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# Ethanol Production from Screened Kitchen Food Wastes

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**Abstract**

Kitchen wastes are generated daily in several households and form the bulk of municipal waste. A good portion of kitchen waste is made up of carbohydrate food materials such as pieces and leftovers of bread, yam, rice, 'eba', noodles, etc. Carbohydrate materials can be readily converted to ethanol via hydrolysis and further fermentation. In this work, kitchen wastes from several households were collected and screened for their carbohydrate portions. 1kg carbohydrate portion of the screened wastes was hydrolyzed enzymatically using amylase to yield 44% w/w fermentable sugar substrates. Subsequent fermentation of the sugar substrates using yeast yielded 14% v/v ethanol, whereupon distillation brought the percentage of ethanol produced to 95% v/v. The total yield of ethanol derived from 1kg of screened kitchen wastes was estimated to be 0.31 L. Rather than being a nuisance to the environment, the carbohydrate portion of kitchen wastes can be converted to a more profitable ethanol which has diverse applications.

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## Introduction

In most urban centres in Nigeria today, the fight to control waste is overwhelming the relevant authorities. Apart from the huge amount of money spent annually, more challenges arise in areas of sourcing new land spaces for disposal, disposal methods, and concern for environmental safety (Ogwuche *et al*., 2012). Inadequate waste management has harmed the ecosystem by contaminating subterranean water through leaching, releasing greenhouse gases during cremation and decomposition, occupying land, and potentially causing an epidemic. (Dung *et al*., 2007).
A great part of municipal waste is comprised of kitchen-generated waste. Taking into consideration the eating habits of the average Nigerian, a greater portion of the kitchen waste is from carbohydrate (Starch) sources. These include leftovers from yam, cocoyam, rice, "eba"( meal from processed cassava)," Garri", noodles (Indomie, spaghetti, etc.), "Akpu"( meal from processed cassava), "Usi"( meal from processed fermented cassava water), cornflakes, wheat meals, bread, etc. (Yamadje *et al*., 2013).
Carbohydrate materials can be converted to ethanol through the fermentation process which is of more commercial benefit. This can therefore be a profitable way of managing waste (Edema *et al.*, 2012, Ocloo *et al*., 2010).
Starch is a complex polymer of several sugar units held together by glycosidic bonds. For fermentation to take place, the starch has to be hydrolyzed to release the free sugar which can then be acted upon by yeast. Hydrolysis of starch involves the introduction of water molecules to break the glycosidic bonds between the glucose molecules, forming smaller polysaccharides, disaccharides, and, ultimately, glucose molecules.
There are three stages involved in the hydrolysis of starch; gelatinization, liquefaction, and saccharification. The starch granules undergo gelatinization, a process where heat and water break the hydrogen bonds holding them together, and liquefaction, which is the result of the amylase enzyme producing oligosaccharides that can be further broken down into glucose and maltose during the third stage, saccharification. (Gaquere-Parker *et al*., 2018)
The glucose is eventually converted to ethanol during the fermentation process when yeast release the enzymes maltase and zymase (Maicas, 2020)
In this research, carbohydrates from screened kitchen wastes were hydrolyzed to sugar and subsequently fermented to ethanol.

## Materials and Methods

### Material Sampling/Pre Treatment

Screened kitchen wastes comprising mainly and limited to leftovers from cooked rice, yam, and eba were collected from five designated houses. The materials were rinsed with hot water (100°C) to remove oil films and to inhibit microbial growth. After

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dripping dry, the lot was transferred into a mortal and pounded uniformly into a pulp.

**Liquefaction/Saccharification**

1kg of the pulp was mixed with a litre of warm water (60°C) into a liquid slurry. Thereafter, 3 litres of warm water (60°C) was added to the slurry and thoroughly mixed until fully liquefied. 250 g of malted barley (b-Amylase) was added to the starch slurry which was stirred and allowed to stand for an hour. The slurry was filtered and the sugar solution recovered.

