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Production of Bioethanol From Cassava and Sweet Potato Peels

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ABSTRACT

The enzymatic production of Bioethanol from cassava and sweet potato peels was examined using two groups of organisms. *Gloeophyllum sepiarium* and *Pleurotus ostreatus were* used to hydrolyse 20g, 35g and 50g of substrates at 28^0C for 7 days. *Zymomonas mobilis* and *Saccharomyces cerevisiae* were further used to ferment the substrates at 28^0C for 5 days. The fermented liquid was distilled at 78^0C and quantity of ethanol produced determined. When both *G. sepiarium* and *P. ostreatus* were used for hydrolysis and both *Z. mobilis* and *S. cerevisiae* were used for fermentation, 50g of cassava peel and 50g of sweet potato peel yield 11.97g/cm^3 (26%) and 6.5g/ cm^3 (12%) of ethanol respectively. When only *Z. mobilis* was used for fermentation, the mass of bioethanol produced from cassava peels and sweet potato peels were 10.6g/cm^3 (23%) and 5.9g/cm^3(12%) respectively and when only *S. cerevisiae* was used for fermentation, the mass of bioethanol produced from cassava peels and sweet potato peels were 10.36g/cm^3 (22%) and 5.68 g/cm^3 (12%) respectively. When 35g of substrate was used, cassava peel had a yield of 9.64g/ cm^3 (20%) while sweet potatoe peel had a yield of 5.3g/cm^3 (10%). When 20g of substrate was used, cassava peel had a yield of 7.8g/ cm^3 (14%) while sweet potatoe peel had a yield of 4.66g/cm^3 (9%). The study revealed that bioethanol can be produced from cassava and sweet potato peels with maximum yield obtained using *Gloeophyllum sepiarium* and *Pleurotus ostreatus* for hydrolysis and *Zymomonas mobilis* and *Saccharomyces cerevisiae* for fermentation.

Key words: Bioethanol, Hydrolysis, *Gloeophylum sepiarium*, *Pleurotus ostreatus*, *Zymomonas mobilis* and *Sacromyces cerevisae.*

Introduction

Bioethanol is a microbiological way of converting simple sugar into ethanol and carbodioxide (CO_2) [6]. Bioethanol is a principal fuel that can be used as petrol substitute for vehicle [4]. It is a renewable energy source produced mainly by sugar fermentation process, although it can also be manufactured by the chemical process of reacting ethylene with steam [3]. The main sources of sugar required to produce ethanol come from fuel or energy crops [11]. These crops include maize, cassava and cassava products, wheat crops, waste straw, guinea corn husk, rice husk, millet husk, sawdust and sorghum plant. Ethanol is a high octane fuel and has replaced lead as an octane enhancer in petrol [17].

By blending ethanol with gasoline we can also oxygenate the fuel mixture so it burns more completely and reduces pollution emission. Ethanol fuel trends are widely sold in the United State. The most common blend is 10% ethanol and 90% petrol (E_{10}) and vehicle engines require no modification to run on E_{10} and vehicle warranties are unaffected also [14]. Ethanol derived from biomass is the only liquid transportation fuels that do not contribute to the green house gas effect [15,12,3]. Ethanol has been produced in batch fermentation with fungi strains such as *Aspergillus niger*, *Mucor mucedo*, *Saccharomyces cerevisiae* that cannot tolerate high concentration of ethanol [13,18,22].

The objective of the study is to produce bioethanol from sweet potatoes peels and cassava peels through fermentation using *Saccharomyces ceevisiae* and *Zymomonas mobilis*.

Materials And Methods

Samples Collection:

Four hundred grams (400g) each of sweet potatoe peels and cassava peels were collected from Kasuwa Gwari market wastes dump site in Minna. These were asceptically collected in a polythene bag

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and taken to Microbiology laboratory of Federal University of Technology, Minna, Niger State, Nigeria, for further analysis.

The organisms used were *Gloeophyllum sepiarium, Pleurotus ostreatus, Zymomonas mobilis and Saccharomyces cerevisiae*. These were collected from stock cultures of Microbiology Laboratory of Federal University of Technology, Minna, Niger State, Nigeria. The cultures were characterized and confirmed using morphological and biochemical methods described by Domsch and Gams [7], Holts, *et al*. [9], Obire [16], Cheesbrough [5], Oyeleke and Manga [19].

Bioethanol Production:

The methods used for Bioethanol production includes; enzyme hydrolysis, fermentation and distillation process.

