International Journal of Engineering Research and General Science Volume 6, Issue 2, March-April, 2018
ISSN 2091-2730

Comparative study of co-digestion of composted mixtures of cassava peels and coffee pulp with or without cow dung.

Nkodi* T.M[1], Kayembe J.S[2]., Biey M. E [3].and Taba K.M[2]
[1]Department of Petrochemistry, Faculty of Gas, Oil and New Energies, University of Kinshasa.
[2]Department of Chemistry and Industry, Faculty of Sciences, University of Kinshasa
[3] Department of environment sciences, Faculty of Sciences, University of Kinshasa.
Corresponding Author: E-mail: nkoditimothee@gmail;com,

Abstract- This work aims to study co-digestion of composted mixture of cassava peels and coffee pulp with cow dung .Cassava peels was mixed with coffee pulp in the following ratios by weight, 1:1, 3:1, 1:3, Cassava peels alone (1:0) and coffee pulp alone (0:1) served as controls. The mixtures and controls were submitted to composting for 30 days then placed in five digesters C1 for 1:1 blend,C2 for 3:1 blend,C3 for 1:3 blend , C4 for cassava peels alone and C5 for coffee pulps alone. Another batch of five digesters consisting of each composted mixture of cassava peels and coffee pulps to which was added equal amount of cow dung labeled as follows: CB1, CB2, CB3, CB4 and CB5. Biodigestion was conducted under mesophilic conditions into 5L biodigesters with a loading rate of 5% of total solids. Biogas production was measured by using water displacement method for 35 days. The highest cumulative volume of biogas was produced by composted mixture with cow dung and the yield decreased in the following order 16.50, 15.38, 15.07, 12.68 and 10.97L/KgTS respectively for CB3>CB1>CB5>CB2>CB4. The composted mixture alone yielded the following amount of biogas: 10.26, 9.11, 8.86, 7.50, and 7.07L/KgTS respectively for C1, C5, C4, C3 and C2. Co-digestion of the composted mixture of cassava peels and coffee pulps with cow dung can be considered as a good system to enhance biogas production from cassava peels.

Key words: biomethanization, cassava peels, coffee pulp, co-digestion, biogas.

1. Introduction

The rapid growth of World population lead to fast urbanization, increase industrialization, waste generation and energy consumption (Ojolo et al., 2007, Sun and Cheng 2002, Subramani and Ponkumar, 2012). To feed the growing population, agriculture and animal production have to be increased (Habtamu Lemma, 2014) and consequently the generation of large amount of organic solid wastes. These improperly manage leads to uncontrolled dumping and create serious environment problems (Oparaku et al., 2013; Ojolo et al., 2007).

One way in which energy consumption and organic solid waste management problems could be solved is by biomethanization to produce biogas and digestate. Biogas has about 55 to 65% of methane gas and 30 to 45% of carbon dioxide. Biogas can be used as replacement of natural gas in industrial and domestic consumption whereas digestate obtained from anaerobic digestion, could be used as fertilizer for crops and vegetables, as feed for fish ponds and livestock and as material to produce charcoal briquette (Akwaka et al., 2014; Lennart and Anne, 2013).

Cassava (*Manihot Esculenta Grats*) is the main source of carbohydrates for human population in Sub-Saharan Africa (Oparaku at al., 2013). DR Congo is the second producer in Africa after Nigeria. In the process of cassava roots, wastes (mostly peels) which constitute one third of the weight of the roots are discarded.

Of the many ways to recycle cassava peels, anaerobic digestion is considered a major promising process. Adelekan and Bamgboye (2009) reported that cassava peels alone produced less biogas than when it's mixed with animal manure and biogas yield depended on the type of manure and on the ratio of cassava peels to the livestock wastes. They showed that the highest cumulative yield of biogas (21.3L/kgTS) was achieved by mixing cassava peels with cow waste in a ratio of 1:1, whereas cassava peels alone produced 0,6L/KgTS.

We reported recently biodigestion of cassava peels with various amount of urea. The highest biogas yield (80.82L/KgTS) was obtained with 0.01% of urea mixed with cassava peels (Nkodi et al., 2016). Co-digestion of cassava waste with agriculture biomass waste have received less attention, therefore, we set here to investigate co-digestion of cassava peels with coffee pulp in different ratio for biogas generation.

