

Bioethanol Production from Cassava Peel Using Some Microorganisms

ABSTRACT

Introduction: The potential of bioethanol production using different microbial inoculants for the fermentation of different feedstocks has been previously described and carried out by various researchers. And bioethanol is considered as cheap and efficient biofuel, and environmentally friendly

Aims: The aim of this study is to produce bioethanol as an alternative source of fuel using cassava peels as raw materials.

Methodology: Peels obtained from garri processing plant in Ado-Ekiti, Ekiti State, were washed, sun-dried, ground into a fine texture and sieved with 1.5 μ nylon sieve. The sieved material was cultured using the following inoculant combinations: A = 20 g + *Bacillus*; B = 20 g + *Pseudomonas*; C = 20 g + *Bacillus* + *Pseudomonas*; D = 40 g + *Bacillus*; E = 40 g + *Pseudomonas*; F = 40 g + *Bacillus* + *Pseudomonas*; G = 20 g + *Aspergillus niger*; H = 20 g + *Fusarium*; I = 40 g + *Aspergillus niger*; J = 40 g + *Fusarium*. The control was not inoculated with organism. The cultures were distilled on the 21st day and the quantity of ethanol produced in each treatment group recorded.

Results: Cassava peels gave the highest ethanol yield of 147 mL using *A. niger*. Similarly, the second highest ethanol yield of 108 mL using the combination *Bacillus* + *Pseudomonas*. Low ethanol yields of 45, 83 and 94 mL were obtained from the cassava peels of in combination with *Fusarium*, *Pseudomonas* and *Bacillus* alone. The yield reported in this study competes favorably with those reported from cassava peels, potato peels and millet husks using other inoculant treatments by other researchers.

Conclusion: Inoculants used in this study thus showed great potential for bioethanol production from cassava peels.

Keywords: Bacteria, Bioethanol, Cassava, Fermentation, Fungi

1. INTRODUCTION

Sugar fermentation is the main process through which bioethanol fuel produced, although this can also be manufactured by the chemical process of reacting ethylene with steam. The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops are grown specifically for energy use and include cassava, corn, maize and wheat crops, waste straw, willow and poplar trees, sawdust, reed canary grass, cord grasses, and sorghum plants. Fukushima and Yamade [1] ventured into research and development of the use of municipal solid wastes to produce ethanol fuel. Bioethanol comes from a renewable resource i.e. crops and not from a finite resource and the crops it derives from can grow well, like cereals, sugar beet and maize). Bioethanol is also biodegradable and far less toxic than fossil fuels. Bioethanol is produced using familiar methods, such as fermentation, and it can be distributed using the same petrol forecourts and transportation systems as before [1].

The processing of cassava tubers yields the following by-products that can be valuable livestock feeds when properly processed: Cassava peels can represent 5 to 15% of the root [2]. Cassava sievate or garri sievate is the by-product of the production of garri (also spelled

Comment [HL1]: Please make concentration unit, ml/L?

gari or gary), a popular West African food. Tubers are peeled, crushed and then fermented [3]. Cassava stumps are the ends trimmed off the cassava tubers as they are manually prepared for onward transmission into the rotary washer and peeler [2]. Cassava whey is the liquid pressed out of the tuber after it has been crushed mechanically. The whey and the pomace may be mixed together to form an effluent (or slurry) [2].

The process of ethanol production generally involves pretreatment, hydrolysis of lignocellulosic biomass to fermentable sugars followed by fermentation of such sugars to ethanol [4]. In a study, waste of cassava peel (*Manihot esculenta*) was hydrolyzed by using sulphuric acid. Yeast isolated from Durian fruit (*Durio zhibetinus*) was also reported to be used in the experiment for fermentation and the concentration of sulphuric acid of hydrolysis process was fermented by yeast for 1; 2; 3; 4; 5; 6; 7; and 8 days [4]. This study therefore aimed to produce of bioethanol as an alternative source of fuel using cassava peels as raw materials.

