Characterization and Prospects of Using Agricultural and Municipal Solid Wastes for Biogas and Livestock Feed Production

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Abstract

A study was conducted to characterize the different constituents of wastes from mango processing and municipal solids wastes in order to establish the baseline data requirements for the conversion of such wastes into biofuel and livestock feed. Both the mango peels and seeds constituted 15 to 23g/100g and 33 to 48 g/100g, respectively, of the fresh whole fruit, leaving about 53 to 67 g/100g as edible flesh yield. When the constituents of both the municipal solids wastes and the household/domestic wastes were sorted into different components, between 80 and 90% of the recoverable wastes would be suitable for biodegradation into biogas which is mainly methane using optimum operating conditions already reported in similar studies.

1. Introduction

The human environment provides appropriate system for continuous solar induced photosynthesis over millions of years to produce fossil fuels as the main source of energy used throughout the world (Al Imam et al., 2013). Such energy source have continued to be rapidly exhausted, to the extent that, the need for renewable energy sources are usually of intermittent and limited supply naturally.

A major area of interest nowadays is the use of agricultural, foods and municipal wastes for recycling purposes, as animal feeds and for fuel production after some carefully controlled processing operations.

The commonly found wastes in the environment include: (i) household/domestic wastes, (ii) agricultural and farm wastes, (iii) food processing wastes (abattoir, fruits and vegetable wastes, roots and tuber wastes), (iv) municipal waste (solids and liquid suspensions/ sludge/domestic waste water) and (v) industrial wastes (agro industrial cottage and large plants)..

The livestock industry have come under pressure to find alternative source of materials for feed formulation (Awonorin et al., 1991) in view of the rising cost of conventional feed ingredients in the form of grains. Hence, various waste and by-products from agricultural and industrial processing wastes (offals, mortality, bones, feathers, blood, etc) have been reported to be potential alternatives for feed formulations and biofuel (Awonorin et al., 1991).

One significant problem associated with human wastes and agricultural and food waste is “safe disposal”, especially where large volumes of wastes are involved as in mechanized systems. This has always been responsible for environmental pollution arising from ineffective method of disposal, such as burying of wastes in the soil, open-air burning and effluent discharge into rivers and water streams as earlier reported (Awonorin et al., 1991). Incidentally the available volumes of agricultural and municipal wastes for recycling depend on the level of production and processing operations and, the human population activity in a particular environment.

According to literature reports (Awonorin et al., 1991; Awonorin et al., 1995; Rabah et al., 2010; Uddin et al., 2011; Meggyes and Nagy, 2012; Al Imam et al., 2013), the reuse of wastes have centered on production of animal feedstuffs and biogas since organic materials, such as food and agricultural wastes, including municipal wastes would naturally degrade in open air.

This is achieved via the presence of oxygen available in the air by decomposing such materials and releasing quite a number of gases which are suitable for collection and further processing in order to utilize the energy values of the gases.

Part of the efforts made in utilizing livestock waste for the production of poultry feed was documented by Awonorin et al. (1991) where some sets of empirical equations (linear, quadratic, cubic and power function were developed to predict quantities of feed material obtained from a specified quantity of waste.

Such data can be summarized as shown in Tables 1 and 2 for specific waste and feed material.

In the case of biogas production, the conditions favourable for optimal performance of bacteria, types of gases which can be produced, process temperature, stages of degradation involved and the type of bacterial can be summarized as follows from the work of Uddin et al. (2011):

i. Biogases are Methane (CH_4) is 40-70% by volume
ii. Carbondioxide ($C0_2$) is 30-60% by volume
iii. Hydrogen (H_2) is 1-5% by volume
iv. Hydrogen sulphide (H_2S) is 0 to 3% by volume
v. The required temperature ranges from 3 to 70^0C and the optimal temperature is between 35 to 38^0C
vi. The commonly used temperatures for specific bacteria are psychophysics (below 20^0C), mesophile (between 20 and 40^0C) and thermophilic (above 40^0C)
vii. Typical calorific value of biogas is approximately 6 (kWh/m^3).

