A Study on Biogas Generation from Non-edible Oil Seed Cakes: Potential and Prospects in India

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Abstract: *The present experimental investigation shows that the Jatropha curcas and Pongamia pinnata oil seed cakes have biogas generation potential in the range of 220 - 250 and 240 - 265 lite per kg of cake respectively under mesophilic temperature range of anaerobic digestion. The methane content of biogas derived from these non-edible oil seed cakes has been found to range from 65-70 % against 55 % from cattle dung. It was observed that dilution ratio of cake is best at 1:4 (cake:water) for Jatropha curcas and 1:3.5 (cake:water) for Pongamia pinnata cakes. The study revealed that biogas production from non-edible oil seed cakes is a simple method of cake disposal and to obtain self-sufficiency in meeting rural energy need. Total biogas generation potential from Jatropha curcas and Pongamia pinnata cakes in India has been estimated as 2, 550 and 377 million cubic metre respectively from 10.2 and 1.45 lakh metric tones of Jatropha curcas and Pongamia pinnata oil seed cakes.*

Keywords: Non-edible Oil Seeds, Biodiesel, De-oiled Cake, Anaerobic Digestion, Biogas, Renewable Fuel

1. INTRODUCTION

India has a lot of potential of non-edible oil tree born seeds. The country is endowed with more than 100 species of tree born no-edible oil seeds occurring in wild or cultivated sporadically, to yield oil in considerable quantities. Table 1. indicates the potential availability of some non-edible tree borne oil seed in the country [4]. Most tree borne oil seeds yield about 25 % oil and 70 % oil cake considering 5 % losses in the oil extraction process using mechanical expeller.

In India, attempts are being made for using non-edible and under-exploited oils for production of esters. The non-traditional seed oils available in the country, which can be exploited for this purpose, are *Madhuca indica, Shorea robusta, Pongamia glabra, Mesua ferra* (Linn), *Mallotus philippines, Garcinia indica, Jatropha curcas* and *Salvadora.* In this regards a National Mission on Biodiesel has been launched in year 2003 under demonstration phase with the objective of producing biodiesel by the year 2011-12 enough to meet 20% blending with high speed diesel of total diesel requirement [5].

One hectare of *Jatropha curcas* plantation on an average will produce 3.75 metric tonnes of seed yielding 1.2 metric tonnes of oil. At the end of two years *Jatropha curcas* plant will give seed to its full potential. Hence four lakh hectares will produce 0.48 million metric tonnes of oil and 1.02 million metric tonnes of oil cakes [5].

Table 1 Potential availability of some non-edible oil seeds in the India

Sl. No	General Name	Botanical Name	Potential, Million Metric Tonnes/Year			Oil Content ,%
			Seed	Oil	Cake	
1	Karanja*	*Pongamia pinnata*	0.20	0.055	0.145	27-39
2	Jatropha*	*Jatropha curcas*	0.05	0.015	0.035	30-40
3	Kusum	*Scheleichera oleosa*	0.08	0.025	0.055	34
4	Neem	*Azadirechta indica*	0.50	0.100	0.400	20
5	Pilu	*Salvadora oleoides*	0.05	0.017	0.033	33
6	Tumba	*Citrullus collocynthis*	0.10	0.021	0.079	21
7	Sal	*Shorea robusta*	1.50	0.180	1.320	12-13
8	Mahua	*Madhuca indica*	0.50	0.180	0.320	35
9	Mango	*Mangifera indica*	0.50	0.045	0.455	7.5

* Availability before introduction of Biodiesel Programme in the country.

Source: P. Radhakrishna 2003. Tree borne oil seeds as a source of energy for decentralized planning. Government of India, Ministry of Non-Conventional Energy Sources, New Delhi, India.

