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Assessing Chemical Properties of Jatropha Hybrid Clonal Seed Oil for Biodiesel Production

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ABSTRACT

Studies were carried out in Forest College and Research Institute to assess the chemical properties of 27 Jatropha hybrid clonal seed oil, which was experimented in the laboratory for properties such as acid value, free fatty acid, saponification value, iodine value and cetane number. As these properties are important to determine the present condition of oil, the current study confirms that, hybrid clonal seeds performed superior with respect to the international standards for saponification value, iodine number and cetane number, which shows that Jatropha hybrid clonal seeds could be an important source to meet the future energy requirements.

Keywords: Acid value, Free fatty acid, Iodine number, Cetane number

1. INTRODUCTION

Oil constitutes over 35% of the primary energy consumption in India. Instability of oil prices, surging energy demand in developing countries, diminishing fossil fuel reserves and greater awareness about climate change threats due to fossil fuel usage have primarily contributed to the serious examination of alternative energy resources. Diesel constitutes 50% of petroleum products consumed in India. The present scenario indicates that there is huge gap between demand and supply of these petroleum resources. Rudolf diesel laid foundation to run first engine on peanut biodiesel, time since, the research has been focused on vegetable oils. However, the use of edible vegetable oils and animal fats for biodiesel production has recently been of great concern because they compete with food materials – the food versus fuel dispute[1]. There are concerns that biodiesel feedstock may compete with food supply in the long-term[2]. Hence, the recent focus is the use of non-edible plant oil source as the feedstock for biodiesel production meeting the international standards. Moreover, Government of India has announced National Policy on Biofuels, 2009 which aims at achieving target of 20% blending of biofuel both for bio-diesel and bio-ethanol by 2017. By virtue of being member of Euphorbiaceae family, Jatropha is an important Tree-Borne Oil seeds (TBOs) to meet the energy independence. It has high adaptability for thriving under wide range of physiographic and climatic conditions. On this backdrop, studies on chemical properties of Jatropha oil viz., acid value, free fatty acid, iodine value, saponification value and cetane number which indirectly influence the quality of oil for biodiesel production were carried out in Forest College and Research Institute, Mettupalayam.

2. MATERIALS AND METHODS

The experimental material for the present study consisted of 27 interspecific hybrids clones established in the form of field trial on 11.02.2008. The current study was carried out using the already established field trial at Forest College and Research Institute, Mettupalayam (11°19'N; 76°56'E; 300 MSL), Tamil Nadu Agricultural University during 2010–2011. Seeds collected from this field were used for oil extraction and to assess the

chemical properties of the same. Oil was extracted by means of solvent extraction using petroleum ether (40–60 °C) as solvent[3]. The chemical properties of 27 hybrid clonal seed oil assessed are shown below.

2.1. Determination of Acid Number and Free Fatty Acid

The acid number and free fatty acid of oil was determined by the procedures of A.O.A.C.[3].

$$\text{Acid value} = \frac{V \times N \times 56.1}{W}$$

where

V=volume of potassium hydroxide used;

N=normality of potassium hydroxide;

W=weight in gram of the sample.

$$\text{Free fatty acid as oleic acid, per cent by weight} = \frac{28.2 \times V \times N}{W}$$

% FFA×1.99=acid value.

2.2. Determination of Iodine Number

The iodine number was determined by Hanus iodine method[3].

$$\text{Iodine number} = \frac{(B-S) \times N \times 12.69}{\text{Weight of the sample}}$$

where

B=ml of 0.1 N sodium thiosulphate required by blank;

S=ml of 0.1 N sodium thiosulphate required by sample;

N=normality of sodium thiosulphate solution.

2.3. Estimation of Saponification Number

The saponification number was estimated as per the method of A.O.A.C.[3].

$$\text{Saponification number} = \frac{(b-a) \times 0.02805 \times 1000}{\text{Weight of the sample}}$$

where

b=ml of 0.5 N HCl required by the blank;

a=ml of 0.5 N HCl required by the sample.

2.4. Determination of Cetane Number

The cetane number of the Jatropha methyl esters was estimated as per Krisnangkura[4].

Cetane number = 46.3+(5458/SN-0.225×IV)

where

SN is the saponification number;

IV is the iodine value.

2.5. Statistical Analysis

The data collected were subjected to the analysis of variance after Panse and Sukhatme[5].

3. RESULTS AND DISCUSSION

Seed oil content variation is more widely reported not only in annual crops but also in wide variety of tree borne oil seeds[6–8]. Hybrid clones exhibited significant variations for seed oil content. It varied between 22.51% (HC 19) and 42.28% (HC 1). The three hybrid clones viz., HC 1(42.28%), HC 6 (40.84%) and HC 23 (39.22%) registered significantly higher values for seed oil content.