From the above analysis, it can be seen that methane (CH_4) is the major component of interest for energy source which has been reported to be produced at an optimum temperature of 6 to 7^0C.

In the present study, the results of typical food processing waste and municipal wastes from three different locations are being presented as primary data needed for environmental waste management.

Hence, the main objectives of this study were to: (1) quantify available waste materials from specific agricultural processing and municipal waste material; and (2) compare the results with those reported earlier in the literature and discuss them for the purposes of future consideration for livestock feed and biogas production.

2. Methodology

2.1 Study Areas and Sample Size

Three locations were randomly selected based on major source of agricultural materials needed for the study; namely, mangoes and municipal waste dumping sites in Lagos (Olorunshogo, Iyana Ipaja and Ketu), Ilaro (Lesley road), Abeokuta (Eleweran/Aregbe) and Ibadan (Apata, Ido township and Oke-Ado area/Okebola)

Sample size for mangoes was based on 500 kg per batch in 3 replicates, while those of municipal wastes were 20 tonnes per batch of 3 replicates, at each location site and were sorted into different physical constituents.

Weighing of samples was as previously reported by Awonorin et al. (1991) and average values were computed.

2.2 Mango Processing Procedure

Whole fresh mangoes were cleaned and separated into components part; namely, the peels, the edible flesh, and the seeds, and were weighed.

3. Results and Discussion

Tables 1 and 2 highlighted the results from mechanized livestock processing operation in which the individual component parts especially those needed as yields and wastes, waste were dried and milled for practical inclusion as meat-and-bone meal, blood meal, feather meal, meat meal, bone meal for use as poultry feedstuffs (Fetuga and Tewe, 1985; Udedibie and Anyanwu, 1988; Shiau and Chai, 1990). The total collectable wastes (Table 1) were from broilers (17.2%), layers (25.8%), Turkey (15.1%) and pigs (27.6%) of the liveweight of each bird or animal. The final dried residues which could serve as potential feed ingredients were only 2.4, 2.4, 2.4 and 7.1%, respectively (Table 2). The reuse of these materials would reduce environmental pollution and produce economically viable feed resources.

The present results, as shown in Tables 3 and 4 also characterized the potential sources of biomass which can be used to produce biogas as alternative energy sources from agricultural processing and municipal solid wastes recovery. As shown in Table 3, values of yield and recoverable individual waste materials are presented using different mango sources from four (4) locations. The yield from mango ranged between 53 and 67g/100g (%) and the average waste estimates ranged from is to 23% for the peels to between 18 and 25% for the seeds. The total recoverable wastes (peels and seeds) ranged from 33 to 48% (Table 3) which can be biodegraded for biogas production. Since methane gas is the main resources of interest, its production output will depend on the volume of mango fruits available for processing and both the effectiveness and efficiency of the biodegradation, and equipment used. Optimum operating conditions of the systems at cottage or large commercial levels have been reported (Uddin et al., 2011). In practice, 41% of whole mango fruit is characterized as wastes (Table 3) which can either be used as poultry feed or processed into biogas for methane recovery.

Table 4 summarizes the results of the various constituents of public refuse dumps and domestic/household wastes from different locations on average basis. Food remnants, leaves/vegetative materials, papers and nylon/plastic materials were identified as the constituents suitable for biogas production.

However, metallic objects, wood and glass/bottles were also included. Generally the total biomass constituents were very high and ranged between 80 and 90% of the total volume of municipal or household/domestic wastes (Table 4). Even so, the variation among the various constituents also depend on the location of the collection site-industrial areas, farming communities, township, village or city areas. It is also expected that large volumes of agro-processing wastes would be needed as biomass for biological treatment. This is also reflected in this study, where the domestic wastes were considerably higher by 10% than the general municipal wastes as shown in Table 4. Thus, the agricultural communities and agro-industrial sectors are much favoured in the management of the environment, control of pollution and biogas production as alternative energy source.

