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COMPARATIVE EVALUATION OF ETHANOL PRODUCTION FROM SWEET POTATO (*Ipomoea batatas*) and Maize (*Zea mays*)

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ABSTRACT: Comparative evaluation of ethanol production was carried out with sweet potato (Red and White Species) and Maize sourced from National Root Crop Research Institute (NRCRI), Umudike and National Seed Centre (NSC), Umudike. About 200g (in powered form) of peeled, sliced, dried and ground samples of sweet potato, and maize were subjected to complete hydrolysis using Azha', 1981 method. The filtrates (hydrolysates) from hydrolysis were later subjected to fermentation process using *Saccharomyces cerevisiae* for 72-96 hours. Distillation was adopted to recover ethanol produced at 78^{0}C. The average volume of ethanol produced from Red Potato, white potato and maize were 28.40ml, 30.00ml and 37.17ml respectively. Ethanol from maize had pH value of 3.6; Red potato, 4.0; White, 4.3. Percentage yield of ethanol was in the order: Maize>White potato> Red potato as their values were 14.72%, 11.93% and 11.19% respectively. The results showed that maize had the highest sugar content thus, highest percentage yield of ethanol.

Keywords: Ethanol, production, sweet potato, maize fermentation, biofuel
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INTRODUCTION

Renewable energy and its associated technologies are gaining global attention. Renewable energy is a type of energy derivable from natural processes which are replenished instantly and particularly by sun. Generally defined, renewable energy is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources and biofuel (Ren, 2009). Renewable energy are said to protect the climate and environment and are otherwise environmentally friendly. Each sources of renewable energy has unique characteristic which influences how and where they are used.

Biofuel as a type of renewable energy, and is said to be any solid, liquid or gaseous fuel derived from relatively dead biological materials. They can be produced from any biological carbon source, although, the common sources are photosynthetic plants. Investment into biofuel production has increased drastically since 2007 and provided about 1.8% of the world transport fuel in 2008 (UNEP, 2008). Biofuel made from sugar, starch, vegetable oil or animal fats using conventional technology, are classified as first generation biofuel (Fareel *et. al*, 2006). They include among others: biodiesel, bioesthers, biogas and bioalcohol (Knothe, 2001; Kolombus, 2007).

Bioalcohol (Bioethanol) is the most common biofuel world wide, particularly in Brazil. Alcohol fuels are produced by fermentation of sugars derived from wheat, corn, sugar beets, sugar canes, etc. About 5% of ethanol produced world wide in 2003 was used as alternative petroleum product (Preet and Arthur, 2007). Materials used in ethanol production are categorized as: Cellulosic materials (e.g. wood, agricultural residues, waste sulphite, etc); crops high in sugar (e.g. sugar cane, sugar beet, sweet sorghum, honey, etc); starchy crops (e.g. root starch like potatoes, cassava; stem starch like yam, and grain starch like rice, wheat, maize, etc). (Jackman, 1976).

The composition of sweet potato includes carbohydrates, proteins, fats and pigments, e.t.c. with carbohydrate component making it useful for the production of ethanol. Maize on the other hand contains moisture, ash, protein and carbohydrate, with salpor, crystalline, floury, sweet, starchy, pop and black types containing 66.0% - 75.9% carbohydrate (Pearson, 1976). The basic steps involved in large scale production of ethanol include microbial fermentation of sugar, distillation, dehydration and denaturation.

Because of its peculiar characteristics, *Saccharomyces cerevisiae* is generally used in alcoholic fermentation process. While distillation and dehydration processes involve the removal of water from produced ethanol, denaturation involves treating ethanol with 2-5% gasoline. The combustion of pure ethanol produces no net carbondioxide which makes it generally acceptable and favoured for environmentally conscious transport schemes (Farwell, *et. al*, 2006).

MATERIALS AND METHODS

Sample Preparation and Preliminary Tests

Sweep potatoes (red and white species) sourced from National Root Crop Research Institute (NRCRI), Umudike were peeled and sliced into thin slices using kitchen knife, spread on paper-covered laboratory tray and dried along with maize grains (Sourced from southeast office field of National Seed Centre, Umudike), in an oven at 60^0C for six hours. Both were ground separately in a laboratory mill and sieved with 1mm sieve to obtain powdered samples.

The samples were first tested for starch using standard reagents and measured weights (4g each), hydrolyzed and tested for sugar.

Samples Hydrolysis

Measured weight of each milled sample (200g) was put in a 2-litre flat bottomed flasks and 800ml of 2M HCL solution added to each, mixed and heated until the mixtures boiled for 30-40 minutes before testing for starch.

When the samples tested negative to starch test, heating discontinued and hydrolysates allowed to cool, filtered first through two-fold muslim cloth, and later through filter papers.

