

Full Length Research Paper

Estimation of proximate composition and biogas production from *in vitro* gas fermentation of sweet potato (*Ipomea batatas*) and wild cocoyam (*Colocasia esculenta*) peels

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The proximate composition in terms of percentage dry matter (DM), crude protein (CP), crude fibre (CF), ether-extract (EE), ash, nitrogen free extract (NFE) and carbohydrate of sweet potato peel (SPP) and wild cocoyam peel (WCP) were determined. Buffered and sieved goat's rumen liquor was added to 200 mg of dried and milled SPP and WCP in 100 ml syringes supplied with CO₂ under anaerobic condition and incubated for 24 h. Total biogas produced was measured at 3 h intervals till the 24th h when the fermentation was terminated. The inoculum was also incubated separately. All treatments were replicated three times and readings were taken in duplicates. The proximate composition of SPP and WCP were similar except for the higher EE content (12%) of SPP. The SPP and WCP used contained 26.81 and 26.97% DM, 3.06 and 3.83% CP, and 78.94 and 79.17% carbohydrate respectively. Both samples had the same crude fibre (7.00%) content. Total biogas produced from SPP, WCP and the inoculum varied from 13.0, 11.0 and 5.0 ml respectively at the 3rd h through 66.5, 61.5 and 18.0 ml at the 18th h to 77.5, 72.0 and 30.0 ml at the 24th h respectively. The differences in biogas production across the treatments were significant ($p < 0.05$). There were no significant differences ($p > 0.05$) in the volumes of methane produced from SPP (42.5 ml) and WCP (39.5 ml) which were significantly ($p < 0.05$) higher than 20.0 ml produced by the inoculum. Fermentation is a cheap method to produce methane gas as fuel for domestic and industrial use, which may sanitize the environment from pollution. The remaining residue can be used as livestock feed.

Key words: Biogas production, fermentation, sweet potato peel, wild cocoyam peel.

INTRODUCTION

With increase in the production of tubers like yam, cocoyam, potatoes, cassava etc. from farms in Southern Nigeria, there is an overabundant supply of peels generated from their processing. Only a small portion of the peels are used as feed for ruminants and swine. The rest are thrown away and it piles up, rotten with foul smell as

a result of fermentation and putrefaction processes by microbes and thereby constituting a nuisance as it pollutes the environment. Due to geometric population growth rate across the globe, there is increasing demand for domestic gas and other aliphatic hydrocarbons. In the USA and some other countries like Japan and India, homes are now utilizing biogas especially methane (CH₄) produced from animal dung such as swine dung as domestic fuel (Fantozzi and Buratti, 2009; Lehtomaki et al., 2007; Alvarez et al., 2006; Ghose et al., 1979). In recent times, research has gone a step further into biogas production from other animals such as ruminants which as a result of the metabolic activities of their rumen micro-organisms (especially the methanogens - methane producing bacteria) on the feed through the process known

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Abbreviations: DM, Dry matter; CP, crude protein; CF, crude fibre; EE, ether-extract; NFE, nitrogen free extract; SPP, sweet potato peel; WCP, wild cocoyam peel.

as "Biodegradation", are capable of producing about 68% methane gas together with traces of Carbon dioxide (CO₂), hydrogen (H₂) and negligible quantity of ammonia (NH₃) gas (Menkel et al., 1979).

About 8% of the energy in diets eaten by ruminants had been reported to be released in the form of methane (Chesworth et al., 1998). Currently, a large-scale production of biogas from ruminants dung has been embarked upon in Africa by Songhai farms in the Republic of Benin (Songhai@sobiex.bj/www.songhai.org). For this reason, biogas has been made an alternative fuel which can replace hydrocarbons from crude oil. Biogas production is basically the result of fermentation of carbohydrate to acetate, propionate and butyrate (Blumel and Orskov, 1992). The Methane (CH₄) gas produced from carbohydrate fermentation of animal dung is very useful as domestic gas fuel, as boiler fuel for industries, as source of heat energy which can be used in heating hatcheries and residential apartment during very cold weather (Parsson and Bartlett, 1981). Biogas production will help to create employment opportunities for the potential producer and marketer apart from sanitizing the environment of indiscriminately dumped agro-industrial by products, refuse and animal dung. The aims of this study are to determine the proximate composition of wild cocoyam (*Colocasia esculenta*) and sweet potato (*Ipomea batatas*) peels and to estimate the amount of biogas production in terms of methane and carbon dioxide produced when these peels are fermented or degraded by rumen-micro-organism *in vitro*.

