International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Biodiesel Production Cost Analysis from the *Pongamia Pinnata*: A Case Study in Yadagiri District of Karnataka-India

Doddabasawa[1], Ravikumar Patil[2]

[1]Author cum corresponding Author, Assistant Professor and Principal Coordinator,
Biofuel Information and Demonstration centre, College of Agriculture, Bheemarayanagudi,
Shahapur-Karnataka-585287, India

[2]Project Assistant, Biofuel Information and Demonstration Centre,
College of Agriculture, Bheemarayanagudi, Shahapur-Karnataka-585287, India

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 per cent 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 per cent and 2 per cent respectively.***

Keywords: P*ongamia pinnata,* biodiesel, seed cake, free fatty acids, seed oil, transesterification and glycerin

1. Introduction

In the energy scenario fossil fuels occupies dominant place. Fossil fuels are being extensively used in transportation and as well as in the industries. The consumption of these fuels is steadily increasing in the world wide. India has 4th rank in the world with respect to consumption of fossil fuels. The availability of fossil fuels in the nature are limited, scares and non-renewable and extensive use causes environmental pollution. Alternatives to fossil fuels are required at this juncture.

Biofuel is gaining importance in the world as alternative source for fossil fuels and these are renewable and eco friendly in nature. Biofuel is broad term which includes ethanol, biogas and biodiesel. Biodiesel is alkyl esters of the fatty acids found in vegetable fats, seeds (edible and non edible) and animal fats can be used as a feed stock for biodiesel production.

The choice of feed stock depends upon the availability, cost, oil content and biodiesel properties. The price of the biodiesel depends upon the chemicals and solvents used in the transesterification process. The results on the performance of diesel engine by using biodiesel is comparable to conventional diesel fuel, apart from this biodiesel usage results in the reduction of particulates, hydrocarbon and carbon emission ***(Garbeski & Mc Cormick, 1998).***

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).*** India which imports almost 80 percent 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 per cent 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. The initiation of biofuel programmes by Government of Karnataka by establishing the **"Karnataka state Biofuel Development Board (KSBDB)"** which initiated many programmes for the development of Biofuel in the state looking after the well known programme of **Biofuel Information and Demonstration centre (BIDC).** 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.*

1.1. 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 mono-glycerides 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 per cent then acid based reaction should be adopted or if FFA is less than 4.5 per cent alkali based reaction should be adopted, which is cheaper and quicker (FFA 1.5 - 4%).

1.2. 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 @ 65^0 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 tri-glycerides 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 (40-50^0 C) to remove the excess soap and methanol in the mixture. The Biodiesel was then subjected to heat @ 110^0 C to remove the excess methanol and soap content remained in the biodiesel. The pure Biodiesel was then subjected to quality tests.

2. Materials and Methods

The Biodiesel production cost from *Pongamia pinnata* was undertaken under adhoc project at Biofuel information and Demonstration center at college of Agriculture, Bheemarayanagudi of Yadagiri district, Karnataka, India in the year 2013-14. The project was sponsored by KSBDB, Government of Karnataka-India in association with University of Agricultural Sciences, Raichur-Karnataka-India. 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.

2.1. Production Unit

The production unit for calculation of production cost of biodiesel from *Pongamia pinnata* seeds is of capacity with 50 LBP which cost of Rs. 10, 00, 000.00 (2012-13) and it was provided by KSBDB, Bengaluru (Malnad Biodiesel extraction Industries, Shimoga, Karnataka-India). 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.

2.2. 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 (H2SO4) 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 per cent (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.

2.3. 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).

2.4. Total cost of Production including operating cost:

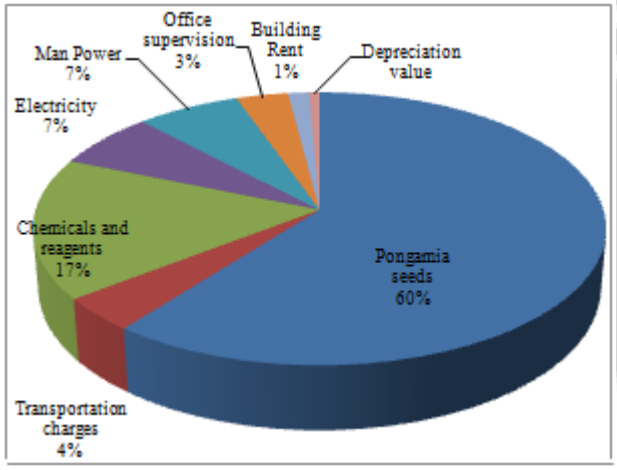
Total cost of biodiesel is generally depends upon the feed stock cost (Pongamia pinnata seeds were used as feed stock and the seeds were purchased with the price of Rs. 15/kg from the local market), total fixed cost, variable cost. The fixed cost which includes building rent, machine depreciation value 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

