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Research Article

Comparative Physical properties of Karanj Seed Oil by Using Different Organic Solvents: an Environmental Viable Fuel

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ABSTRACT

Oil yielding crop plants are very important for economic growth of the energy and agricultural sectors. The oil seeds containing polyunsaturated fatty acids are important source of biodiesel. These organic seed oils are better than diesel fuels in terms of physico-chemical properties and biodegradability. One such plant species is *Pongamia pinnata* belonging to family Fabaceae. It is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. Detail physical study in different organic solvents (n-Hexane, ethyl acetate and petroleum ether) intends to identify all advantages and disadvantages of *pongamia pinnata* as a sustainable feedstock for the production of Biodiesel equivalent to fossil fuel as per ASTM.

Keywords: *Pongamia pinnata* , Biodiesel, polyunsaturated fatty acids, biodegradability, physico-chemical properties, American standards for testing and materials (ASTM).

INTRODUCTION

An ever increasing demand of fuels has been a challenge for today's scientific workers. The fossil fuel resources are dwindling day by day. Biodiesel seem to be a solution for future. It is an environmental viable fuel. Several researchers have made systematic efforts to use plant oil and their esters (biodiesel) as a fuel in compression ignition (CI) engines .There is various types of raw material like Jatropha curcus, *Pongamia Pinnata* (Karanja), Moha, Undi, Castor, Saemuruba, Cotton seed etc. An non- edible oil seeds and Various vegetable oils including palm oil, soybean oil, sunflower oil, rapeseed oil and canola oil have been used to produce biodiesel fuel and lubricants (Bobade and Khyade., 2012). Out of these *Pongamia pinnata* can be a definite source of raw material due to its easy availability in wild. It is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. The tree bears green pods, which after 10 to 11 months gets matured and changes to a tan colour in the month of May-June. The pods are flat to elliptic, 5-7 cm long and contain 1 to 2 kidney shaped brownish red seeds. The dried pods usually split with a hammer and the seeds are obtained. The yield of seeds per tree is between 8-24 kg. The fresh extracted oil is orange to brown and rapidly darkens on storage. It has a disagreeable odour and bitter taste.

The seeds are reported to contain on an average about 28–34% oil with high percentage of polyunsaturated fatty acids (Sarma *et al*., 2005). The seeds are largely exploited for extraction of non-edible oil commercially known as "Karanj oil", which is well known for its medicinal properties. **S**eeds are anthelmintic, bitter, acrid, haematinic and carminative. They are useful in inflammation, chronic fevers, anaemia and haemorrhoids. The oil is anthelmintic, styptic and recommended for ophthalmia, leprosy, ulcers, herpes and lumbago. Its oil is a source of biodiesel (Porwal *et al*., 2010).

Biodiesel is expanding at a very rapid rate because of increasing demand, necessary policy support and technological availability. India consumes approximately 40 million tones of biodiesel and ranked fifth in the world after U S, China, Russia and Japan in terms of fossil fuel consumption. Recently, Government of India launched " National Mission on Bio-diesel" with a review to find a cheap and renewable liquid fuel based on vegetables oils. Biodiesel fuel can be defined as medium length (C16 ± C18) chains of fatty acids and is comprised mainly of mono-alkyl fatty acid esters. It has the benefits of being non-toxic, biodegradable and essentially free of sulfur and carcinogenic ring components (Yamane *et al*., 2001). *Pongamia* tree has also been recognized as "Biodiesel", as several parameters of diesel and *Pongamia pinnata* oil are comparable (Gerphen *et al*., 2004 ; Shaine *et al*., 2004).

Therefore, of the exceeding aspects present study is deals with the following objectives: (i) extraction and quantification of the total oil yield from the seeds using different solvents (ii) to analyze and compare the physical properties of the seed oil of n-Hexane, ethyl acetate and petroleum ether fractions.

MATERIAL AND METHOD

(i) Collection of plant material

The plant material used in the current study were healthy and fully ripened matured seeds from *P. pinnata* collected from the campus of University of Rajasthan, Jaipur. Specimens were compared with the voucher specimens at Herbarium of Department of Botany, University of Rajasthan, Jaipur. The seeds were dried at 65°C in an oven for approximately 5–7 days, after that live it on room temperature. They were then macerated to powder form with a mixer grinder. The powder was stored in air sealed polythene bags at room temperature before extraction.

(ii) Oil extraction

The seed oil was extracted from 100 gm powdered seeds following the Soxhlet extraction method using different solvents (n-Hexane, petroleum ether and ethyl acetate) at their boiling points. Extracted oil was left at room temperature for whole night to evaporate the solvent. The crude oil was stored at 4°C until further use (maximum 1 month) for physical analysis.

(iii) Determination of physical properties of seed oil

Basic physical and fuel related properties of Pongamia seed oil of n-Hexane, petroleum ether and ethyl acetate fractions *viz*; colour, odour, oil content %, cloud point, pour point and flash point were determined by the following standard procedures.