Comment [HL2]: This process is common used in lignocellulosic bioethanol or second generation bioethanol. Is the cassava peel is lignocellulosic biomass?, please add some reference that clearly state that cassava peel is lignocellulosic biomass. And add the chemical content in cassava peel (cellulose, hemicellulose and lignin)

Comment [HL3]: There are some publication about bioethanol form cassava peel, please mention the uniqueness from this study

2. MATERIAL AND METHODS

2.1 Study area

The study area is Ado-Ekiti, Ekiti State, Southwestern Nigeria. Ado Ekiti is the capital and largest city of Ekiti State with Coordinate: Latitudes (7° 37' 23.84" N and Longitudes 5°13' 15.13"E)

2.2 Collection of samples

The cassava peel was obtained from a cassava processing industry around Ado-Ekiti, Nigeria. The microorganisms used are *Bacillus*, *Pseudomonas*, *Aspergillus niger*, *Fusarium* and made obtained from the department of Science Technology (Microbiology Option), The Federal Polytechnic, Ado-Ekiti.

Comment [HL4]: Can author mention the detail about the species of these microorganisms

2.3 Preparation of the Cassava Peels

The cassava peels were washed under running tap to remove sand and other impurities, sun dried for 7 days under the sun, pounded into powder (flour) from using mortar and pestle with a sieve. The flour was packed into sterile plastic container, sealed and labelled.

Comment [HL5]: Please add moisture content from the cassava peel after dried

2.4 Fermentation

20g of the sieve cassava peel was weighed into four (4) conical flask and dissolved each in 500ml of distilled water. And another 40g of the sieve cassava peel was weigh into four conical flask and also dissolved back with 500ml of distilled water, the flask was plugged with foil paper, tight with paper tape, shaken thoroughly and autoclave for 15mins at 121°C. At the eight flasks containing 20g (4 flasks) and 40g (4 flasks) respectively was inoculated with the following;

Comment [HL6]: Its better if author state it as the concentration of substrate loading, i.e . 4% or 8% w/v

Is author conduct the hydrolysis? If yes, please add the method.

Or the cassava pell directly fermented by microorganisms

For 20g of flask.

- First flask – 10ml of *Bacillus*
- Second flask – 10ml of *Pseudomonas*
- Third flask – 10ml of *Bacillus* + 10ml of *Pseudomonas*
- Fourth flask – Control

For 40g of flask

First flask – 10ml of *Bacillus*
Second flask – 10ml of *Pseudomonas*
Third flask – 10ml of *Bacillus* + 10ml of *Pseudomonas*
Fourth flask – Control

The mixture in each conical flask was sealed with aluminium foil and cotton wool then sealed with paper tape to avoid contamination and kept for 21 days at room temperature and after another 2 days the bioethanol was extracted using Soxhlet extractor.

For the other organism i.e. *Aspergillus niger*.

20g of cassava peels was weighed into three flasks and 40g in 3 conical flasks and the same procedure was carried out for the 6 flasks respectively and inoculated with the following.

For 20g of flask.

First flask – 10ml of *Aspergillus niger*
Second flask – 10ml of *Fusarium*
Third flask – Control

For 40g of flask

First flask – 10ml of *Aspergillus niger*
Second flask – 10ml of *Fusarium*
Third flask – Control

The mixture in each conical flask was sealed accordingly and kept for 28 days at room temperature and the bioethanol was extracted using Soxhlet extractor.

