African Journal of Agricultural Research Vol. 4 (10), pp. 991-995, October, 2009
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2009 Academic Journals

Full Length Research Paper

Biomethanation potential of *Jatropha* (*Jatropha curcas*) cake along with buffalo dung

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Accepted 7 September, 2009

A laboratory experiment was conducted to find out the biomethanation potential of dried and powdered Jatropha cake along with buffalo dung at 6% total solids. The experiment was run on daily feeding basis in five litre capacity glass digesters for 180 days. Biogas production was recorded at 24 h interval. Quality of biogas and nutritive value of effluent slurry was also determined. Results show significantly higher (139.20%) biogas production in test (Jatropha cake + Buffalo dung) over control (Buffalo dung only) digesters with methane content of 71.74%. Nutritive value of effluent slurry of test digester was significantly higher in terms of available nitrogen and potassium; calcium; magnesium and carbonate contents than that of control digesters. Co-digestion results in 92.94% decrease in chemical oxygen demand.

Key words: Biomethanation, Jatropha cake, buffalo dung, co-digestion.

INTRODUCTION

Human population living on earth today is facing with a plethora of energy crises. There is a gap between electricity demand and supply in India. This gap was widened from 3015 million units in April 2004 to 4695 million units in April 2005. The final energy consumption in India in the year 2001 - 2002 was 202 MTOE (million tones of oil equivalent) and energy supply has relied heavily on non-renewable crude oil derived liquid fuels (TERI, 2001 - 2002). Beside it, the actual consumption of petroleum products in 2004 - 2005 was 111.59 million tones, out of which 90 percent is estimated to be consumed for energy generation and transportation (indianpetro.com, 2005). If the consumption of these petroleum products are still keep continued then it estimated to be depleted in less than 50 year. Such a threatening situation opens new area of researches and development for renewable energy sources.

Since India's economy depend mainly on agricultural activities and little bit on livestock therefore, utilization of natural resources for energy production is an extremely important issue. However, large availability of cattle dung in India forms sound base for use of biogas as a prominent renewable energy source. Chynoweth et al. (1993) suggest potential biogas production from cattle waste, buffalo waste, piggery waste, chicken waste and human excreta as 0.360, 0.540, 0.180, 0.011 and 0.028 $m^3 kg^{-1}$.

Presently, the most attempts are diverted towards Biodiesal, an alternative diesel fuel made from vegetable oil and animal fat. One billion tons of diesel fuels are consumed annually, worldwide. About 115 million tons feed stock is available for biodiesal production which is contributing 12% of diesel fuel (Hanna et al., 2005). Recently, *Jatropha curcas* has been found most suitable source as a biodiesal, among the many species, which can yield oil as a source of energy in the form of biodiesal. *J. curcas* (Greak word: Jatros means physician and trophe means food) has common name physic nut or purging nut. It belongs to family Euphorbiacae. Biodiesal, generated from *J. curcas* plants increase the ignition quality of diesel. This biodiesal does not contain any sulphur and therefore it is clean and low emission fuel

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Table 1. Nutrients content in raw materials used (dry weight basis).

Characteristics	Contents
Buffalo dung	
pH	7.92
Organic carbon content (%)	16.25
Total Kjeldahl nitrogen (%)	0.56
Available phosphorus content (ppm)	780
Available potassium content (ppm)	217.33
Calcium content (mg L^{-1} as $CaCO_3$)	192.38
Magnesium content (mg L^{-1})	82.83
Total solids content (g %)	24.00
Total volatile solids content (g %)	17.45
***J. curcas* seed cake**	
pH	6.65
Organic carbon content (%)	37.83
Total nitrogen content (ppm)	81250
Total phosphorus content (ppm)	11800
Total potassium content (ppm)	1480
Calcium content (mg L^{-1} as $CaCO_3$)	216.43
Magnesium content (mg L^{-1})	165.68
Total solids content (g %)	96.00
Total volatile solids content (g %)	70.65
Crude protein content (%)	51.38
True protein content (ppm)	4406.25

(Sasikala, 2005). From 100 kg of Jatropha seeds only 30 kg of Jatropha oil is extracted and 70 kg of deoiled cake produced (Kumar and Sharma, 2005). This cake is generally used as fertilizer. Its use for biogas production certainly enhances its economic value.

MATERIALS AND METHODS

Four experimental sets were prepared each contains one five Liter capacity glass digester bottle connected with gas holder and water displacement bottle of two Liter capacity each. Among these two sets were used as control (buffalo dung alone) and remaining two sets were used as test (buffalo dung along with Jatropha cake). All the sets were fed daily at 24 h interval with 120 mL feeding slurry of 6% total solids (TS) containing buffalo dung (TS- 24%) and water for 40 days (Hydraulic Retention Time (HRT) for Gujarat Region). Since biomethanation requires active microflora, so mixed inoculums, from running biogas plant of our institute, was added in all the digesters @ 10% (v/v). From 41st day onwards a portion (6 g) of buffalo dung in feeding slurry of test digester was replaced with powdered Jatropha cake (TS- 96%) to maintain 6% TS. Care was taken to maintain 4.8 L working volume in digester bottles by withdrawing effluent slurry.