Enzyme hydrolysis:

Different quantities of the substrates was weighed inside separate 500cm^3 conical flasks; carried out in quadruple (i.e.20grams each in four different conical flaks, 35grams each in another sets of four conical flasks and 50grams in another four different conical flasks). Sterile distilled water was added to make up to the mark and the flasks were plunged with sterile cotton wool wrapped in aluminium foil to avoid contamination. The mixtures were sterilized in an autoclave at 121^{0}C for 15 minutes, allowed to cool and sterile distilled water was aseptically added to make up to mark again. Freshly harvested cells of *Gloeophyllum sepiarium* was inoculated into a set of 20grams, 35grams and 50grams of each substrates mixture under aseptic condition. *Pleurotus ostreatus* was also added aseptically to another set of each of the substrate mixtures (20g, 35g and 50g). *Gloeophyllum sepiarium* and *Pleurotus ostreatus* was added into another set of the flasks containing the mixtures while the other set serves as control for the two substrates. The flasks were covered and were then incubated at room temperature (28^{0}C) for seven days. The flasks were shaken at interval to produce a homogenous solution and even distribution of the organisms in the substrates mixture. The mixtures were separately filtered after seven days using No 1 Whatman filter paper.

Fermentation:

Supernatant from the above hydrolysis process were transferred into another sets of conical flasks correctly labelled, covered, autoclaved at 121^{0}C for 15 minutes and allowed to cool. Freshly harvested cells of *Zymomonas mobilis* was aseptically added into a set of flasks containing the hydrolysed supernatants (20g, 35g and 50g supernatants) and *Saccharomyces cerevisiae* was also added into another set of hydrolysed supernatant. The two organisms were combined into the third set of the hydrolysed supernatants while the control set still served as control. The flasks were corked using cotton wool, shake and incubated at room temperature (28^{0}C ±2^{0}C) for five days. The flasks were shaken at interval to produce a homogenous solution and even distribution of the organisms in the substrates mixture.

Distillation:

This was carried out at using distillation apparatus (set up). The fermented liquid was transferred into round bottom flask and placed on a heating mantle fixed to a distillation column enclosed in running tap water. Another flask was fixed to the other end of distillation column to collect the distillate at 78^{0}C (standard temperature for ethanol production). This was done for each of the fermented broth.

Determination of Quantity of Ethanol Produced:

The distillate collected was 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 (0.8033g/cm^3) [10].

Determination of Ethanol Concentration:

Ethanol concentration was determined by comparing the density of the ethanol produced with the standard ethanol density curve. Standard ethanol curve was obtained by taking series of percentage (v/v) ethanol (10%, 20%, 30%, 40% and 50%) solution which were prepared in a 100ml volumetric flask and the weights were measured as described by Amadi, *et al*. [2], Oyeleke and Jibril [20]. The density of each of the prepared ethanol solution was calculated and a standard curve of density against percentage ethanol (v/v) was plotted.

Results:

Bioethanol Produced from Cassava Peel:

Table 1 shows the volume (cm^3), mass (g/cm^3) and percentage yield of biethanol (%) of bioethanol produced from cassava peel when hydrolysed with *Gloeophyllum sepiarium* and *Pleurotus ostreatus* and fermented with *Zymomonas mobilis and Saccharomyces cerevisiae*. Maximum yield of 11.97g/cm^3 with a concentration of 26% was produced from cassava peel when *S. cerevisiae and Z. mobillis* was used for fermentation.

Bioethanol Produced from Sweet Potato Peels:

Table 2 shows the volume (cm^3), mass (g/cm^3) and percentage yield (%) of bioethanol produced from sweet potato peel as a result of enzyme hydrolysis with *Gloeophyllum sepiarium* and *Pleurotus ostreatus* and fermention with *Zymomonas mobilis and Saccharomyces cerevisiae*. $6.5g/cm^3$ with a concentration of 12% was the highest yield of ethanol produced.

Table 1: Bioethanol Produced from Cassava Peel.

Qty (g)	Microorganisms Hydrolysis	Fermentation	Volume of Bioethanol Produced (cm^3)	Mass of Bioethanol (g/cm^3)	percentage yield (Conc) (%)
20	*G. sepiarium*	*S. cerevisiae*	8.4	6.75	12
20	*P. ostreatus*	*Z. mobillis*	9.1	7.31	13
20	*G. sepiarium* + *P. ostreatus*	*S. cerevisiae* + *Z. mobillis*	9.7	7.80	14
35	*G sepiarium*	*S. cerevisiae*	9.0	7.23	12
35	*P. ostreatus*	*Z. mobillis*	11.0	8.84	16
35	*G. sepiarium* + *P. ostreatus*	*S. cerevisiae* + *Z. mobillis*	12.0	9.64	20
50	*G. sepiarium*	*Z. mobillis*	13.2	10.60	23
50	*P. ostreatus*	*S. cerevisiae*	12.9	10.36	22
50	*G. sepiarium* + *P. ostreatus*	*S. cerevisiae* + *Z. mobillis*	14.9	11.97	26

Table 2: Bioethanol Produced from Sweet Potato Peel.