(a) Determination of Oil content %

Volume of oil was recorded and expressed as oil content (%) as follow:

$$\text{Oil content \%} = \frac{\text{Oil weight}}{\text{Sample weight}} \times 100$$

(b) Determination of cloud point and pour point

The temperature at which a cloudy or hazy appearance is noticed is called the 'cloud point' of the oil. Likewise, the temperature at which the oil just solidifies is called the 'solid point'. The temperature at which the oil ceases to flow or pour or become semisolid is known as 'pour point'. The apparatus employed for the determination of cloud and pour point is shown

in Figure-1, known as cloud and pour point apparatus.

(c) Determination of flash point

Flash point of oil is the lowest temperature at which the combustible liquid gives off sufficient vapours that ignite for a moment when a small flame is brought near the liquid surface under specified conditions. Pensky-Martens apparatus is the most commonly used apparatus for determination of oils (Figure-2).

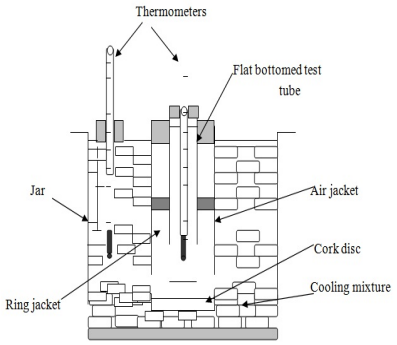

Fig. 1 Cloud and Pour point apparatus

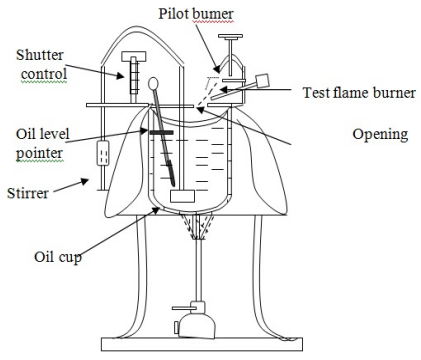

Fig. 2 Pensky-Marten apparatus

RESULTS

For *Pongamia* to be an effective, economical and promising biodiesel plant it should possess traits of significance such as high seed yield with high oil content of desirable quality. For obtaining seed oil we used ethyl acetate (polar) and n-Hexane, petroleum ether (non-polar) organic solvents. Table -1 gives the comparative study of fuel related physical properties for the seed oil from three different solvents *viz.*, n-Hexane, ethyl acetate and petroleum ether. The oil color was dark yellow in ethyl acetate, dark brown in petroleum ether and dark orange in n-Hexane with a disagreeable odour (Fig.3). Maximum oil yield of 33.10 % was observed when n-Hexane used as a solvent for extraction using soxhlet extraction method. Whereas, minimum oil yield 30.90 % was observed in petroleum ether solvent. The flash point recorded for pongamia extracted seed oil were 204 °C for n-Hexane, 214 °C and 218 °C for ethyl acetate and petroleum ether extraction respectively. The cloud point were observed 4.12 °C for n-Hexane , 4.82 °C for ethyl acetate and 5.00 °C for petroleum ether extracted oil. Moreover, its pour point was maximum of 4.11 °C in case of petroleum ether and minimum 3.09 °C was observed in n-Hexane extracted oil.

Characteristics	**Organic solvents**		
	n-Hexane	**Ethyl acetate**	**Petroleum ether**
Colour and Odour	Dark orange/brown and repulsive	Dark yellow and repulsive	Dark brown/ black and repulsive
Oil content %	33.10 ± 0.22	31.80 ± 0.52	30.90 ± 0.25
Flash point (°C)	204 ± 0.65	214 ± 0.19	218 ± 0.32
Cloud point (°C)	4.12 ± 0.10	4.82 ± 0.29	5.00 ± 0.42
Pour point (°C)	3.09 ± 0.12	3.90 ± 0.43	4.11 ± 0.15

Each value = mean ± SE of three replicates

Table-1: Physical properties from seed oil of *Pongamia pinnata* (L.) in different solvents.