After 40 days of experimentation produced biogas was measured daily by water displacement method. Quality of biogas in terms of relative proportions of methane, carbon dioxide and oxygen, was determined by Orsat method at weekly interval. Nutritive value of feeding and effluent slurries of 40 days material was determined weekly using standard methods (Singh et al., 2001). Statistical analysis of data was done according to Rangaswami (1995).

RESULTS AND DISCUSSION

Composition of *Jatropha* seed cake used (Table 1) clearly indicates that they are nutritionally rich than compared to buffalo dung. Higher amount of nutrients in Jatropha seed cake results into higher biogas production in test digesters than control. Data presented in Table 2 reveals the positive effect of *J. curcas* seed cake addition on daily biogas production. Its addition results in a minimum of 16.00% (41 day age of digester) and a maximum of 256.7% increase (151 day) in daily biogas production over control digesters. Total amount of biogas production during 120 days of experimentation in control and test digesters were 147309.82 and 352367.28 mL with their respective average values of 1227.58 and 2936.39 mL d^{-1}. It shows 139.20% average increase in test digesters over control digesters.

Use of *Jatropha* seed cake in powdered form further increased the microbial activity by providing them more surface area for action. Experimental results of Saini et al. (2003) also state that co-digestion of agricultural wastes and cattle dung results in higher amount of biogas

Table 2. Effect of *J. curcas* cake addition on daily biogas production (mLd^{-1}).

Age of digester (Days)	Biogas production		Per cent increase in test over control
	Control	Test	
1	2	3	4
41	1666.63	1933.30	16.00
42	1693.30	2393.28	41.34
43	1586.63	2696.94	69.98
44	1653.30	3346.58	102.42
45	1766.64	3979.90	125.28
46	1579.97	4319.09	173.42
47	1566.63	3619.92	131.06
48	1333.31	3646.58	173.50
49	806.65	2159.95	167.77
50	1106.65	2519.94	127.71
51	1339.98	3886.58	190.05
52	1346.64	3866.58	187.13
53	946.65	2813.27	197.18
54	1039.98	2726.61	162.18
55	1046.65	3033.24	189.80
56	1006.64	3213.26	219.21
57	1013.31	3126.59	208.55
58	1079.98	3186.59	195.06
59	1339.97	3479.92	159.70
60	1379.97	3426.58	148.31
61	1233.31	3239.92	162.70
62	1299.98	3626.58	178.97
63	1226.64	3446.59	180.98
64	1353.31	3806.58	181.28
65	1473.31	3839.91	160.63
66	1479.97	3733.24	152.25
67	1459.97	3513.26	140.64
68	1393.31	3233.25	132.06
69	1546.64	3559.91	130.17
70	1613.30	3353.27	107.85
71	1673.30	3646.59	117.93
72	1419.97	2966.60	108.92
73	1619.96	3399.91	109.88
74	1633.30	3146.60	92.65
75	1739.96	3506.58	101.53
76	1579.97	3419.92	116.45
77	1486.62	3359.92	126.01
78	1406.64	3139.93	123.22
79	1553.30	3499.91	125.32
80	1419.97	3553.25	150.23
81	1786.63	3126.59	75.00
82	1833.29	3326.59	81.45
83	1826.62	3453.25	89.05
84	1899.96	3679.92	93.68
85	2099.96	3633.26	73.02
86	1959.96	3579.92	82.65
87	1846.62	3546.58	92.06

Table 2. Contd.

88	2253.28	3599.91	59.76
89	1879.96	3659.92	94.68
90	1239.97	2506.60	102.15
91	1446.63	2826.60	95.39
92	1339.97	2873.26	114.43
93	1559.97	3333.26	113.67
94	1466.64	3006.60	105.00
95	1326.64	3026.60	128.14
96	1353.30	3099.93	129.06
97	1086.65	3019.93	177.91
98	1386.63	3039.92	119.23
99	1052.81	2559.95	143.15
100	906.65	2739.94	202.20
101	959.98	2493.28	159.72
102	1099.98	2686.60	144.24
103	1286.64	3386.59	163.21
104	1506.63	4006.57	165.93
105	1326.64	3253.26	145.23
106	799.99	2219.95	177.50
107	993.31	2453.28	146.98
108	1046.65	2906.61	177.71
109	1086.64	3086.59	184.05
110	1126.64	3393.26	201.18
111	1219.98	3119.93	155.74
112	1419.97	3079.93	116.90
113	1219.97	2966.60	143.17
114	1226.64	2919.93	138.04
115	1266.64	3053.27	141.05
116	1193.31	2933.27	145.81
117	1166.65	2746.61	135.43
118	1086.65	2906.61	167.48
119	1159.98	3019.93	160.34
120	1119.98	3033.27	170.83
121	1086.64	2773.93	155.28
122	1106.65	2806.60	153.61
123	1126.64	2813.26	149.70
124	1173.31	3033.27	158.52
125	1173.31	3393.27	189.20
126	1139.98	2837.93	148.95
127	1133.31	2639.94	132.94
128	1066.65	2579.94	141.87
129	1046.65	2472.96	136.27
130	939.98	2539.94	170.21
131	1066.64	2673.27	150.63
132	999.98	2639.94	164.00
133	926.65	2333.28	151.80
134	873.31	2193.29	151.15
135	853.31	2339.94	174.22
136	799.98	2333.28	191.67
137	913.32	2573.28	181.75
138	926.65	2699.94	191.37
139	973.31	2826.60	190.41