4. Conclusion

The baseline data needed to minimize environmental pollution, biogas production and the conservation of wastes to livestock feed have been obtained to enhance future consideration for energy, the environment and waste management programmes. The results have direct implication on fruits processing and, municipal/household or domestic disposal of solid wastes, including wastes from hotels, restaurants, school and hospital, etc. However the process of conversion or recycling as the case may be requires efficient and safe handling.

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Table 1. Weights of carcasses, parts and organs of animals relatives to their liveweight

Animals	Liveweight (kg)	Components of liveweight (%)									Total waste
		Dressed carcass	Head	Intestine	Liver and kidney	Clean gizzard	Blood	Leg	Hair	Feathers /hooves	
Broiler	2.15	71.7	2.7	9.6	-	2.6	1.4	5.8	6.2	-	17.2
Layer	1.85	66.0	2.1	11.2	-	2.1	2.7	4.0	11.9	-	25.8
Turkey	10.85	78.8	1.6	6.9	-	1.6	2.9	2.9	5.3	-	15.1
Pig	52.56	72.4	-	15.9	4.2	-	5.1	-	2.2	0.2	27.6

+ Sum of blood, feather/hairs intestines and hooves, as well as liver and kidney, for pigs

Source: Awonorin et al. (1991).

Table 2. Quantity of meat-and-bone meal obtained from the wastes collected from poultry and pigs

Animals	Total liveweight+ (kg)	Total wastes rendered++ (kg)	Meat-and-bone meal recovered		Fat recovered/centrifuged	
			% of waste rendered	% of liveweight	% of waste rendered	% of liveweight
Layers and broilers	28,402.0	4,828	12.1	2.0	14.1	2.4
Turkey	7,890.2	1,420	11.9	2.2	13.3	2.4
Pigs	31,619.1	6,956	7.5	1.7	32.3	7.1

+Data included additional weights o whole carcasses (460.2kg of poultry and 83.12kg of pig) resulting from mortality.

++ Raw wastes rendered (meat, bone, fat and intestine)

Source: Awonorin et al. (1991).

Table 3: Mango constituents from different sources/ locations

Varietals/ source location	Mango constituents (g/100g)							
	Edible flesh (yield)		Waste contents					
			Peel		Seed		Total Waste+	
	$\bar{x}$	s_x	$\bar{x}$	s_x	$\bar{x}$	s_x	$\bar{x}$	s_x
Wudi	53	2.88	23	3.25	25	2.65	48	2.85
Gboko	55	3.01	20	2.14	25	3.41	45	2.75
Enugu	62	3.73	18	2.08	20	2.64	38	2.36
Ogbomoso	67	7.14	15	2.11	18	3.02	33	2.57

Mean value ($\bar{x}$), standard deviations (s_x) of triplicate determinations
+Mass of peels plus seeds

Table 4: Measured constituents of municipal and household solid wastes

Individual constituents	Solid waste constituents (g/100g)			
	Municipal dumping sites		Household/domestic	
	$\bar{x}$	s_x	$\bar{x}$	s_x
Food remnants	14.0	2.3		1.3
Metallic object	8.0	0.1	7.5	1.3
Leaves/vegetative Materials	17.0	3.4	25.5	3.1
Rubbers and plastics	9.0	1.1	11.0	1.8
Paper materials	9.0	1.7	17.0	1.5
Polyethylene	6.5	0.5	12.5	0.8
Ceramics	4.0	0.5	-	-
Soil and particulates	9.0	1.3	5.5	0.3
Stone	0.5	0.01	-	-
Glass and bottles	7.0	1.3	2.0	0.01
Wood materials	5.0	1.1	1.3	0.01
Synthetic materials	10.5	1.b	8.5	0.5
Egg shells	0.5	0.01	0.1	0.01
Total	100		100	

Mean values ($\bar{x}$), standard deviations (s_x) of triplicate determinations
Total biomass constituents: municipal dumping sites, 80.5%; household/ domestic, 90.5%