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Production of oil from *Pongamia pinnata* seeds is a source of energy

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Abstract
In Energy scenario fossil fuels plays dominant role. These fuels are scarce, non-renewable and exhaustive in nature. Biofuels acts as alternative source and they are renewable and eco-friendly. A case study was undertaken to know the production cost of *Pongamia* oil into biodiesel with a small 50 LPB biodiesel extraction unit and it was found that the net production cost of biodiesel from *Pongamia* seeds was of Rs. 56.54 per liter. The cost of feedstock was the major factor which occupies of 60% of total cost of production fallowed by chemicals and operating cost. The production cost was reduced by the co-products such as seed cake and glycerin which accounts 21% and 2% respectively.

Keywords: Production, oil, *Pongamia pinnata*, source, energy

Introduction
Biofuels are gaining ground around the world as a renewable and environmentally friendly alternative to fossil fuels. Biofuel is a broad term that includes ethanol, biogas and biodiesel. Biodiesel is an alkyl ester of fatty acids found in vegetable fats, seeds (edible and non-edible), and animal fats that can be used as feedstocks for biodiesel production.
Feedstock selection depends on availability, cost, oil content, and biodiesel properties. The price of biodiesel depends on the chemicals and solvents used in the transesterification process. The results regarding the performance of diesel engines using biodiesel are comparable to conventional diesel fuel, except that the use of biodiesel reduces particulate matter, hydrocarbons, and carbon emissions (Graboski & Mc Cormick, 1998) [1].
The economical production of biodiesel in the world is already in place. US and Europe are leading countries in the production of biodiesel in the world (Mc Coy, 2005) [2]. India which imports almost 80% of the crude oil and by spending 1/3rd of its total GDP on the procurements of the fossil fuels. To reduce the import and to achieve self reliance in energy, India initiated a Biofuel policy on 2009.
In the context of India situations extraction of biodiesel from non edible oil seeds is economically viable rather than edible oil seeds. *Pongamia pinnata* is medium evergreen tree which contains about 25-32% of oil in their seeds and this tree has special characters such as wide adoptability and multipurpose in nature grows in waste land and marginal lands. This tree is planted as biofuel species in the various afforestation programmes and also found naturally. Many individuals are interested to take up Biofuel production unit. Keeping this in view this study was undertaken with small 50 LBP Biofuel Unit to know the biodiesel production cost from *Pongamia pinnata*.

Production Process
Transesterification means chemical conversion of triglycerides in the presence of alcohol (methanol or ethanol) and catalyst (NaOH or KOH) into di-glycerides and monoglycerides and then into alkyl esters and glycerol to improve the conversion process and purity of esters. Glycerol is produced under this process is by-product of the transesterification process. In transesterification methanol and ethanol are generally used. The methanol is most commonly used because of low cost. Transesterification reaction can be alkali or acid method it depends upon the presence of free fatty acids in the oil. Acid is costlier and requires more time than the alkali method. If the FFA exceeds 4.5 percent then acid based reaction should be adopted or if FFA is less than 4.5% alkali based reaction should be adopted, which is cheaper and quicker (FFA 1.5-4%).

Trans-esterification process details

The cleaned seeds were used for crushing in the expeller having a capacity to crush 200-300 kgs seeds per day. The oil obtained was kept for natural settling and later it was filtered by using the micro-filtration unit. The pure oil was then used for the analysis of free fatty acids content in the oil. Based on the presence of the FFA Tran esterification process has been carried out.

The oil was transferred to reactor-I and was heated @ 65 °C temperature. Simultaneously methoxide solution was prepared (methanol and NaOH mixture) based on FFA and was added to reactor-I through catalyst reactor. The process was continued for 90 minutes during the period the triglycerides were converted into Biodiesel and glycerin. After 90 minutes this was transferred to reactor–II for biodiesel and glycerin separation due to variation in the density biodiesel and glycerin were settled in the upper and lower layer respectively. The glycerin was taken and used as byproduct. The Biodiesel was then transferred to washing chamber and was washed with the warm water (40-50°C) to remove the excess soap and methanol in the mixture. The Biodiesel was then subjected to heat @ 110°C to remove the excess methanol and soap content remained in the biodiesel. The pure Biodiesel was then subjected to quality tests.

