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# Economical Biodiesel Production with Microwave Method Model

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## ABSTRACT

*The present document examined the costs of the cottonseed oil to biodiesel transforming process and the returns from the byproducts using the microwave transesterification, a key technology in the development of biodiesel production. Capital expenditures and variable costs are part of biodiesel conversion costs. Initial investments in equipment are subject to capital investment, and variable costs including chemical, labour, fuel, electricity, and recurring cost of maintenance. The processing estimated has been measured for a daily output of 500 liters. In the report, clean cottonseed oil as feedstock was recommended. The operating time of the plant was also 8 hours, and transport, insurance and tax expenditure is 15 percent. The conversion cost of processing biodiesel with microwave assisted process was estimated to be around INR 3.35/ liter, so that INR 73.35/liter of pure biodiesel. This paper would indeed be useful for the purposes of research and development on biodiesel with microwave assistance.*

***Keywords:*** *Bio-diesel, Microwave Oven Reactor, Cost, Estimation.*

## 1.0 Introduction

Batch production of biodiesel from cottonseed oil using microwave has been explored as an important technology for oilseed processing regions. Silitonga et al. (1) concluded that the microwave reactor has been suited to a small-scale biodiesel synthesis that mitigates wastage of raw oil. The transesterified biodiesel through a microwave has both a high degree of purity and oxidation strength improves by two folds. The microwave assisted one-stage biodiesel production method of wet microalgal biomass was successfully applied by Wahidin et al. (2). In their analysis Peng et al. (3) found that the use of a microwave heating system improved the output of biodiesel.

Dehghan, Golmakani, and Hosseini (4) compared the two processes of biodiesel production and reported that when compared to the traditional magnetic stirrer transesterification process, the Microwave assisted technique was able to enhance methyl ester yield while concurrently reducing reaction time and energy usage. Falowo, Oloko-Oba, and Betiku (5) studied the possibility for biodiesel synthesis from a fusion of the neem rubber seed oil with an elephant ear tree pod husk via a trans-esterification of microwave irradiation with a microwave heat capacity of 150W and a response time of 5.88 min with a corresponding biodiesel amount of 98.77 wt. per cent.

Zhou et al. (6) studied the optimization process for microwave assisted bio diesel palm oil production and stated that the approach is becoming more relevant due to the much reduced response time and good energy efficiency. The study on optimizing conditions in the development of biodiesel was checked and found by Khedri, Mostafaei, and Safieddin Ardebili (7) that higher cost of biodiesels for fossil fuels is driving factor. Microwave-assisted biodiesel production is believed to be potentially encouraging among various methods of biodiesel production.

Athar, Zaidi, and Hassan (8) have observed that a microwave heating process outperforms traditional heating and provides a fast, easy method in the presence of organic acid catalyst DBSA for the biodiesel synthesis of triglycerides. Milano et al. (9) used an alkaline-catalyst with microwave irradiation transesterification technique, in order to make biodiesel from a mixture of waste cooking oil and

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Calophyl inophyllum oil. Through utilization of microwave irradiation greatly speeded up the process, which ultimately helped to reduce reaction time considerably in comparison to the traditional method of transesterification.

In comparison with the conventional stirrer method, Kumar Garg and Pal (10) found a sharp decrease in the input power consumption by the microwave method. The results of their study showed the utility of microwave in small-scale generation of bio-diesel as power efficient tool. Cost of production and returns are essential considerations once it comes to financing in the synthesis of biofuels. Defining the key fiscal issues in the development of biodiesel production will lead to better informed decisions by potential biodiesel producers.

Agriculture practice of harvesting oil seed crops are typically rare and small-scale oilseed crops, and on-farm production of biodiesel continues to be largely unconsidered. Local farmers don't feel they are equipped or experienced to grow these crops. But if farmers can grow or reap such crops, press the seeds into vegetable oil and oilseed fodder followed by turning that oil into biodiesel then both the biofuel and cattle feed can be produced separately. Earlier studies of converting oil seeds into vegetable oil and meal has shown that the processing of on-farm oil and meal is technologically possible.

The expense of extracting biodiesel comprises capital investments and variable costs. Initial equipment investments falls under the head of capital investment and variable costs include chemical, labour, fuel, power and annual maintenance costs.

Farmers are expected to acquire a newer or just used oil extracting machine. The extractor uses a screw to press the oil-bearing seeds under considerable pressure to extract the oil against a limited opening. Expelled products seem to be 50 percent to 85 percent of available oil and reducing the amount of animal food fat to 6 percent –7 percent. The seeds has to be clean and contain moisture about 6 to 9 percent in order to get pressed properly. When the seeds are wet or the moisture content is more, it becomes sticky and clogs the small opening. At the same time if the seeds found to be completely dry, the machine rattles the seeds and make them to powder. A biodiesel processor i.e, a microwave oven in the present study, uses chemicals to turn the oil into biodiesel and the costs of a biodiesel processor differs according to the capacity. The cost of depreciation of the equipment per litre would rely upon its yearly biofuel output.