MATERIALS AND METHOD

Test materials

Wild cocoyam (*Colocasia esculenta*) and sweet potato (*Ipomea batatas*) tubers were acquired from the University of Ibadan, and peeled.

Determination of moisture content

These peels were weighed separately and oven dried at 105°C until constant weights were obtained. Percentage moisture content was calculated as the difference between the fresh and oven dried weights expressed as a percentage of the initial fresh weights. The percentage dry matter was then calculated thus: % dry matter (DM) = 100 - moisture content.

Proximate analysis

The ash, ether extract, crude fibre and crude protein components of the dried samples were determined according to the procedure of AOAC (1990) from which the Nitrogen Free Extract (NFE) and carbohydrate (CHO) constituents were calculated.

In-vitro incubation

Rumen liquor was collected from four (4) West African Dwarf (WAD) goats previously fed and allowed to graze on *Panicum*

maximum for 3 days with adequate supply of water in order to activate the microbial activities in the rumen. The rumen content of goats was then collected by the improvised technique of using sterile rubber tubing via the mouth and oesophagus through anti-peristaltic movement and suction. The rumen liquor collected was kept in a thermos flask and taken to the laboratory where the content was sieved, using a clean cheese cloth into a medium bowl with a constant supply of CO₂ gas so as to maintain the anaerobic condition of microorganisms. McDougha's buffered solution was added to the sieved liquor at ratio 2:1 to make the inoculum. MacDougha's solution contained (g/liter) NaHCO₃, 9.80; NaHPO₄.12H₂O, 8.98; KCl, 0.57; NaCl, 0.47; MgSO₄ anhydride, 0.06; and CaCl₂ anhydride, 0.04 (Nahm, 1992).

Inoculation

200 mg each of the milled dried samples that is WCP and SPP was separately weighed into 100 ml lubricated plastic syringes. Fermentation was initiated by adding the inoculum (buffered rumen liquor) to the 30 ml mark. The affirmed silicon tube to the pointed end of the syringe was clipped tightly so as to prevent the escape of gas. A control treatment contained only the buffered rumen liquor inoculum without the substrate (sweet potato and wild cocoyam peels). All the treatments were replicated three (3) times.

Incubation

The syringes were incubated at a temperature of 39°C for 24 h and the volumes of biogas produced were constantly read at 3 h intervals (that is at the 3rd, 6th, 9th ... 24th h respectively). Fermentation was terminated after 24 h period by introducing 4.0 ml of 10.0 M Sodium Hydroxide (NaOH) solution into the syringes via the silicon tubes to absorb the Carbon (IV) Oxide gas to form Sodium Carbonate (Na₂CO₃) solution which caused the volume of biogas produced to be reduced. The reduced volume was measured as the volume of (CH₄) gas while the trapped volume was the volume of CO₂ gas produced.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) and the respective means were separated using the Duncan option of the General linear model (GLM) procedure of SAS (1999).

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of wild cocoyam peel (WCP) and sweet potato peels (SPP). Results of the proximate analyses revealed that WCP and SPP contained 73.03 and 73.19% moisture content or 26.97 and 26.81% dry matter respectively. The WCP and SPP had similar proximate composition (Table 1). Both had low CP, CF, but were rich in CHO. Values obtained for the DM (26.97%), EE (9.00%) and NFE (72.17%) in WCP were higher than the values (17.62, 2.05 and 37.89%) previously reported (Oyenuga, 1968) for the same sample. However, values obtained for CP (3.83%), CF (7.00%) and ash (8.00%) were lower than the values reported for WCP by Oyenuga (1968). The DM, CF, ash and EE contents of SPP were higher than the values (11.73, 0.34, 4.55 and 1.34% respectively) reported by Oyenuga

Table 1. Proximate composition of wild cocoyam peel (WCP) and sweet potato peel (SPP).

Sample	%DM	%CP	%CF	%Ash	%EE	%NFE	%CHO
WCP	26.97	3.83	7.00	8.00	9.00	72.17	79.17
SPP	26.81	3.06	7.00	6.00	12.00	71.94	78.94

Table 2. *In-vitro* biogas production from fermented SPP, WCP and the inoculum.