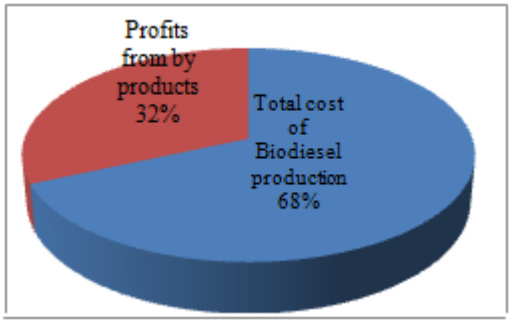
Sl. No	*Particulars*	*Quantity*
1	Pongamia oil	1500 ltrs
2	Seed cake	4200 kgs
3	Biodiesel	1410 ltrs
4	Glycerin	240 ltrs

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**



Graph 1: Total cost of biodiesel production for 6000 kgs of pongamia seeds



Graph 2: Return shares from by-products for 6000 kgs of pongamia seeds

3. Result and Discussion

The pongamia seeds which were subjected to crushing by mechanical expeller which was yielded 25 per cent 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 per cent of the total cost of production (Graph 1). Fallowed by chemicals used to convert oil into biodiesel (17%) and operating cost. In line with this ***Nelson et., al., (1994)*** reported that the major factors that affect the cost of production were of cost of feed stock, plant size and value of glycerin.

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)*** 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 per cent of the total cost of the production **(Graph 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).*** 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 per cent the alkali method can be employed. If it exceeds 4.5 per cent 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 per cent and 2 per cent respectively. In the same way ***Bender M (1999) and Zang Y et. al.,*** **(2003)** reported that reduction of total cost of production was reduced to the extent of by 6-6.5 per cent by the value of glycerol co-products.

4. Conclusion

It was found that the major factors for the cost of production of biodiesel were the cost of feed stock which was accounted to 60 per cent of the total cost of production followed by chemicals used in the transesterification process which accounts 17 per cent and operating cost 10 per cent. The total cost of production was substantially reduced by the value of seed cake and glycerin which comprises 21 per cent and 2 per cent respectively. The production cost will become minimal if we take into consideration of socio-economic benefits like afforestation, carbon sequestration, and reduction in pollution and employment generation.

References

[1] M. McCoy, "An unlikely impact: growth of biodiesel has big implications for the oleochemical industry," Chem Eng News 83(8):19–20, 2005.

[2] M.S. Graboski, R.L. Mc Cormick, "Combustion of fat and vegetable oil derived fuels diesel engines," Prog Energy Combustion Sci, 24, 125-126, 1998.
[3] R.G. Nelson, S.A. Hower, J.A. Weber, "Potential feedstock supply and costs for biodiesel production," Bioenergy: Proceedings of the Sixth National Bioenergy Conference, Reno/Sparks, NV, 1994.
[4] Yii-Der You, Je-Lueng Shine, Ching-Yaun chang, Shang-Hsuan Haung, chong Yu pai, Yue-Hwu and Chung tang Ho Chang, "Economic cost analysis of Biodiesel production: Case in Soybean oil,: Energy and fuels, 22:182-189, 2008.
[5] M.G. Kulkarni, A.K. Dalai "Waste Cooking Oils an Economical Source for Biodiesel," A Review. *Ind. Eng. Chem. Res 45,* 2901-2913, 2006.
[6] M. Bender, "Economic feasibility review for community-scale farmer cooperatives for biodiesel," Bioresour. Technol 70, 81–87, 1999.
[7] Y. Zang, M.A. Dube, Mc Lean DD, M. Kates, "Biodiesel production from waste cooking oil: 2. Economic assessment and sensitivity analysis," Bioresource. Technol., 90: 229-240, 2003.

Author Profile

Dr. Doddabasawa is working as an Assistant Professor (Forestry) and Principal coordinator (Biofuel Information and Demonstration Centre, Yadagiri District of Karnataka), College of Agriculture, Bheemarayanagudi, Shahpur under the University of Agricultural Sciences, Raichur. He has completed his B.Sc. and M.Sc. forestry in the University of Agricultural Sciences, Dharwad.