## 2.0 Methodology/ Processing Cost

Assumptions: The estimated processing cost of biodiesel output has been characterized by the following:

- It is estimated that the capacity of the plant has been 500 litres daily.
- Operating hours have been expected to be 8 hours/day.
- The cottonseed oil used has been free from impurities and water.
- Transport, insurance and taxes deemed to be 15%

**Table1: Price of Raw Materials for Biodiesel Production**

| Product | Quantity | Price(INR) |
|---|---|---|
| Cottonseed oil | 1 kg | 70 |
| Methanol | 1 liter | 40 |
| KOH | 1 kg | 300 |

### 2.1 Cost of raw material

Feedstock, methanol and KOH are the basic raw materials required.

#### 2.1.1 Cost of feedstock

Cost of cotton seed oil = INR 70/kg

Collection and transportation cost = (5/kg)*(500 kg/day) = INR 2500/day

Total expenses on feedstock/day = cost of cotton seed oil +collection& transportation cost = (70*500) + 2500 = INR 37500

#### 2.1.2 Cost of methanol

Price of 1 liter of methanol [11] = INR 28

Requirement of methanol/ day = 110.5kg

Expense on methanol/ day = 110.5*28= INR 3094

#### 2.1.3 Cost of catalyst (KOH)

Price of 1 kg of KOH [12] = INR 300

Requirement of KOH/day = 5 kg

Expense on KOH/ day =5*300= INR 1500

Total expenses on raw materials/ day = cost of oil + expense on methanol + expense on KOH

= 37500+ 3094 + 1500= INR 42094

**2.2 Expenditure towards use of electrical energy charges**

Assumptions: 1 kWh of electricity price (Unit Price) [13] = INR 7.75 (for industrial use)
Specific heat of water = 4.18 kJ/kgK
Heat loss in radiation by microwave = 1%

**2.2.1 Electricity charges for stirring methanol and KOH**

Motor power =10 kW
Duration of stirring for thorough mixing = 10 minutes
Expenses Electricity cost for the stirring per day= 10*(10/60)*7.75= INR 12.91/day

**2.2.2 Electricity cost for trans-esterification process in microwave processor**

Working power of microwave processor = 100W
Duration of trans-esterification in microwave processor = 22 minutes (for 400gm)
Energy required for trans-esterification of 500kg in microwave = P*time = 100*165000 J=45.833 kW-hr
Electricity cost for the process per day= 45.833*7.75= INR 355.20

**2.2.3 Electricity cost for heating of water**

Requirement of water for washing of 500kg of oil = 200 kg (around 40% of oil)
Heat energy required for the heating Q= m*cp*dT/ efficiency
= 200×4.18*(50-20)/0.99
= 25333.33 kJ
= 7.037 kW-hr
Electricity cost for the process per day = 7.037*7.75= INR 54.53

**2.2.4 Electricity cost for final heating**

Power of microwave processor is maintained at 180W Energy required for heating of oil from 20ºC to 110ºC =P * time
=180*3750 J
= 18.75 kW-hr
Electricity cost for the process per day= 18.75 *7.75= INR 145.31
Total charges on electrical energy per day= 12.91+ 355.20+ 54.53+ 145.31= INR 567.95

**3.0 Apparatus and Equipment Cost**

Total cost of microwave processor and equipment is about INR 500000, assuming these apparatus works for 10 years and taking 15% interest rate.

Apparatus and equipment cost for 15 years = 500000(1+15*10/100) = INR1250000

Apparatus and equipment cost per day = 1250000/ (10*12*30) = INR 347.22/day

**4.0 Miscellaneous Cost**

Labour cost per month = INR 25000
Rent per month = INR 10000
Maintenance = INR 1000
Total miscellaneous cost per month= INR 36000
Total miscellaneous cost per day=INR 1200
Grand total cost per day = (42094 + 567.95 +347.22 + 1200) = INR 44209.17

**5.0 Income from by product (Glycerin)**

Quantity of glycerin produced per day= 30 kg
Income from glycerin per day (@ 300 per kg) = 300*30 = INR 9000/day
Net cost per day= 44209.17 - 9000= INR 35209.17
Quantity of biodiesel produced per day = 500*0.96 (yielding efficiency is 0.96) =480 liter
Cost of cottonseed biodiesel per liter = 35209.17/480 = INR 73.35
Conversion cost of biodiesel from cotton seed oil = 73.35-70 = INR 3.35/ kg of oil

**6.0 Conclusion**

Based on the above cost estimation, the present study concludes as follows:

- The bio-diesel conversion cost with a microwave processor found to be around 3.35 rupees per liter and the net biodiesel costs of cottonseed oil are thus 73.35 rupees/liter excluding exemptions.
- In the year 2022, INR1119529 could be saved in India.
- Countries like India, will be able to save a lot of money spent on import of crude oil.
- Countries may become self-sustained and self-reliant.
- With increase in use of blended fuel the pollutants coming out of CI engines can be mitigated.
- Farmer will be benefitted by promoting them to install small units to process non-edible seeds into biodiesel.

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