Coffee is among the largest export agriculture products of DR Congo. The process of coffee leaves a large amount of waste (80,000 tons /yearly) which is discarded. It is reported that composting coffee pulp prior to its digestion achieved large amount of biogas (Taba et al., 1999). Coffee pulp compost could be obtained in 20 days while in the due process the C/N ratio value decreases from 43.4 to 22, a value favorable for biodigestion (Kayembe et al., 1999).

Hence, in this work cassava peels and coffee pulp were mixed in different ratio and composted for 30 days prior to anaerobic digestion. Then to each of the composted mixture was added equal amount of cow dung. The obtained mixtures of these three wastes (cassava peels, coffee pulp and cow dung) were also submitted to anaerobic digestion.

2. Materials and methods

2.1. Material

Cassava peels were collected from Mbanza-Lemba (Kinshasa) market and pretreated as previously reported to remove cyanide (Nkodi et al., 2017). Coffee pulp was obtained from the African Coffee Company in Kinshasa/Kingabwa. Cow dung was obtained from the slaughterhouse in Masina/ Kinshasa and kept in cold until used. Standard methods were used to determine the proximate composition of materials (pH, moisture, total solids, organic matter, organic carbon and ash) before and after composting.

2.2. Composting

Cassava peels (CaP) were mixed with coffee pulp (CoP) in the following ratios 1:1 (CaP/CoP), 3:1 (CaP:CoP) and 1:3(CaP/CoP) by weight. Cassava peels alone (1:0) and coffee pulp alone (0:1) with the same total solids weight as the mixture, served as control. Each mixture and the controls were placed in polyethylene bags of 10L and composted for 30 days as described by Kayembe et al. (1999).

Composted mixture of Cassava peels and Coffee pulp were then put in five digesters labeled as followed C1 for 1:1 mixture, C2 for 3:1 for mixture, C3 for3:1 mixture, C4 for cassava peels alone (1:0) and C5 for coffee pulp alone (0:1).

To another part of each composted mixture and controls was added equal amount of cow dung by weight (1:1) and placed in the following five digesters labeled as followed, CB1 for 1:1 composted mixture (CaP/CoP), CB2 for the 3:1 composted mixture CaP:CoP),CB3 for the 1:3 composted mixture (CaP:CoP),CB4 for composted cassava peel alone and CB5 for composted coffee pulp alone. The different digesters composition are shown in table 1

Table 1: Composition of various digesters

Ratio CaP:CoP (gTS/gTS)	Digesters	Ratio CO:CD (gTS/gTS)	Digesters
1:1	C1	1 :1	CB1
3:1	C2	1 :1	CB2
1:3	C3	1 :1	CB3
1:0	C4	1 :1	CB4
0:1	C5	1 :1	CB5

CaP: cassava peels, CD: cow dung, CoP: coffee pulp, CO: compost and gTS: gram of total solids.

2.3. Biogas production essays

Each of the ten digesters had a working volume of 5L; the slurry was made with distilled water and then loaded to about three quarter of working volume to achieve 5% of total solids (TS). Digesters were shaken manually twice daily, morning and evening and the volume of biogas produced was measured by water displacement method. Experiments were conducted in mesophilic conditions and the retention time dependent on the essays. Each experiment was carried out in triplicate

3. Results and discussion

A. Physico-chemical properties of substrates

The physico-chemical parameters of feedstock are presented in tables 2, while those of mixture before and after composting are shown in tables 3 and 4 respectively.

Table 2: Physicochemical properties of feedstock

Parameter	Cassava peels	Coffeepulp	Cow dung
pH	5.30± 0.31	7.13±0.32	8.13±0.55
Moisture (%)	12.16 ±0.73	12.63±2.62	80.59±0.81
Total solids (%)	87.84±0.73	87.37±2.62	19.41±0.77
Organic matter (%)	95.98±0.28	91.88±0.32	88.56±5.90
Organic carbon Total (%)	53.32±0.16	51.04±0.18	49.20±3.39
Ash (%)	4,03±0,28	8,12±0,32	11.44±5.90

Cassava peels have acidic pH due most likely to the presence of cyanogenic glycosides (Cuzin et al.1992; Ofoefule and Uzodimna, 2009), cow dung has a slightly basic pH (8.13) and coffee pulp have a neutral pH of 7.13 (Table 2). Total solids and ash obtained from the substrate are closed to those reported by other researchers (Steiner, 2011; Habtamu, 2014 and Corro, et al., 2013). According to Steiner (2011), coffee pulp can be digested as mono-charge without inhibiting the process and it is a good bioresource for methane generation because of its high nutrient content.

