

## Biodiesel of Groundnut Oil: A Safe Alternate Fuel in the Transport Sector

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Considering pure biodiesel of groundnut oil and its blend up to 10% in particular with heavy duty Karnataka State Road Transport Corporation (KSRTC) vehicles, it is one of the important alternative safe fuels to stabilize green house gas (GHG) emission level in the atmosphere and the results were quite encouraging leading to 22% mileage improvement in groundnut oil ester diesel blend (GOED 10%) compared to 20% in pure groundnut oil ester (GOE). But both have selective improvement compared to diesel. Thus GOED 10% shows 74% improvement and considerable reduction in exhaust emission compared to 73% improvement in pure GOE. The best performance safe fuel compared to HSD is GOED 10% and besides biodiesel of groundnut oil having an agricultural base, it is one of the possible renewable, oxygenated fuel with high calorific value. It strengthens the environmental issues in reducing emission particulates due to low sulphur content of 0.20 in GOE compared to 0.25 in high speed diesel (HSD).

**Key Words:** Groundnut oil, Diesel, Fuel, Alternative fuel.

### INTRODUCTION

Biodiesel of groundnut oil is a cleaner-burning diesel replacement fuel made from natural, renewable sources such as edible oil<sup>1-3</sup>. These esters of groundnut oil are used because they have a lower viscosity and better fuel properties than pure groundnut oil and operate in compression ignition engines<sup>4-6</sup>. A blend of up to 10% pure GOE mixed with petroleum diesel fuel is used on heavy duty vehicles of diesel equipment<sup>7</sup>. These low level blends of 10% GOE do not require any modifications<sup>8</sup> and will provide the same payload capacity and range as diesel. Fuel properties of biodiesel GOE and its blend GOED 10% compare well with those of petroleum diesel (HSD).

Depleting reserves of fossil fuel and increasing effects of pollution from petroleum fuels demand eco-friendly safe alternatives, which will supplement or replace fossil fuels. So, these alternative biofuels of groundnut oil and its blend are renewable and environmentally safe. In view of a strong agricultural and

forestry base<sup>18</sup>, biofuels are emerging as an alternative transportation fuel due to their ecofriendliness and economy in India<sup>5, 7, 9, 14</sup>.

Taking cognizance of these facts, the Planning Commission, Government of India, has taken a decision to promote biofuels as one of the policy decisions of the National Autofuel Policy<sup>15</sup>.

Biodiesel development worldwide is well documented<sup>7</sup>. In the last 15 years 28 countries have embarked on biodiesel projects and biodiesel production has grown from trials at pilot plant scale to full industrial production<sup>8</sup>. To date, a total of 85 production plants of biodiesel have been identified with capacities ranging from pilot plant to industrial scales upto 1,20,000 tonnes per year. Biodiesel is being currently used commercially in Brazil, Germany, Italy, Australia and Sweden, the Czech Republic, Slovakia and in USA<sup>21-25</sup>.

But India is heavily dependent on imported fuels to meet its energy demands and needs. According to the Ministry of Petroleum and Natural Gas, Government of India, the annual consumption of petro-diesel was about 400 lakh tonnes in 2000–2001<sup>5</sup>, which constitutes about 40 per cent of the total petroleum products consumption in the country. The surplus availability of overall edible oilseed<sup>10</sup> production is about 93% and the current annual ethanol production is 1900 million litres (out of a total sugar production of 19.6 million tonnes). Moreover, out of the total production of oilseeds, the production of groundnut is 64%<sup>10, 19, 20</sup>.

The production of biodiesel from groundnut oil is done through a simple chemical processing technology of trans-esterification and purification<sup>3, 9, 12</sup>. The results are leading to significant economic benefits to both the urban and rural sectors in the replacement for diesel fuel in heavy duty training vehicles, in order to examine the variance in the operating aspects of blending of biodiesel (GOE) and its blend (GOED 10%) in terms of output and environmental impact in reducing emissions of particulates. Thus, biodiesel of groundnut oil (GOE) and its blend upto 10% is one of the possible efficient alternative ecofriendly fuels for diesel replacement in compression ignition (CI) engines. Besides being an oxygenated fuel which has high calorific value in GOED 10% and high cetane number greater than 50 strengthens the agricultural economy. Finally, an evaluation of biodiesel GOE as a substitute or as a blend up to 10% to assess the improvement in mileage and % improvement in smoke reduction in the transport sector saves about Rs. 10,000 crores/annum<sup>1</sup> and results in significant economic benefits to the rural sector in irrigation pumpsets on a small scale.