The chemical properties are the most important properties that determine the present condition of oil[9]. In the current study, significant differences were recorded for acid value and free fatty acid (%) of the oil of Jatropha hybrid clones. Analysis of acid number and free fatty acids indicated that significantly lower values were found among 10 hybrid clones presented in Table 1. The acid number is used to determine the level of free fatty acids

Table 1: Chemical properties of Jatropha hybrid clonal seed oil

Hybrids	Oil content (%)	Acid value	Free fatty acid (%)	Saponification value	Iodine value	Cetane number
HC 1	42.28*	3.95	1.98	198.26	106.15	49.95
HC 2	24.97	1.44	0.72	199.94	105.30	49.91
HC 3	32.45	3.60	1.81	198.75	106.16	49.88
HC 4	34.03	1.63	0.82	198.47	108.25	49.44
HC 5	33.80	3.30	1.66	198.52	106.88	49.75
HC 6	40.84*	1.40	0.70	200.81	107.10	49.38
HC 7	35.66	2.46	1.23	198.48	106.45	49.85
HC 8	26.65	1.67	0.84	200.00	106.60	49.61
HC 9	34.43	2.91	1.46	198.55	106.37	49.86
HC 10	28.65	2.67	1.34	198.78	109.70*	49.08
HC 11	27.24	2.45	1.23	199.41	105.71	49.89
HC 12	31.69	6.33*	3.18*	197.19	105.60	50.22
HC 13	34.84	1.73	0.87	199.97	107.85	49.33
HC 14	28.47	2.22	1.12	198.74	107.47	49.58
HC 15	35.47	1.16	0.58	199.67	104.11	50.21
HC 16	29.00	3.83	1.93	198.33	108.15	49.49
HC 17	24.23	6.33*	3.18*	199.06	101.91	50.79*
HC 18	37.22	2.97	1.49	198.14	105.56	50.09
HC 19	22.51	6.36*	3.19*	201.45*	105.82	49.58
HC 20	30.66	7.58*	3.81*	199.58	105.40	49.93
HC 21	34.59	5.57*	2.80*	198.90	105.65	49.97
HC 22	28.86	2.54	1.28	198.46	102.03	50.85*
HC 23	39.22*	1.61	0.81	199.11	104.33	50.24
HC 24	24.67	4.34	2.18	199.89	106.63	49.61
HC 25	32.58	3.59	1.80	198.22	107.08	49.74
HC 26	24.31	5.61*	2.82*	198.48	107.07	49.71
HC 27	31.84	5.10*	2.56*	198.26	101.63	50.97*
MEAN	31.52	3.49	1.76	199.01	105.96	49.88
SEd	2.29	0.48	0.24	0.76	1.34	0.31
CD(.05)	4.54	0.97	0.49	1.53	2.70	0.62
CD(.01)	6.00	1.30	0.65	2.03	3.59	0.82

*Significant at 1% level.

or processing acids that may be present in biodiesel. Biodiesel with a high acid number has been shown to increase fueling system deposits and may increase the likelihood for corrosion. All the 27 hybrid clones recorded significantly higher values for acid value compared to the Bureau of Indian standard[10] value of 0.5. These values increase during storage and are specified to ensure proper ageing properties of the biodiesel. High acid values were reported in *Jatropha curcas*[11,12], *Simarouba glaitca*[13–15], *Taxus baccata*[16], *Pongamia glabra*[17] and in *Madhuca indica*[18].

The free fatty acid content of the biodiesel should be less than 1%. In the present study, HC 2 (0.72), HC 4 (0.82), HC 6 (0.70), HC 8 (0.84), HC 13 (0.87), HC 15 (0.58) and HC 23 (0.81) have recorded absolute free fatty acid content, which can be recommended for biodiesel production. It was observed that lesser the free fatty acid in oil, better the biodiesel recovery[19].

Saponification value is an index of the average size of fatty acid present, which depends upon the molecular weight and percentage concentration of fatty acids components in the oil[20]. It differed significantly among different hybrid clonal seeds. Only one hybrid clone HC 19 (201.45) recorded significant higher value for this property. Saponification value will be higher if the oil contains more of saturated fatty acids (C14:0, C16:0, C18:0) as it determines the length of carbon chain and increase cloud point, cetane number and improve stability of bio-diesel[19]. Higher saponification value was already reported in *Jatropha curcas* by Singh and Padhi[12] and Emil[21].

The hybrid clonal seeds registered significant variation for iodine value which is a measure of the unsaturation of fats and oils. In the present analysis, hybrid clone value ranged from 101.63 (HC 27) to 109.70 (HC 10). Higher iodine value indicated that higher unsaturation of fats and oils[22,23]. The limitation of unsaturated fatty acids is necessary due to the fact that heating higher unsaturated fatty acids results in polymerization of glycerides. This can lead to the formation of deposits or to deterioration of the lubrication[20,24]. Fuels with this characteristic are likely to produce thick sludges in the sump of the engine, when fuel seeps down the sides of the cylinder into crankcase[25]. The iodine value should be less than 115 as per biodiesel standards. These values indicate that the iodine values of the oils of hybrid clones are well under the maximum limits of 115 set by the European standards EN14214[26].

The ignition quality of a fuel is defined by its cetane number[20,27,28]. It is actually a measure of a fuel's ignition delay. This is the time period between the start of injection and start of combustion (ignition) of the fuel. The investigated hybrid clonal seeds differed significantly due to cetane number. The cetane value was found to be significantly higher for three hybrid clone viz., HC 17 (50.79), HC 22 (50.85), HC 27 (50.97) which is near to the acceptable minimum standard value of 51 as per the IS: 15607[10] biodiesel specification of the Bureau of Indian Standards. The minimum acceptable cetane number as per the American standards for biodiesel is 47 and most of the hybrid clones recorded significantly higher cetane number compared to the American standard ASTMD 6751[29]. Hence most of the hybrid clones deployed for the current investigation which recorded cetane number in the range 49–51 indicates their usability as biodiesel.

6. CONCLUSION

The chemical properties revealed that the Jatropha hybrid clones exhibited higher acid value and free fatty acid contents when compared to the Indian and International biodiesel standards. All the 27 hybrid clones had fulfilled the specification of ASTM and EN standard values for saponification value, iodine value and cetane number. Therefore the present study confirms that, the Jatopha hybrid clonal seed has immense potential to serve as an important raw material for biodiesel production.

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