Considering the future scenario of non-edible oil seeds utilization for biodiesel production in the country from *Jatropha curcas* (Jatropha) and *Pongamia pinnata* (Karanja) there is need for efficient utilization of their cakes. The current production of karanja seed is around 0.056 million tonnes per annum against potential of 0.20 million tonnes per year. Similarly, the production of *Jatropha curcas* seed would be very large in comparison to karanja seed by the introduction of National Biodiesel Mission started in year 2003 in the country. These two crops in India have been selected as major source of non-edible oil for production of biodiesel. One of the major problems arising in the coming years is disposal of cake after expelling oil from seed. The cake neither can be used for animal feeding nor directly can be used in agricultural farming due to its toxic nature. The generation of biogas from these cakes would be a best solution for its efficient utilization. Biogas from cake provides energy for heating, cooking, lighting and engine operation and digested cake slurry can be directly put for agricultural farming.

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2. PROSPECTS OF NON-EDIBLE OIL SEEDS UTILIZATION

The direct utilization of cake is also not recommended for use as organic manure. The present and forthcoming use of non-edible oil seeds in India is production of biodiesel due to massive plantation of *Jatropha curcas* and karanja on waste lands in the Biodiesel Mission Project. The utilization of generated cakes (70 % yield of total non-edible oil seeds) in a environment friendly manner can not be ignored, because its disposal as waste would create environmental problems. The presence of non-edible oil seed cakes in the open atmosphere would generate following gases due to self decomposition of biomass over the action of various microorganism.

1. Gases from Waste Sources: CH_4, N_2O, H_2S, NH_3, CO_2
2. Volatile organic compounds (VOCs)

The best strategy is to manage and utilize non-edible cakes as "biomass" resources rather than disposing of as "waste" so that energy and economic benefits, as well as environmental benefits, can be realized. Anaerobic digestion of these cakes could significantly reduce the gaseous emissions (CH_4, VOCs, H_2S) from waste disposal. Therefore, anaerobic digestion of these cakes would be a better way of cake utilization for energy generation and further, effluent as enriched organic manure for organic farming.

A possible way of utilization of non-edible oil seed is presented in Figure 1. Figure shows route of appropriate utilization as oil