**Preparation of Yeast Solution (20%)**

20 grams of commercial dry baker's yeast (*Saccharomyces cerevisiae*) was added to a
100 ml of distilled water at 37°C. The solution was allowed to stand for 10 min.

**Fermentation/Ethanol Recovery**

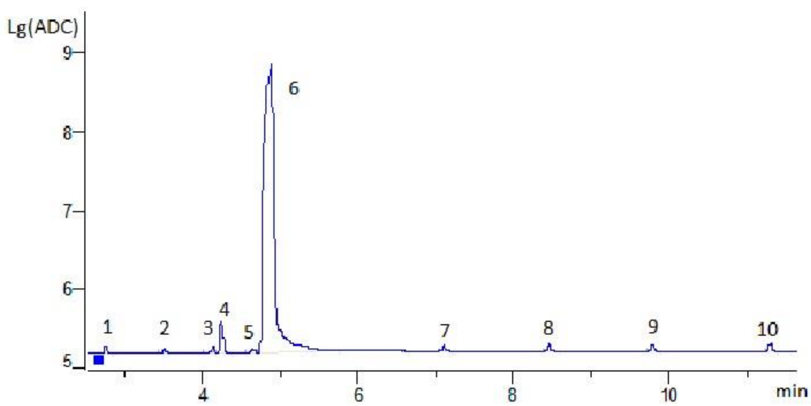
100mI yeast solution was added to the sugar solution and fermentation was allowed to take place inside aspirator bottles fitted with tubings to enable $CO_2$ gas to escape. The fermentation proceeded at normal room temperature in the dark for five days thereafter, the ethanol solution was filtered. The pH was recorded. 100mI of the solution was further distilled at 80°C to recover 95% ethanol. Identification of ethanol was done using gas chromatography (Hewlett-Packard Model 5890 GC)

**Determination of Sugar Concentration**

The concentrations of sugar in the substrates were determined through redox titration using Standard Benedict's Solution (Hernández-López, 2020).

**Results and Discussion**

The concentration of reducing sugar obtained from lkg Screened Kitchen waste was 44 % w/v. The concentration of the sugar decreased from 44% w/v to 9% w/v after fermentation. The decrease in concentration is an indication of the conversion of sugar molecules to ethanol by the enzymes. This is evidenced in the gradual rise of the ethanol concentration (Fig. 1).




Chromatogram of ethanol-water solution (95% and 5%).

*1 – acetaldehyde, 2 – methyl acetate, 3 – ethyl acetate, 4 – methanol, 5 – 2-propanol, 6 – ethanol, 7 – 1-propanol, 8 – isobutyl alcohol, 9 – n-butanol, 10 – isoamyl alcohol.* The chromatogram in figure 1 shows the presence of ethanol in the fermented product.

The concentration of the sugar remained at 9%w/v at days 4 and 5, while the concentrations of ethanol were slightly 13.5% v/v. This is an indication that the fermentation has stopped and the remaining sugars are no longer been converted by the enzymes. This is evidenced by the stoppage of $CO_2$ bubbling from the aspirator bottles (Uduak *et al*., 2008). The pH of the solution at this point was measured to be 4. At this pH, the yeast enzyme is inactivated (Ocloo *et al*.,2010)
The total yield of ethanol fuel derived from lkg of screened kitchen wastes was estimated to be 0.31 L. The yield is indicative of the fermentation efficiency (Table 1)

Table I: Concentrations of Ethanol Produced Relative to Sugar concentration

| Fermentation Day | Sugar Conc.( % w/v) | Ethanol Conc.( % v/v) |
|---|---|---|
| 1 | 44 | 0.0 |
| 2 | 31 | 7.0 |
| 3 | 16 | 11.0 |
| 4 | 9 | 13.3 |
| 5 | 9 | 13.5 |

## Conclusion

The ethanol yield is a function of the total reducing sugar present. Kitchen wastes contain a sufficient amount of starch which can be hydrolyzed into sugar. It can therefore serve as a feedstock for ethanol production. Rather than being a nuisance to the environment, the carbohydrate portion of kitchen wastes can be converted to a more profitable ethanol which has a wide range of applications.

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