3. RESULTS AND DISCUSSION

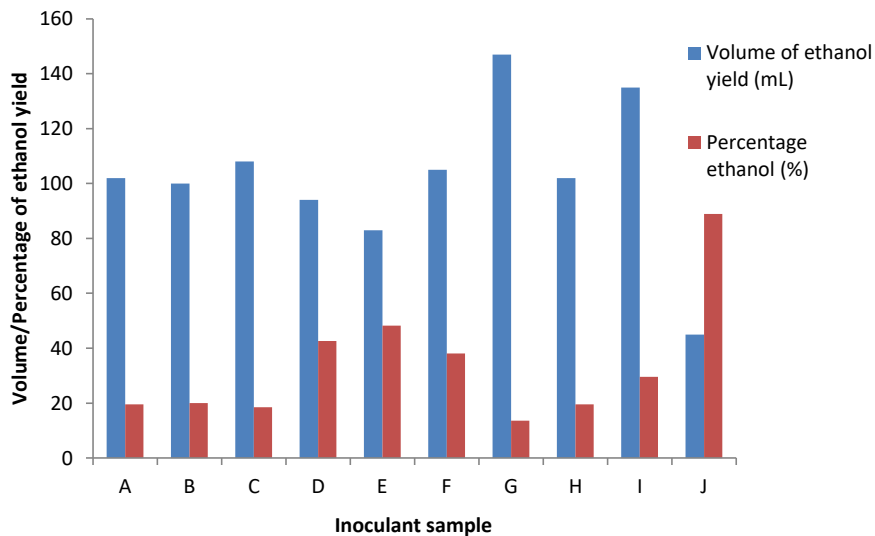
3.1 Results

The result from the production of ethanol from 20g sample (cassava peels) + *Bacillus* and *Pseudomonas* produced the highest volume yield while 20g sample + *Pseudomonas* produced the least (Figure 1). The ethanol produced from 40g sample + *Bacillus* and *Pseudomonas* has the highest volume yield while 40g sample + *Pseudomonas* has the least volume yield, also production of ethanol from 20g sample + *Aspergillus niger* produced the highest volume yield while 40g sample + *Fusarium* produced the least volume yield. The volume concentration yield obtained amongst the inoculants and varieties of the cassava peels gram, inoculum G (*Aspergillus niger*) consistently produced the highest volume yield in all the inoculants while *Fusarium* produced the least in all inoculants and varieties of cassava grams.

Comment [HL7]: Why author add the 2 days for this method

Comment [HL8]: How to measure the alcohol content?

Comment [HL9]: Why this method is separated? Its look like similar.. Please combine the method



A = 20 g + *Bacillus*; B = 20 g + *Pseudomonas*; C = 20 g + *Bacillus* + *Pseudomonas*;
 D = 40 g + *Bacillus*; E = 40 g + *Pseudomonas*; F = 40 g + *Bacillus* + *Pseudomonas*;
 G = 20 g + *Aspergillus niger*; H = 20 g + *Fusarium*; I = 40 g + *Aspergillus niger*; J = 40 g + *Fusarium*

Figure 1: Ethanol yield from the cassava peels sample treated with different inoculants

3.1 Discussion

The microorganisms expectedly produced different amylolytic enzymes and to different levels which acted on the cassava peel. The highest ethanol yield of 147 mL was obtained from *A. niger* and a concentration of 13.6% (v/v). This could be attributed to the presence of more carbohydrates from *A. niger* which is fermented to ethanol in the presence of the amylolytic microorganism. This result is in line with the work of Sulphari *et al.* [5] that gave a higher yield because of the presence of cassava peel substrate and good pH conditions. The present result is higher than that obtained by Khoja *et al.* [6], who obtained 9.3 (v/v) and 8.3% (v/v) of ethanol from sugarcane molasses using *Z. mobilis* and *S. cerevisiae*, respectively.

The average percentage concentration of ethanol obtained in the present study is relatively high as compared to the average yield reported by Agulejika *et al.* [7]. They reported an average ethanol concentration yield of 16%. This is likely to be due to the presence of more carbohydrate content in cassava peels than in cocoyam peels. The present report is also higher than the 8.5% given by Adetunji *et al.* [8] using *A. niger* and *Fusarium* spp. on cassava peel slurry. On the other hand, the percentage concentration of ethanol obtained in the present study is much lower than reports by Oyeleke and Jubrin [9] of 67.7 and 63.8% when *A. niger* and *Bacillus* were used simultaneously on guinea corn husk and millet husk, respectively. It is also lower than the 83% yield reported by Sivamani and Baskar [10] in cassava peel using a saccharification and fermentation mixture containing glucoamylase with optimum conditions of 69.82 g/L substrate concentration, 24.74% (v/v) α -amylase concentration. Sometimes, the differences in ethanol yield may be attributed to the actual amount of carbohydrate present in the peel at the start of the experiment.