## EXPERIMENTAL

- 100% pure biodiesel of groundnut oil (GOE) was prepared by *trans*-esterification and purified by double distillation.
- The biodiesel of groundnut oil GOED 10% was prepared by blending diesel 10% and GOE 90% by volume.
- To identify the functional group of the ester and moisture content present in pure GOE and its blend. FTIR spectra of the pure GOE and GOED 10% were taken in KBr medium (Figs. 1 and 2).

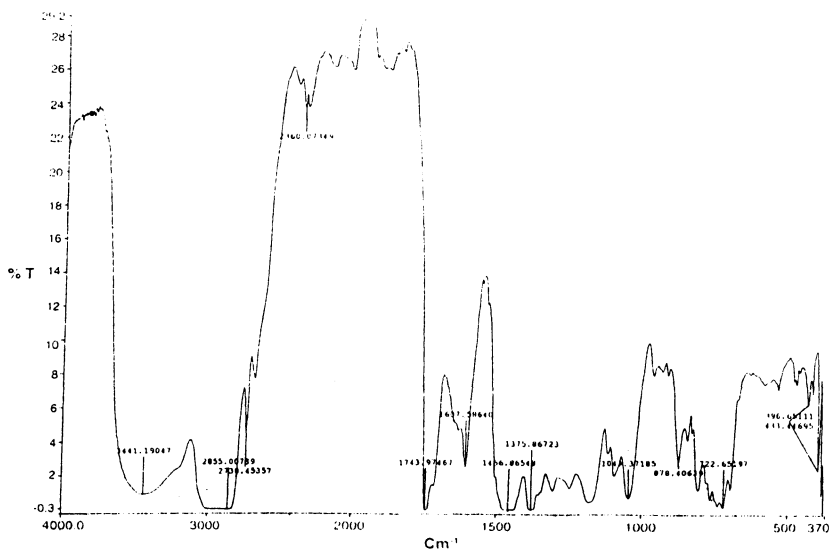


Fig. 1. FTIR spectra of groundnut oil (GOE)

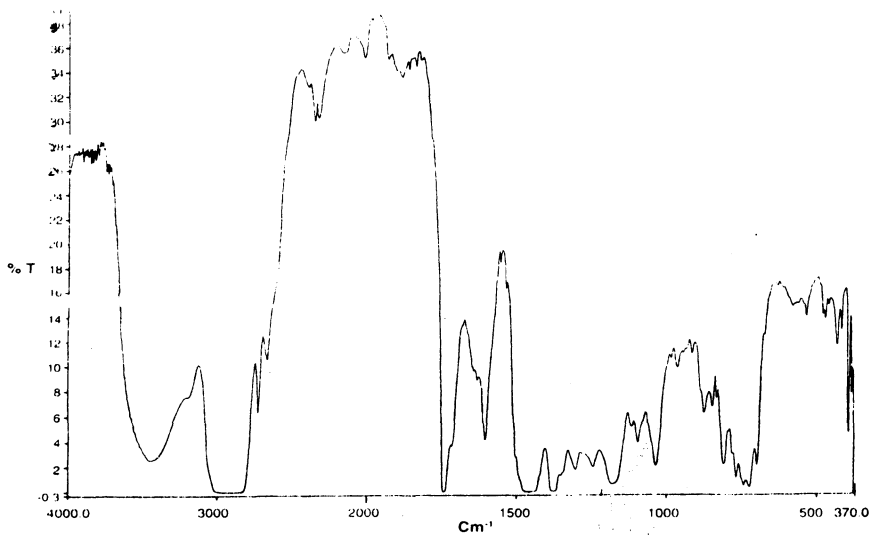


Fig. 2. FTIR spectra of GOED 10% (90% diesel + 10% GOE)

- Calorific values of biodiesel GOE, GOED 10% and HSD were calculated by using automatic bomb calorimeter AC-350 (Lecomake) at Central Power Research Institute (CPRI), Bangalore (Table-1).  
*i.e.*, GOE: groundnut oil ester (pure biodiesel)  
 GOED 10%: ground nut oil ester 10% + 90% diesel by volume.  
 HSD: High Speed Diesel
- Basic fuel test reports for GOE and its blend GOED 10% from Indian Oil Corporation Limited (IOCL) at Korukkpet, Regional Laboratory, Chennai (Table-2).