Fermentation of Filtrates

Hydrolysate filtrates from each sample were treated separately with 7.5% V/V of backer's yeast (*Saccharomyces cerevesiae*) in a mini-fermentation vat and allowed undisturbed to ferment for 72-96 hours. Yeast slurry was removed by centrifugation.

Distillation

The supernatant obtained from saccharified fermented samples were subjected to distillation using laboratory distillation apparatus at boiling point of ethanol (78^0C). The distillate of each was recorded as the volume of ethanol produced.

pH and Specific Gravity Determination

pH values of the produced ethanol samples were obtained using pH-meter. Specific Gravity (S.G) values were determined using pyrometer gravimetric method which involved the weighing of empty specific gravity bottle to obtain its weight (Wb), weighing of bottle and distilled water (Wd) and, bottle with sample distillate (Ws). Each sample's specific gravity (S.G) was then calculated using the formula below:

$$S.G = \frac{Ws - Wb}{Wd - Wb}$$

Calculation of percentage yield (% yield) was based on the formula:

$$\% \text{ yield} = \frac{\text{Wt. of alcohol obtained}}{(\text{Vol.} \times \text{S.G})} \times \frac{100}{1}$$

$$\text{Wt. of Sample}$$

RESULTS

The results of laboratory analysis carried out on ethanol produced from white and red potato species showed similar values. The average pH values were 4.3 and 4.0 respectively.

Average values of weight, volume, specific gravity (S.G) and percentage yield for white potato species were 15.801g, 30.00ml, 0.787 and 11.93% respectively, red species recorded 15.828g, 28.40ml, 0.788 and 11.19% respectively (Table 1).

Ethanol from maize recorded average pH value of 3.6; weight of produced ethanol, 15.848g; volume of ethanol, 37.17ml, ethanol S.G, 0.789 and percentage yield value of 14.72%.

Table 1. Average values of Weight, volume, pH, S.G and % yield of ethanol produced from potato and maize.

Sample	Weight(g) of sample	pH	Weight. (g)	Volume (ml)	%S.G	%yield
Red Potato	200	4.0	15.828	28.04	0.788	11.19
White Potato	200	4.3	15.801	30.00	0.787	11.93
Maize	200	3.6	15.848	37.17	0.789	14.72

NB: Weight of S.G bottle = 22.42g; Weight of distilled water=20.08g

DISCUSSION

During fermentation process, changes were observed: a general decrease in sugar content, and specific gravity.

In this study, the observed decrease in sugar content was in accordance with the work of Meneze (1978) who stated that it was as a result of the yeast *(Saccharomyces cerevisiae);* feeding on the sugar and at the same time given out ethanol as bye-product. Results showed that maize had the highest sugar content followed by red and white potato; this shows that the sugar content is directly proportional to ethanol; yield i.e. the higher the sugar content the higher the ethanol yield and vice versa. The variation in sugar content of the two varieties of sweet potatoes could be as a result of source of the sample, may be one had more nutrient in the soil than the other. According to Austin (1985), variation in two species of potato depends on either the soil, location, climate and weather.

The pH of the fermenting broth decreases with time, this is because *Saccharomyces cerevisiae* operated at low pH (that is to say that low pH favours yeast), hence increases ethanol production from sugar. This is in accordance with Prescott and Durin (1959) which stated that yeast grows well in aerobic condition but produces no alcohol but under anaerobic condition, growth slows with production of alcohol.

According to Panachl and David (1983) *Saccharornyces cerevisiae* can tolerate ethanol up to 10- 12% and can operate at low pH making contamination negligible.

There was slight variation in specific gravity due to some residual moisture content present in sample during fermentation process. This tends to bring up the specific gravity of the three samples.

The percentage ethanol yield obtained from maize, red and white were $14.72^0/0$, 1.93% and 11.9% respectively.

The quality and quantity of ethanol produced from sweet potato agreed with the work of Prescott *et al.* (1959) who got a range between 7-12% by volume. The difference in that of maize was a result of high sugar content.

CONCLUSION

From the result gotten, the production of ethanol depends on the sugar content and pH. When there was high sugar content, the yeast fed on sugar, lowering the pH of the system (because *Saccharomyces cerevisiae* were said to operate more at low pH) under anaerobic condition, produces high degree of .ethanol as its byproducts. Only carbohydrate sources that have high sugar content can be used. With this view, one can say that sweet potato and maize can produce ethanol because they are rich in starch.

Growing of sweet potato and maize should be encouraged in Nigeria through the use of modern technologies that are now available to help cultivate and produce them throughout the year without seasonal limitations. By so doing, it will help to solve the problem of low production and scarcity as well as increase production of ethanol.

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