all acid concentrations are higher than that of RH.
2. Similar trend was recorded for the effect of yeast concentration on percentage bioethanol yield. Increase in yeast concentration from 1g/l to 5g/l results in an increase on yield.

3. Effect of reaction time for the maximum of 72h was investigated. Higher ethanol yield of 8.2% for CC was recorded against 6.2% for RH.
4. The heating value of 5565 kcal/kg for CC and 5024 kcal/kg for RH were recorded. The bioethanol produced from CC is of higher yield and better properties than that of RH when compared with standard values.

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