Table 3: Physicochemical properties of cassava peels blended with coffee pulp before composting

Composter / Parameter	C_1(50%CaP)	C_2(75%CaP)	C_3(25%CaP)	C_4(100%CaP)	C_5(0%CaP)
pH	6.2±0.20	5.5±0.1	6.7±0.1	5.2±0.1	6.9±0.2
Total Solids (%)	77.59±0.10	82.56 ±1.17	78.56±1.48	87.84 ± 0.73	87.33± 2.59
Organic Matter (%)	93.03 ±0.27	93.95±0.78	91.98± 0.40	95.98 ± 0.28	91.88±0.32
Org. Total Carbon (%)	51.68±0.15	52.19±0.45	51.09± 0.23	53.32 ± 0.16	51.04±0.18
Ash (%)	6.97± 0.27	6.05±0.78	8.02±0.40	4.02± 0.28	8.12±0.32

Table 4.Physicochemical properties of cassava peels blended with coffee pulp after composting

Compost / Parameter	C_1(50%CaP)	C_2(75%CaP)	C_3(25%CaP)	C_4(100%CaP)	C_5(0%CaP)
pH	8.4± 0.1	9.0±0.1	7.8±0.1	9,1±0.1	8.5±0.1
Total Solids (%)	71.8 ±3.25	79.05±0.48	74.12±10.2	84.11±0.86	55.64±0.98
Organic Matter (%)	68.01±0.44	69.05±0.18	64.19±0.11	62.00±0.92	80.01±0.15
Org.Total Carbon (%)	37.78±0.25	38.36±0.10	35.66±0.06	34.44±0.53	44.45±0.09
Ash (%)	31.99±0.44	30.95±0.35	35.81±0.11	38.00±0.92	19.99±0.15

Physicochemical parameters of cassava peels mixed with coffee pulp before and after composting are shown in tables 3 and 4. The pH of the mixture moved from neutral to slightly basic after composting, a favorable pH for biomethanisation. The change of pH was very remarkable for cassava peels alone with a change of about 4 units (5.2 to 9.1) It has been pointed out that change in pH could be an indication of bacterial activities during composting. The total organic matter decreased in all the composted mixtures whereas ash increased in the process of composting which is a clear indication of significant mineralization during the composting processes (Montgomery and Bochmann, 2014). The slight decrease in organic matters could be due to the low rate of hydrolysis in most biological pretreatment processes (Cheng, 2002). Thus, 30 days of composting could be deficient to allow bacteria to break down all the cellulose cristallinity in solid wastes used.

B. Comparative biodigestion of composted mixture of cassava peels and coffee pulp

The cumulative values of biogas produced from the ten digesters are reported in figure 1.