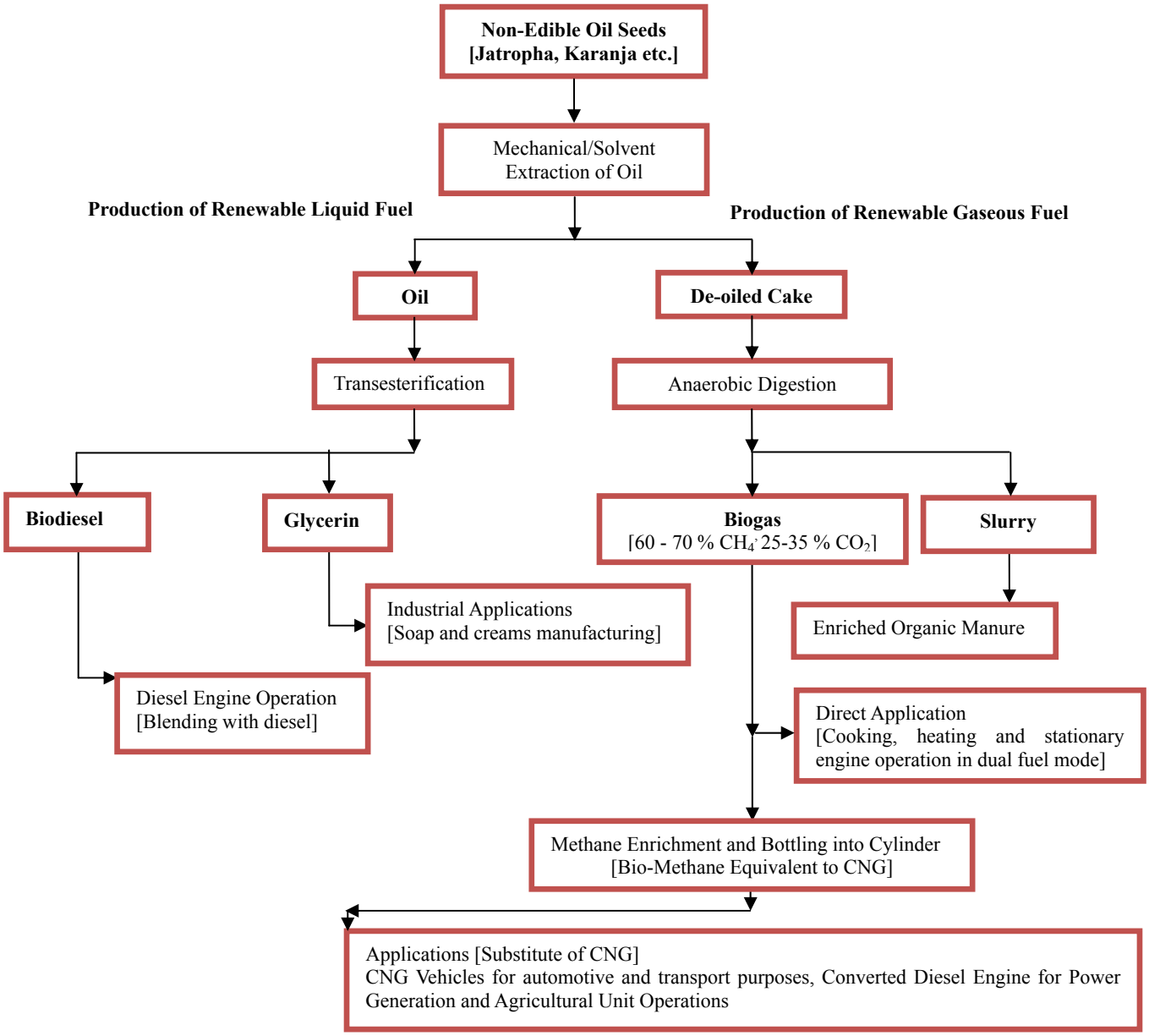

Fig. 1 Schematic diagram showing utilization of non-edible oil seeds for production of renewable liquid (biodiesel) and gaseous (biogas) fuels

extracted from non-edible oil seeds used for biodiesel production using transesterification process and cake is used for anaerobic digestion to produce biogas.

3. METHODOLOGY

A study has been carried out to explore the potential of biogas generation from *Jatropha curcas* and *Pongamia pinnata* oil seed cakes. The aim of the investigation was to evaluate various operating parameter of biogas generation under anaerobic condition from non-edible oil seed cakes.

Anaerobic digestions of *Jatropha curcas* and *Pongamia pinnata* non-edible oil seed cakes were carried under messophilic range in the laboratory conditions using 5 litre glass fermentors. The feed materials were *Jatropha curcas*, *Pongamia pinnata*, cattle dung and various combination of cake with cattle dung (co-digestion) [1, 2, 3, 6 and 7].

3.1 Preparation of Feed Material and Their Properties

Total numbers of treatments in the study were 25 at different dilution ratio and cattle dung percentage for co-generation as tabulated below. Hydraulic retention time for anaerobic digestion of selected feed materials was taken as 30, 45 and 60 days.

Substrate	Number and level of treatment
Cattle dung	1[1:1 dilution ratio]
Jatropha curcas cake	6+6 [6 at 3:1 dilution ratio and 6 at 4:1 dilution ratio] Levels were without mixing of cattle dung and with mixing of cattle dung at the level of 10, 20, 30, 40 and 50 % of cake weight basis.
Pongamia pinnata cake	6+6 [6 at 3:1 dilution ratio and 6 at 3.5:1 dilution ratio] Levels were without mixing of cattle dung and with mixing of cattle dung at the level of 10, 20, 30, 40 and 50 % of cake weight basis.

The physico-chemical properties of feed material viz. moisture content, oil content, total solids, volatile solids, carbon, hydrogen and nitrogen are presented in Table 2 and 3.