Comment [HL10]: How to measure the ethanol concentration? Its calculated? Please add equation in methods

Volume ethanol and percentage ethanol is different,

Comment [HL11]: Its hard to say to gave this value ethanol concentration in broth fermentation. I thiks is the concentration after distilled. And cannot be compared with Khoja that use 8.3% is from broth (before distilled)

Comment [HL12]: If author mentiod that the volume is 147 ml with the concentration is 13.6%, did its mean the ethanol content is only 13.6% * 147 ml = 19.99 ml ethanol

Comment [HL13]: Its important to measure the carbohydrate content in the cassava peel.

4. CONCLUSION

The result of this study confirmed that ethanol can be produced from cassava peels which are agricultural waste. Despite the ability to use cassava peels for ethanol production, the yield can be influenced by several factors especially temperature, pH, time and substrate concentration. Since cassava contains starch contains of about 20-30%, 7kg of cassava peels leads to the production of 1litre of green energy bioethanol. To increase the production of cassava, the potential conversion of cassava peels for producing bioethanol via fermentation can be synthesized to bioethanol using simultaneous saccharification fermentation (SSF) and separate hydrolysis fermentation (SHF).

COMPETING INTERESTS

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. Fukushima F, Yamade K. A novel process of ethanol production accompanied by extraction of sugar in cane chips. *Journal of Fermentation Technology*, 1988; 66(4): 423–426.
2. Aro SO, Aletor VA, Tewe OO, Agbede JO. Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south-western Nigeria. *Livest. Res. Rural Dev.*, 2010; 22 (11)
3. Nwokoro SO, Ekhosuehi EI. Effect of replacement of maize with cassava peel in cockerel diets on performance and carcass characteristics. *Trop. Anim. Health Prod.*, 2005; 37 (6): 495-501
4. Hermansyah TX, Nguyen HT, Miksusanti F, Almunadi TP. Bioethanol Production from Cassava (*Manihot esculenta*) Peel Using Yeast. Isolated from Durian (*Durio zhibetinus*). Published under licence by IOP Publishing Ltd. *Journal of Physics: Conference Series*, 2016; 1095, 1.
5. Sulhahri SM, Eko S, Irvansyah MY, Remia SU, Sarwoko M. Ethanol production from algae *Spirogyra* with fermentation by *Zymomonas mobilis* and *Saccharomyces cerevisiae*. *J. Basic Appl. Sci. Res.*, 2011; 1(7):589-593.
6. Khoja AH, Yahya SM, Nawar A, Ansari AA, Qayyum M. Fermentation of Sugarcane Molasses Using *Zymomonas Mobilis* for Enhanced Bioethanol Production. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 2018; 11 (1): 31-38
7. Agulejika EO, Olabode FI, Babatunde KA. Ethanol production from waste fruits. *Intl. J. Food Agri. Res.*, 2005; 2(2):190-194.
8. Adetunji RO, Youdeowei PK, Kolawole OO. Production of bioethanol from cassava peel. *Proceedings from International Conference on Renewable energy and power held at Atlanta, Georgia, 2015; Vol 1.*
9. Oyeleke SB, Jibrin NM. Production of bioethanol from guinea corn husk and millet husk. *Afr. J. Microbiol*, 2009; 3(4):147-152.
10. Sivamani S, Baskar R. Optimization of bioethanol production from cassava peel using statistical experimental design. *Environ. Prog. Sustainable energy*, 2015; 34:567-574.

Comment [HL14]: The conclusion must be answered the goal of this study. In this study was conducted fermentation of cassava peel using some microorganism, so the conclusion must be answered that.

UNDER PEER REVIEW