Materials and Methods

The biodiesel production cost from *Pongamia pinnata* was worked out based on the average production per month which accounts crushing 6000 kgs of *Pongamia* seeds. The whole work has been carried out in the lab of forestry Deptt. of Jabalpur (M.P.)

Production Unit: The unit includes decorticator, oil expeller with a capacity of 40 kgs/hr, settling tank, micro-filtration unit, trans-esterification unit and other instruments like Hot air oven, flash point, copper corrosion, hydrometer, kinematic viscometer and soxhlet apparatus and all the glass wares required for the production of biodiesel.

Chemicals and Reagents: The production of biodiesel from *Pongamia pinnata* is done through transesterification process. Transesterification is the process of exchanging of organic group R' of an ester with the organic group R' of an alcohol (Methanol or Ethanol), these reactions are often catalyzed by the addition of an acid (H_2SO_4) or base (NaOH or KOH) as catalyst and which requires the following chemicals and reagents under this study alkali method was employed because FFA of *Pongamia* is less than 4.5 percent (Table 1).

Table 1: List of Chemicals and reagents required for biodiesel production for 6000kgs of *Pongamia* seeds

Sl. No	List of Chemicals and Reagents	Unit	Qty	Rate per unit/ltr/kg	Amount (Rs.)
1	Isopropyl alcohol	ml	2500	1924	1924
2	Phenolphthalein Indicator	ml	50	75	75
3	Methanol	ltrs	375	55	20625
4	Sodium Hydroxide	kgs	10	2256	2256
Total					24880

Ref: All the chemicals and reagents used in this research work were analytical grade and were purchased from SDFCL (sd fine chem. Limited) and commercial methanol was purchased from Pawar Chemicals, Banglore for production of Biodiesel from *Pongamia* seeds.

Products obtained in the Biodiesel production process

The clean seeds were crushed in the mechanical expeller; during the process seed cake was obtained as byproduct and oil as a major product. This oil was subjected to transesterification where oil was converted to biodiesel and glycerin (Table 2).

Total cost of Production including operating cost: Total cost of biodiesel is generally depends upon the feed stock cost (*Pongamia pinnata* seeds were used as feed stock and the seeds were purchased with the price of Rs. 15/kg from the local market), total fixed cost, variable cost. The fixed cost which includes building rent, machine depreciation value it was calculated with depreciable life of 15 years. The escalation rate @ 1 per cent/ year, labors cost, office expenditure, electricity cost were included but the cost of working capital and vat on biodiesel were excluded in this study (Table 3). (Chemicals cost and other reagents which were used in transesterification process, FFA and final test of biodiesel were included).

Table 2: Products obtained in the process of biodiesel production for 6000 kgs of *Pongamia* seeds

Sl. No	Particulars	Quantity
1	*Pongamia* oil	1500 ltrs
2	Seed cake	4200 kgs
3	Biodiesel	1410 ltrs
4	Glycerin	240 ltrs

Table 3: Production cost of biodiesel from 6000 kgs of *Pongamia* seeds

Sl. No.	Description/ Particulars	Qty.	Rate (Rs)	Amount (Rs.)
I. Total cost of production				
1	*Pongamia* seeds	6000 kgs	15	90000
2	Transportation charges	6000 kgs	10	6000
3	Chemicals and reagents	-	-	24862
4	Electricity	1520units	6.50	9880
5	Man Power (6-days) Helpers (2 No's)	2	5000	10000
6	Office supervision	-	-	5000
7	Production Unit building Rent/month	-	-	2000
8	Depreciation value @ 1%/month	-	-	1000
Total				148742
II. Income from the byproducts				
9	Seed cake	4200 kgs	15	63000
10	Glycerin	240 ltrs	25	6000
Total				**69000**
III. Net production cost of biodiesel for 1410 ltrs				
11	Total cost of Biodiesel production	-	-	148742
12	Profits from byproducts	-	-	69000
Total				79742