Table 2 Properties of the feed materials

Substrate	Properties			
	Moisture content, % (db)	Oil content, %	Total solids, %	Volatile solids, % (wb)
Cattle dung	532.00	NIL	15.80	12.10
Jatropha curcas cake	9.70	12.0	91.20	84.60
Karnaja cake	17.20	5.0	85.30	81.00

The properties of cakes were determined in regard of biogas generation parameters of substrates. The C-N ratio of *Jatropha curcas* and *Pongamia pinnata* oil seed cake was found in between 12.7 and 8.7 respectively and for cattle dung it was found in the range of 22.7. The initial pH values of *Jatropha curcas* cake substrate were found in the range of 5 to 10 and of *Pongamia pinnata* cake it were in the range of 4.8 to 9.4 depending on percentage of cattle dung, cake and water dilution ratio.

Table 3 Carbon, Hydrogen and Nitrogen content of the different feed materials

Sl. No.	Feed Material	C (%)	H (%)	N (%)	C/N
1.	Jatroha Cake	48.80	6.20	3.85	12.70
2.	*Pongamia pinnata* Cake	47.80	6.50	5.50	8.70
3.	Cattle Dung	35.20	4.60	1.55	22.70

The treatments were prepared using cattle dung, *Jatropha curcas* and *Pongamia pinnata* oil seed cakes at different mixing levels as given in Table 4.

Table 4 Total and volatile solids present in some selected treatments

Sl. No.	Treatment	Substrate constituents, g			
		Water	Total Solid	Volatile Solid	Total Mass of Substrate
1	CD[1.0DR]	3683.20	316.80	243.20	4000.00
Jatropha curcas Cake Substrates					
2	JC[3.0DR, 0%CD]	1544.00	456.00	423.00	2000.00
3	JC[3.0DR, 50%CD]	1754.40	495.60	453.40	2250.00
4	JC[4.0DR, 0%CD]	2044.00	456.00	423.00	2500.00
5	JC[4.0DR, 50%CD]	1754.40	495.60	453.40	2750.00
Pongamia pinnata Cake Substrates					
6	KC[3.0DR, 0%CD]	1573.30	426.70	405.20	2000.00
7	KC[3.0DR, 50%CD]	1783.70	466.30	435.60	2250.00
8	KC[3.5DR, 0%CD]	1823.30	426.70	405.20	2250.00
9	KC[3.5DR, 50%CD]	2033.70	466.30	435.60	2500.00

[Notations: CD: Cattle Dung, DR: Dilution ratio (water:cake), JC: *Jatropha curcas* cake and KC: *Pongamia pinnata* cake]

4. RESULTS AND DISCUSSION

It was found that dilution ratio of cake was having quite significant effect on biogas production and slurry handling inside digester. The best dilution ratio was found as 1:4 (cake:water) for *Jatropha curcas* and 1:3.5 (cake:water) for *Pongamia pinnata* cakes.

4.1 Biogas Yield and Methane Content of the Gas

The gas production of various treatments at different hydraulic retention time is presented in Figure 2. The gas production in T1 was found 40 litre at 60 days of HRT. However, gas production at 60 days of HRT in the treatments T2, T3, T4, T5, T6, T7, T8 and T9 were 220, 235, 240, 250, 240, 255, 255 and 265 respectively (litres/kg weight of cakes). The ambient temperature during the period of experimentation was in the range of 25 to 37 ^{0}C during March 06 to May 06. The methane content of generated biogas in different treatments T1, T2, T3, T4, T5, T6, T7, T8 and T9 were 55.5, 65.0, 66.50, 67.2, 68.0, 65.0, 66.0, 68.5 and 70.0.