Qty (g)	Microorganisms Hydrolysis	fermentation	Volume of Bioethanol Produced (cm^3)	Mass of Bioethanol (g/cm^3)	Percentage Yield (conc) (%)
20	*G. Sepiarium*	*S.cerevisiae*	4.2	3.37	6
20	*P. ostreatus*	*Z. Mobillis*	5.4	4.34	6
20	*G .sepiarium* + *P .ostreatus*	*S. cerevisiae* + *Z. Mobillis*	5.8	4.66	9
35	*G .sepiarium*	*S.cerevisiae*	5.7	4.58	7
35	*P. ostreatus*	*Z. mobillis*	5.9	4.74	10
35	*G. sepiarium* + *P ostreatus*	*S. cerevisiae* + *Z .mobillis*	6.6	5.30	10
50	*G. sepiarium*	*Z. mobillis*	7.4	5.90	12
50	*P. ostreatus*	*S. cerevisiae*	7.2	5.78	12
50	*G. sepiarium* + *P .ostreatus*	*S. cerevisiae* + *Z. Mobillis*	8.1	6.51	12

Discussion:

The enzymatic production of bioethanol from cassava and sweet potato peels was analysed using *Gloephyllum sepiarium and Pleurotus ostreatus* to hydrolyse the substrates and fermented with *Zymomonas mobilis and Saccharomyces cerevisiae*. The result revealed that *Z. mobilis* has a maximum yield of ethanol ($10.6g/cm^3$) and from $5.9g/cm^3$ from cassava peels and sweet potato peels respectively while *S cerevisiae* has a maximum yield of $10.36g/cm^3$ and $5.78g/cm^3$ from cassava and sweet potato peels respectively; this result reveals a higher

production by *Z. mobilis* than *S. cerevisiae*. This may be because *Z. mobilis* posseses pyruvate decarboxylase and alcohol dehydrogenase as reported by Gunasekran and Chandra [8] as the key enzymes in ethanol production and they tends to facilitate continuation of fermentation at high concentration of ethanol, they also stated that comparative laboratory- and pilot-scale studies on kinetics of batch fermentation of *Z. mobilis* versus a variety of yeast have indicated the suitability of *Z. mobilis* over yeasts due to its higher sugar uptake and ethanol yield, its lower biomass production and its higher ethanol tolerance, all these might be responsible for high ethanol produced from both cassava and sweet potato peels. When the organisms were mixed, maximum bioethanol yield of 11.97g/cm^3 (26%) for cassava peel and 6.5g/cm^3 (12%) for sweet potato peel was produced and these could be because the two organisms have potential to produce ethanol which makes them produce more when in combination than when used separately.

The result also revealed maximum yield of ethanol 12g/cm^3 (26%) for cassava peel and 6.5g/cm^3 (12%) for sweet potato peels respectively. This could be due to presence of more carbohydrate which could be fermented to ethanol in cassava peels than in sweet potato peels.

Average ethanol yield (concentration) of 17.6% produced from cassava peels is more than the average ethanol yield (concentration) reported by Agunlejika, *et al*. [1] who reported an average ethanol concentration of 16% from spoilt mangoes. This is likely due to presence of more carbohydrate content in cassava peel than in spoilt mangoes. But this agreed with Oyeleke, *et al*. [21] who reports an average ethanol yield (concentration) of 17.6% from spoilt fruits.

Average ethanol yield (concentration) of 9.3% produced from sweet potato peel is in contrast with Agunlejika, *et al*. [1] who reported average ethanol yield (concentration) of 16% from spoilt fruits and Oyeleke and Jubril [20], who reported percentage ethanol concentration of 67.7% and 63.8% as observed when *A. niger* and *Z. mobilis* were used simultaneously on guinea corn husk and millet husk respectively. This could be because of more carbohydrates content in spoilt mango, guinea corn husk and millet husk than in sweet potato peels.

The result of this study confirmed that ethanol can be produced from cassava and sweet potato peels which are agricultural wastes. More ethanol was produced from cassava peels than from sweet potato peels, thus making cassava peel a better alternative to sweet potato peel, as well as spoilt fruits. The use of cassava and cassava peels is a worthwhile venture for ethanol production; considering their cost and because it is a means of controlling environmental pollution since bioconversion of cellulosic biomass into fermentable sugar for production of ethanol was done using cellulose degrading microorganisms, thus making bioethanol production economical and environmentally friendly and also renewable.

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