Result and Discussion

The *Pongamia* seeds which were subjected to crushing by mechanical expeller which was yielded 25% of oil. Later, it was converted into biodiesel through transesterification process. The biodiesel and glycerin obtained in the ratio was

90:10. During the study, it was found that the major factor that affected the cost of production where cost of feed stock, which was accounted to 60% of the total cost of production (Fig.1). Fallowed by chemicals used to convert oil into biodiesel (17%) and operating cost. In line with this Nelson *et al*., (1994) [3] reported that the major factors that affect the cost of production were of cost of feed stock, plant size and value of glycerin.

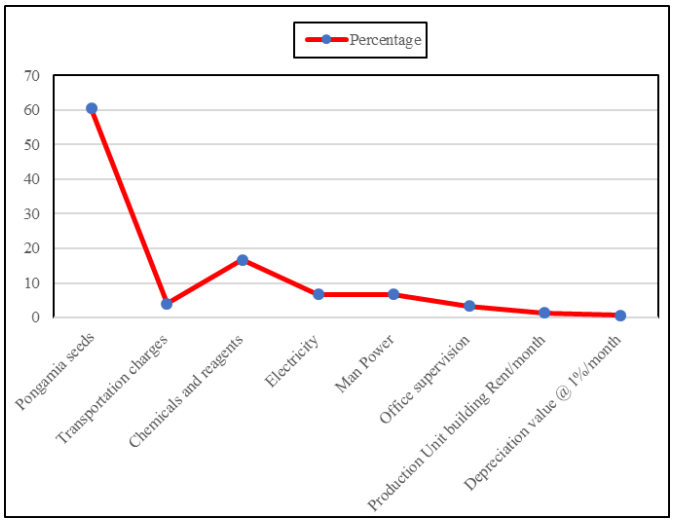

Fig 1: Total cost of percentage biodiesel production for 6000 kgs of *Pongamia* seeds

The plant size which was used under this study was of 50 LBP can be used for small scale industries for the production of biodiesel. The plant size also has an impact on total production cost. Yil Der You *et al.*, (2008)[4] studied that the economic cost analysis with biodiesel plants with different capacities of about 8000, 30,000 and 1,00,000 tons/year with alkali method for soya oil and they found that the higher the capacity unit were more viable than the others.

The study revealed that the second most major factor for the total cost of production was chemical solvents used in the transesterification process which accounts 17% of the total cost of the production (Fig. 1). The chemicals cost mainly depends on the acid or base catalyst employed in the transesterification process. The alkali method was cheaper and quicker and acid-base method was costlier and time consuming process (Kulkarni *et al.*, 2006) [5]. Use of acid or base catalyst method mainly depends on the free fatty acid content in the oil. If the FFA is less than 4.5% the alkali method can be employed. If it exceeds 4.5% acid-base method is employed, for this study alkali method was used.

The co-products which were obtained during the process of production of biodiesel from *Pongamia pinnata* were seed cake and glycerin. These co-products were used as manure and soap industries respectively. These co-products which were sold and income accrued by these products substantially reduced the total cost of production by 21% and 2% respectively. In the same way Bender (1999) [6] and Zang *et al.*, (2003) [7] reported that reduction of total cost of production was reduced to the extent of by 6-6.5% by the value of glycerol co-products.

Conclusion

The main factors affecting the production cost of biodiesel are the cost of feedstock, which accounts for 60% of the total production cost, followed by the chemicals used in the transesterification process, which accounts for 17%, and operating costs 10%. The overall cost of production was significantly reduced by the seed cake and glycerin values, which accounted for 21% and 2% respectively. Considering socioeconomic benefits such as afforestation, carbon sequestration, pollution reduction and job creation, production costs are minimal.

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