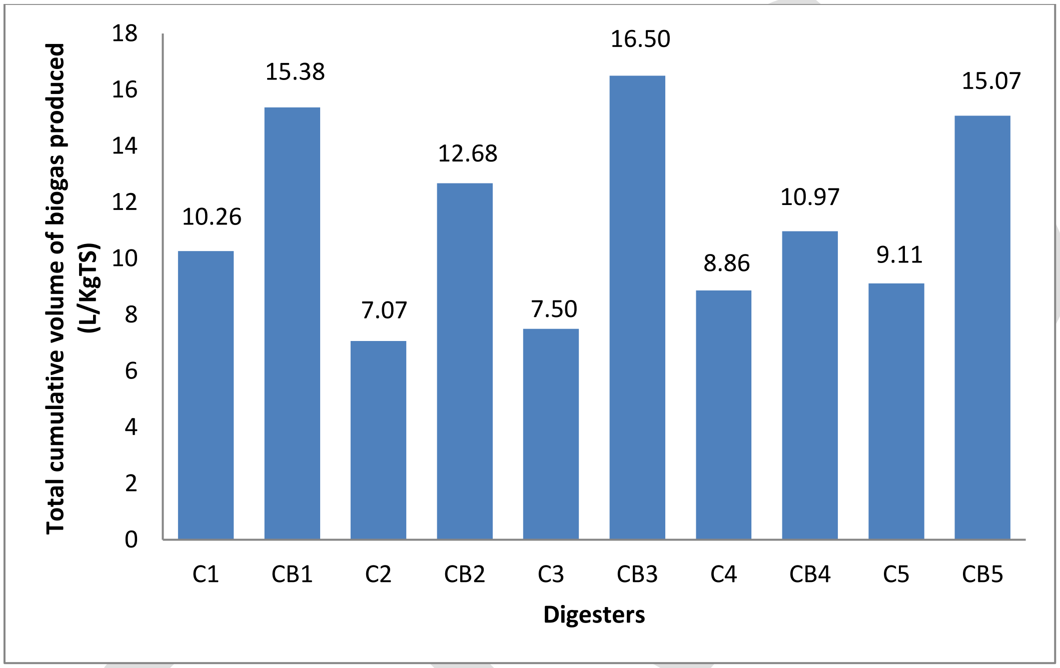

Figure 1. Cumulative volume of biogas produced from biodigesters of different composted mixture of cassava peels and coffee pulp with cow dung.

The cumulative volume of biogas was much higher for the composted mixture of cassava peels and coffee pulps blended with cow dung than the composted mixture alone. Cow dung improved the biogas yield in all the digesters. Composted cassava peels with coffee pulp gave higher biogas yield than the composted of cassava peels alone (C1>C4). This shows that co-digestion of cassava peels with coffee pulp give better results than cassava peels alone. Cassava peels alone gave less biogas than cassava peels mixed with cow dung or with its blend with coffee pulp and cow dung (C4<CB4 or C4<C1). Coffee pulp alone gave more biogas than cassava peels (C5>C4), their mixture with cow dung showed the same CB5>CB4. Increasing biogas production by co-digestion of animal manure to organic solid waste is well documented (Ezekoye Ezekoye (2009); Ofoefule and Uzodimna (2009), Oparaku and al. (2013)). Our results shows that digester CB3 produced the highest amount of biogas (16.50L/KgTS), followed by CB1 (15.38L/KgTS), CB5 (15.07L/KgTS), CB2 (12.68L/KgTS) and then CB4 (10.97L/KgTS). The biodigesters which produced the highest amount of biogas (CB3 and CB1) were made by 50% of compost and 50% cow dung respectively. The cumulative biogas obtained for composts alone decreased in the following order of the mixture (peels-coffee pulp): 1:1>0:1>1:0>1:3>3:1 respectively for digester C1>C5>C4>C3>C2. Digester C1 produced 10.26L/KgTS of biogas with a mean daily production of 0.29L/KgTS per day, while digesters C4 and C2 with higher quantity of cassava peels 100% and 75% respectively, produced 8.86 and 7.07L/KgTS respectively. It means that different combination of wastes can give different composition of nutrients (Oparaku et al., 2013). It is found that the yield of the digester CB1 were lower (15.38L/KgTS) than that of digester CB3 (16.50L/KgTS) containing (37.5% pulp;

12.5% peels; 50% dung) (Adelekan and Bamgboye (2009). The lower biogas production in digester CB1 could be due to the low presence of coffee pulp (25%), rich in nutrients (C: 58.5%, N: 1.3%), (Pujol, D. et al., 2013).

4. Conclusion

In this work, two set of experiments were carried out for producing biogas: composted mixture of cassava peels and coffee pulp alone and then composted mixture with cow dung by varying quantities. The combination of compost with cow dung yielded the largest volume of biogas on the cumulative basis than the compost alone. After 35 days of digestion, the highest cumulative volume of biogas flammable at the 4th day was produced by the compost mixed with cow dung and the cumulative yields were 16.50, 15.38, 15.07, 12.68 and 10.97L/KgTS respectively for CB3>CB1>CB5>CB2>CB4. However, composts alone produced biogas in the following order 10.26, 9.11, 8.86, 7.50 and 7.07L/KgTS respectively for C1, C5, C4, C3 and C2. This work showed that co-digestion of composted mixing of cassava peels and coffee pulp give more biogas than any single substrate antd that addition of cow dung to composted mixture improve tremendously of biogas production.