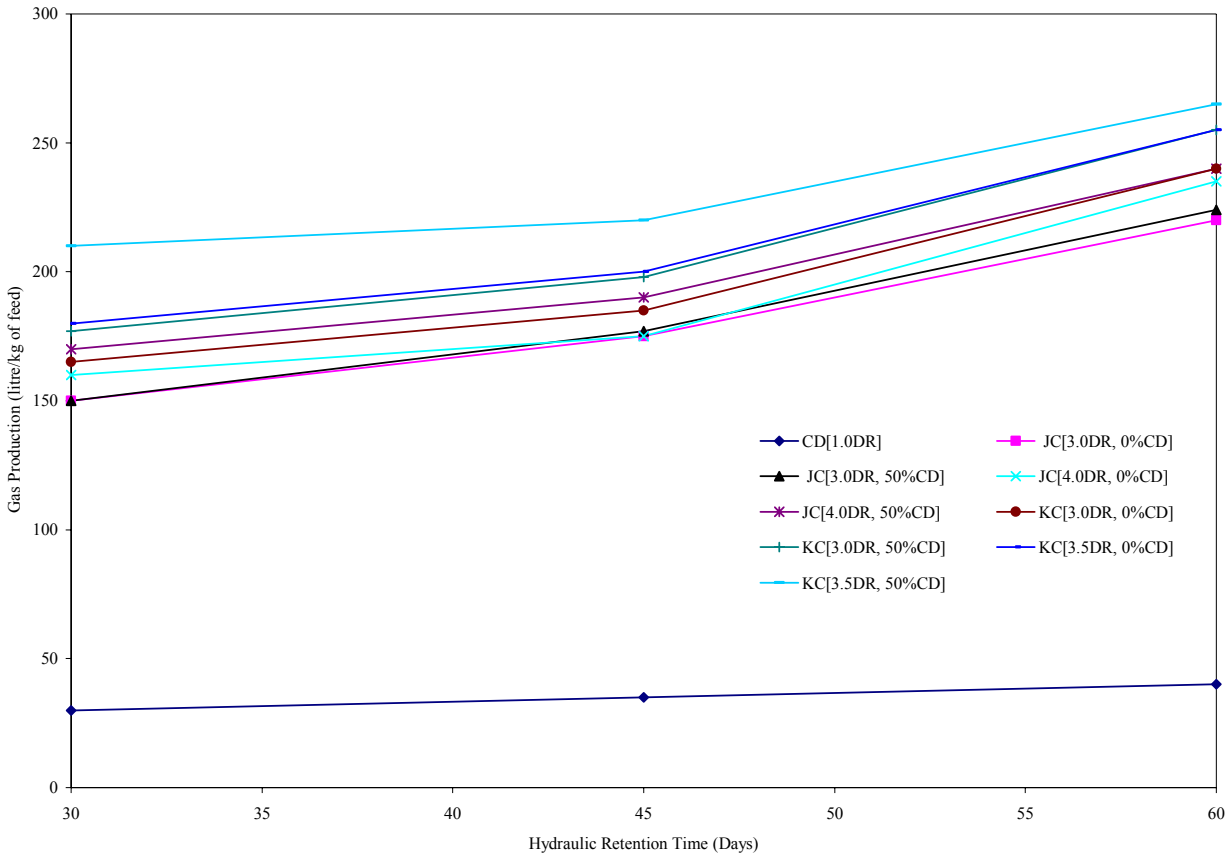

Fig. 2 Biogas production potential of *Jatropha curcas* and *Pongamia pinnata* oil seed cakes under anaerobic digestion

4.2 Manurial Value of Various Feed Material for Their Use as Organic Manure

The manurial values of different selected feed material were found as follows:

Bio-manure	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Cattle Manure	1.55	0.69	1.66
Jatropha curcas curcas oil cake	3.85	2.09	1.68
Pongamia pinnata oil cake	5.50	1.00	1.00

5. CONCLUSION

The study revealed following conclusions:

- Anaerobic digestion of non-edible oil seed cakes is good way of cake disposal which provide a better quality renewable gaseous fuel (biogas) than cattle dung generated biogas. Along with fuel anaerobic digestion give good manurial value effluent for organic farming.
- Biogas generation potential of *Jatropha curcas* and *Pongamia pinnata* oil seed cakes is in the range of 220 - 250 and 240 - 265 lite per kg of cake respectively.
- Total biogas generation potential from *Jatropha curcas* and *Pongamia pinnata* cakes has been estimated as 2, 550 and 377 million cubic metre respectively from 10.2 and 1.45 lakh metric tones of *Jatropha curcas* and *Pongamia pinnata* oil cakes which could be available for this purpose in India.

6. REFERENCES

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