Treatment	Volume (ml) of									
	Total Biogas								C0 ₂	CH ₄
	3 h	6 h	9 h	12 h	15 h	18 h	21 h	24 h	24 h	24 h
Fermented SPP	13.00 ^a	31.00 ^a	41.00 ^a	53.67 ^a	61.00 ^a	66.50 ^a	71.00 ^a	77.50 ^a	35.00 ^a	42.50 ^a
Fermented WCP	11.00 ^a	21.00 ^b	35.00 ^b	45.50 ^b	54.50 ^b	61.50 ^b	70.00 ^a	72.00 ^b	32.50 ^a	39.50 ^a
Inoculum	5.00 ^b	7.00 ^c	13.00 ^c	15.00 ^c	17.00 ^c	18.00 ^c	24.00 ^b	30.00 ^c	10.00 ^b	20.00 ^b
SEM	0.41	0.47	0.27	0.40	0.29	0.42	0.32	0.55	0.48	0.68

NOTE *a.b.c Means with different superscripts along the same column are significantly ($p < 0.05$) different.

(1968), while the CP and the NFE contents of SPP obtained in this study were lower than 6.33% CP and 87.44% NFE reported by Oyenuga (1968). It was however seen from the analysis that SPP has more oil (12.00% EE) than WCP (9.00% EE). This could probably be due to the exudates from the juicy peels of sweet potato, when freshly peeled and this explains why sweet potato can store longer than cocoyam without dehydrating since oil ordinarily prevents loss of water from the tuber through dehydration.

Table 2 showed the *in-vitro* biogas production from fermented SPP and WCP and the inoculum. The production of biogas at the 3rd h of incubation was an indication that degradation or fermentation has commenced. At the 3rd h 13.0 and 11.0 ml of biogas were produced by the fermented SPP and WCP respectively which were not significantly ($p > 0.05$) different but significantly ($p < 0.05$) higher than the biogas produced (5 ml) by the inoculum. Biogas production from SPP, WCP and the inoculum were 31.0, 21.0 and 7 ml respectively at the 6th h, 41.0, 35.0 and 13.0 ml at the 9th h, 53.67, 45.50 and 15.0 ml at the 12th h, 61.0, 54.5 and 17.0 ml at the 15th h, 66.5, 61.5 and 18.0 ml at the 18th h respectively. There were significant ($p < 0.05$) differences in the biogas produced from the three treatments with SPP producing the highest biogas value, followed by WCP and the inoculum alone producing the lowest biogas. The same trend was observed at the 24th h. At the 21st h there were no significant ($p < 0.05$) difference in biogas production from SPP (71 ml) and WCP (70 ml) which were significantly higher than that of the inoculum (24 ml). At the end of the 24th h of fermentation, 35 ml of CO₂ were produced from the degraded SPP and 32.50 ml of CO₂ were produced from WCP which were significantly ($p < 0.05$) higher than 10 ml produced from the inoculum. Methane was the useful biogas produced from the fermentation. Similar

amounts of methane were produced from both SPP and WCP fermentation. Without substrate, only about half the methane was produced. About 45.84 and 54.86% of biogas produced from SPP and WCP respectively was methane which can serve as domestic gas fuel or used industrially. The methane gas generated can be passed through a hose with clip and can be used as domestic fuel by connecting it to a burner in the kitchen. A tripod can be constructed upon which the cooking utensils like pot can be placed while the burner is placed underneath. Mongami et al. (2006) had reported that goats are capable of producing between 60.00 - 88.15% methane of the total biogas. The *in vitro* gas fermentation method allows prediction of biogas production on a large scale. Assuming the fermentation rate of 0.2 ml methane per mg peel in 24 h, a kg of peel will produce about 213 l of methane. Biogas production will reduce the cost of heating in homes and serve as alternative source of fuel especially in Nigeria with ever-increasing price of petroleum fuel and its incessant artificial scarcity. It will also reduce environmental pollution. Parsson and Bartlett (1981) had asserted that biodegradation for biogas production had helped in sanitizing the environment by preventing indiscriminate dumping of agro-industrial by products. The substrate or residue after fermentation can be oven dried and used as feeding stuff for both monogastric and ruminant animals.

Conclusion and recommendations

Both SPP and WCP have close nutrient compositions and they are cheap and readily available. The use of SPP and WCP to produce biogas will provide larger volume of methane for domestic and industrial use, control environmental pollution and prevent exposure to health

hazards. Large volume of SPP, WCP and other agro-industrial by products can be fermented for longer incubation period to generate more methane gas.

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