Table 2. Contd

140	959.97	2546.61	165.28
141	993.31	2453.28	146.98
142	919.98	2453.25	166.66
143	1019.58	2673.27	162.09
144	953.31	2579.94	170.63
145	1033.31	2673.27	158.71
146	1086.64	2339.55	115.34
147	1013.32	2473.27	144.08
148	939.98	2279.95	142.55
149	793.32	2133.28	168.91
150	666.65	2253.28	238.00
151	646.65	2306.62	256.70
152	653.32	1833.30	180.61
153	679.99	1433.30	110.78
154	633.32	1493.30	135.79
155	613.33	1546.63	152.17
156	679.99	1779.96	161.76
157	719.99	2033.29	182.41
158	753.33	2173.29	188.49
159	733.32	2346.61	220.00
160	713.32	2386.62	234.58
Total	147309.82	352367.28	139.20
Average	1227.58	2936.39	139.20

production than that of cattle dung alone. Daily fluctuation in TS content of feeding slurry (since it depends on many factors like age, feeding, health of cattle and season also) and in environmental temperature are responsible for fluctuation in biogas production.

Qualitative analysis of biogas (Table 3) shows the average percentage of CH_4, CO_2 and O_2 gases in control and test digesters as 74.32, 23.54, 2.14, 71.74, 27.36 and 0.9%, respectively. Although the methane content in test digesters was lower than that of control digesters but it was non-significant. Significantly reduced oxygen content in test digesters show higher anaerobic conditions in these digesters.

Microbial production of biogas depends on carbon content of feeding material which is being utilized by microorganisms as carbon source. Significant decrease in organic carbon content in test digesters (Table 3) indicates higher microbial activity in these digesters which may yield high biogas production. Per cent decrease in total solids and total volatile solids were also higher in test digesters (Table 3) although the differences were non-significant.

Higher microbial activity may result into higher conversion of bounded nutrients into their available form. Significant increase in available nitrogen, potassium, calcium, magnesium and carbonate content in test digesters (Table 3) clearly indicates higher fertilizer value of produced biogas slurry in these digesters. Further,

Table 3. Effect of *J. curcas* seed cake addition on quality of biogas and fertilizer value of digested slurry.

Sr. No.	Parameters	Average values		t- value (calculated)	t- value (tabulated)	
		Control	Test		5%	1%
1	Quality of Produced Biogas					
	Methane	74.32	71.74	1.338207	2.306	3.355
	Carbon dioxide	23.54	27.36	2.055368	2.306	3.355
	Oxygen	2.14	0.9	3.527057**	2.306	3.355
2	% decrease in TS	58.31	56.15	0.200764	2.12	2.921
3	% decrease in TVS	68.95	61.26	0.961308	2.12	2.921
4	% decrease in OC	41.15	69.79	7.086562**	2.12	2.921
5	% increase in available N	60.81	271.26	5.2731358**	2.145	2.977
6	% increase in available P	59.21	42.12	1.408745	2.101	2.878
7	% increase in available K	51.16	73.64	2.710274*	2.101	2.878
8	% increase in calcium	55.76	329.62	6.370393**	2.306	3.355
9	% increase in magnesium	150.69	392.65	6.711653**	2.306	3.355
10	% increase in carbonate	270.83	3595.65	4.269306**	2.101	2.878
11	% increase in bicarbonate	301.80	366.01	1.077419	2.101	2.878
12	% decrease in chemical oxygen demand	73.28	92.94	5.514923**	2.101	2.878

*significant at 5% level of significance.
**significant at 1% level of significance.

significant decrease in chemical oxygen demand in test digesters suggests that biomethanation process is Eco-friendly also.

From the foregone discussion we can conclude that co digestion of *J. curcas* seed cake along with buffalo dung at 6% total solids concentrations on daily feeding basis in conventional type biogas digesters gave significantly higher biogas production with higher fertilizer value than that of biomethanation of buffalo dung alone.

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