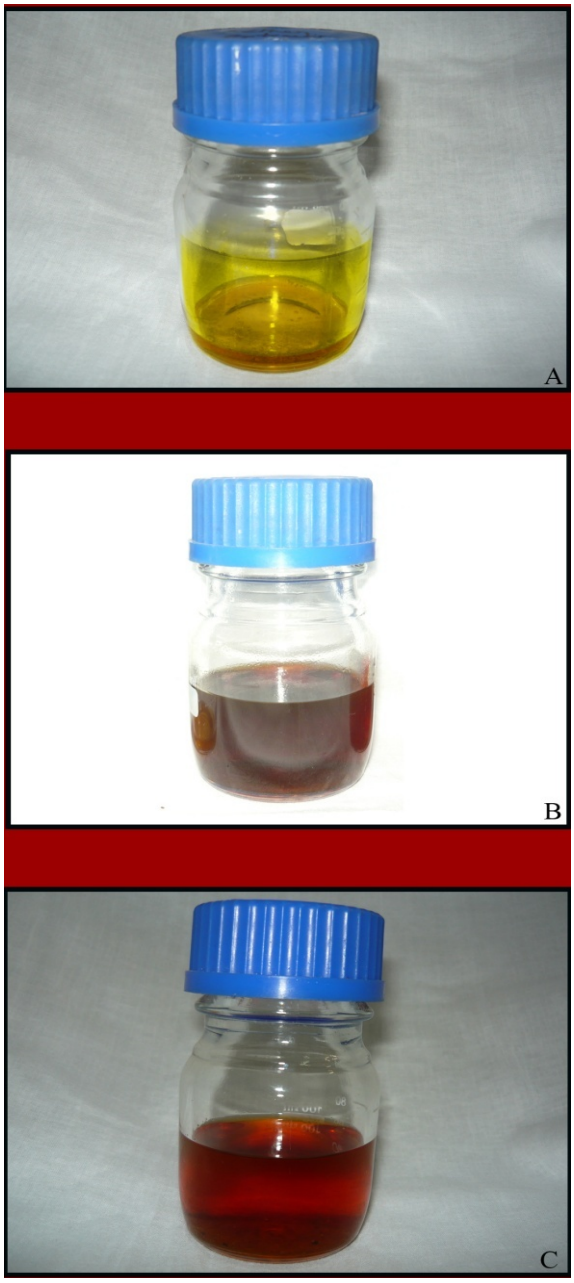

Fig-3: Extracted seed oil of *Pongamia pinnata* (L.) in different solvents.
(A)- Extracted seed oil in Ethyl acetate.
(B)- Extracted seed oil in petroleum ether.
(C)- Extracted seed oil in n-Hexane.

DISCUSSION

Self-reliance in energy is vital for overall economic development of India and other developing countries in the world. The need to search for alternative sources of energy which are renewable, safe and non polluting assumes top priority in view that fossil fuel sources are finite, and they are the major source of releasing sequesteral carbon to atmosphere as CO2 and CO causing global warming. In addition, uncertain supplies and frequent price hikes of fossil fuels in the international market are posing serious economic threats for developing countries. Amongst the many species, which can yield oil as a source of energy in the form of bio-fuel, *Pongamia pinnata* has been found to be one of the most suitable species in India being widely grown, it is N2-fixing trace and oil is non-edible. The seeds are largely exploited for extraction of non-edible oil commercially known as 'Karanja oil', which is well known for its medicinal properties. The crude oil is yellow orange to brown in color, with bitter taste and offensive odour.

In present study seed oil yield extracted using Soxhlet method was found to be in the range of 30.90 –33.10 % by using different solvents as shown in Table- 1. The oil is dark in colour with a offensive odour. Soxhlet extraction yielded best results with maximum yield being closer to 33.10 % using n-Hexane. Advantage of using organic solvents in extraction technique is that they can be recovered during the process and is easy for implementation and has been employed in many potential biodiesel crops (Akintayo , 2004).

The flash point recorded for Pongamia seed oil were 204 °C and 218 °C for non-polar solvents (n-Hexane and petroleum ether respectively) and 214 °C for polar solvent (ethyl acetate) which were less as compared to the other vegetable oils, but far greater than that of the conventional diesel fuel (55 °C). All vegetable oils have relatively high flash points, so they are considered to be safe fuels under normal conditions.

In present study, the cloud point were 4.12 °C and 4.82 °C for n-Hexane and ethyl acetate extracted oil were observed respectively. Pongamia seed oil had the lower cloud point when compared to the other vegetable oils.

Moreover, its pour point was maximum of 3.7 °C in case of ethyl acetate extracted oil, which is within the range of 12–31 °C reported for vegetable oils (Scott *et al.*, 2008).

In earlier kesari *et al.*, 2008 used two solvents (n-hexane and ethyl acetate) for the extraction of pongamia seed oil and it was found that flash point were 205.00 ± 0.50 °C in n-hexane and 215.00 ± 0.60°C in ethyl acetate, whereas cloud point for n-hexane and ethyl acetate were found 4.00 ± 0.10 °C and 4.90 ± 0.13°C respectively and pour point also for the above two solvents was founded to be 3.00 ± 0.36 °C and 3.70 ± 0.42 °C respectively.

CONCLUSION

From the results of this present study it is clear that not much difference lies in the physical properties of seed oil of Pongamia, extracted using solvents of three different polarities and that n-Hexane fraction showed only a marginal improvement in physical parameters with regard to fuel properties. In view of limited supply of natural fossil fuel, Pongamia is undoubtedly one of the key source-species and a potential source of viable biodiesel. The study reported here has an applied significance. Current study on characterization of crude oil for various physical properties demonstrated that, almost all the important properties of seed oil from the seeds of *Pongamia pinnata* are in very close agreement with the biodiesel making it a potential candidate for the application in CI engines.

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