REFERENCES:

1. Akwaka, J-C., Kukwa, D.T. and Mwekaven, S.S. (2014). Preliminary study on co-digestion of cow manure with pretreated sawdust for production of biogas and biofertilizer. IJST, vol.(3):4, pp.222-228.
2. Corro G., Paniagua L., Umapada P., Bañuelos F. and Minerva R. 2013. Generation of biogas from coffee-pulp and cow-dung co-digestion: Infrared studies of postcombustion emissions. Energy Conversion and Management, 74: 471–481
3. Corro, G., Umapada Pal & Surinam Cebeda. (2014). Enhanced biogas production from coffee pulp through deligninocellulosic photocatalytic pretreatment. Energy science & Engineering published 2(4):177-187.
4. Esposito, G., Frunzo, L.; Liotta, F.; Panico, A.; Pirozzi, F. (2012). Bio-Methane potential tests to measure the biogas production from the digestion and co-digestion of complex organic substrates. Open J.Environ. Eng. 5: 1-8.
5. Estevez, M.M., Linjordet, R., and Morken, J. (2012b). Effects of steam explosion and co-digestion in the methane production from Salix by mesophilic batch essays. Bioressour.Technol. 104, 749-756.
6. Ezekoye, V.A. and Ezekoye, B.A.(2009). Characterization and storage of biogas produced from the anaerobic digestion of cow dung, spent grains/cow dung and cassava peels/rice husk. The Pacific Journal of Science and Technology, vol.10 (2), pp.898-904.
7. Habtamu Lemma Didanna, (2014).A critical review of feed value of coffee waste for livestock feeding. World Journal of Biology and Biological Sciences Vol. 2 (5), pp. 072-086.
8. Kayembe S.,Yengula H.M., Ndunga D., Litanga J., Taba K.M., (1999). Compostage contrôlé des parches de café, Med.Fac.Landbouww, Univ.Gent ; 64/1,281-284.
9. Montgomery, L.F.R. and Bochmann, G. (2014). Pretreatment of feedstock for enhanced biogas production.IEA Bioenrgy.
10. Mshandete, A., Bjornsson, L., Kivaisi, A.K., Rubindama-Yugi, M.S.T., Mattiasson, B. (2006). Effect of particle size on biogas yield from sisal fibre waste.Renewable Energy 31, 2385-2392.
11. Nkodi T.M., Taba, K.M., Kayembe, S., Mulaji, C. and Mihigo, S. (2016). Biogas production by co-digestion of cassava peels with urea. IJSET, vol.(5):3, pp.139-141.
12. Ofoefule, A.U and Uzodimna, E.O. (2009). Biogas production from blends of cassava (Manihotutilissima) peels with some animal wastes. International Journal of Physical Sciences, Vol.4 (7), pp.398-402.

13. Ojolo, S.J., Dinrifo, R,R. and Adesuyi, K.B. (2007). Comparative study of biogas production from five substrates.Advanced Materials Research Vols 18-19, pp.519-525.
14. Oparaku, N.F, Ofomatah, A.C and Okoroigwe, E.C. (2013). Biodigestion of cassava peels blended with pig dung for methane generation. African Journal of Biotechnology. Vol.12 (40), pp. 5956-5961.
15. Pujol, D., Liu, C., Gominho, J., Olivella, M.A., Fiol, N., Villaescusa, I. and Pereira, H. (2013). The chemical composition of exhausted coffee waste. Industrial crops and products, 50: 423-429.
16. Steiner, R. (2011). Biogas production of coffee pulp & waste waters. Renewable Energy & Energy Efficiency promotion in international cooperation.
17. Subramani, T. and Ponkumar, S (2012). Anaerobic digestion of aerobic pretreated organic waste. International Journal of modern Engineering Research, vol.2, issue.3, pp.607-611.
18. Sun, Y and Cheng J. (2002). Hydrolysis of lignocellulosic materials for ethanol production: a review. Bioressource Technology 83, pp.1-11.
19. Taba K.M., kayembe S., Mutombo L.D., Nzita N. (1999). La biométhanisattion des déchets de café pré- compostés ; Med.Fac. Landbouww. Univ. Gent : 64/1, 174-176.