TABLE-1  
GROSS CALORIFIC VALUE OF DIESEL, PURE  
BIODIESEL (GOE) AND GOED 10% BLEND

Sample	Gross calorific value (kcal/kg)
Diesel	10004.00
Groundnut oil ester (GOE) (pure 100% biodiesel)	9085.00
Ground nut oil ester 10% + 90% diesel (GOED 10%)	10459.00

TABLE-2  
PROPERTIES OF DIESEL AND PURE GOE AND GOED 10% BLEND

Characteristics	Diesel	Pure GOE	GOED 10%
Specific gravity at 60°F	0.8500	0.902	0.912
Cetane No.	50	53	51
ASTM density 15°C kg/m <sup>3</sup>	833	840	841
Flash point °C min	36	38	40
Distillation 90% vol.	90 mL	90 mL	90 mL
Recovery °C min	336	340	343
Kinematic viscosity at 40°C cst	2.52	2.946	3.046
Water content % by volume	0.03	0.01	0.01
Ramsbottom carbon residue % m/m	0.36	0.19	0.18
Ash content % m/m	0.010	0.002	0.008
Sulphur content weight %	0.25	0.20	0.19

Biodiesel blend GOED 10% and pure biodiesel GOE were put on training vehicle of KSRTC in replacement of diesel; the mileage and percentage improvement in comparison with diesel were tabulated. Here regular full load governed speed is 1960 engine rpm (Table-3).

TABLE-3  
EFFECT OF DIESEL AND BIO-DIESEL GOE AND ITS BLEND  
ON MILEAGE IMPROVEMENT IN A HEAVY DUTY BUS

Particulars	K m/L	Improvement (%)
GOE (Pure Biodiesel)	6.95	20.80
GOE 10%	7.14	22.00

**Note:** Results are based on performance of engine while running on high speed diesel which has an yield of 5.5 kmpl.

Manatec diesel smoke meter with web camera was used to check the vehicle's smoke emission level which should be normally within 65% opacity. Exhaust emission reports of GOE and its blend GOED 10%, diesel (Tables 4–6).

TABLE-4

Test No.	Opacity (%)	K (1/m)
1.	64.0	2.38
2.	38.9	1.14
3.	30.2	0.83
4.	28.5	0.78
5.	30.3	0.84
6.	27.4	0.74
Average	29.1	0.80

TABLE-5

Test No.	Opacity (%)	K (1/m)
1.	18.4	0.47
2.	19.9	0.51
3.	20.5	0.53
4.	19.1	0.49
Average	19.4	0.50

TABLE-6

Test No.	Opacity (%)	K (1/m)
1.	27.4	0.74
2.	46.4	1.45
3.	40.1	1.19
4.	29.8	0.82
5.	29.1	0.80
6.	26.6	0.72
7.	18.9	0.48
8.	18.4	0.47
9.	15.4	0.38
10.	16.3	0.41
Average	17.2	0.43

- Smoke meter AVL-437 is used to check the opacity, *i.e.*, smoke density in terms of particulate matter is measured and percentage improvement in smoke reduction (Table-7).

TABLE-7  
EXHAUST EMISSION TEST REPORT ON HEAVY DUTY  
KSRTC BUS USING GOE (BODIESEL) AND ITS BLEND

Particulars	1st smoke mean value	Smoke value with blend	Difference	Improvement (%)
Diesel	36	—	—	63.62
GOE (pure biodiesel)	36	26.3	9.7	73.06
GOED10%	36	26.5	9.5	73.60

- Analysis of variance is given by comparative % improvement in smoke reduction and mileage (Fig. 3).

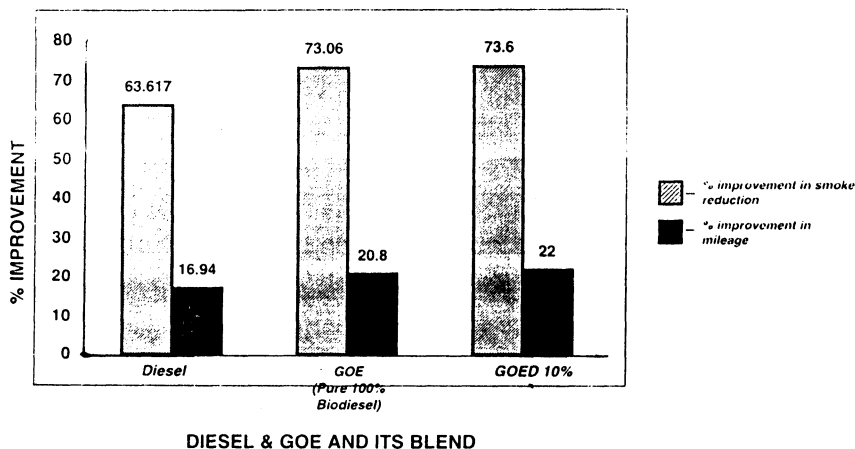


Fig. 3. Comparative % improvement in smoke reduction and mileage

## RESULTS AND DISCUSSION

Table-1 shows that GOED 10% biodiesel has greater calorific value than pure diesel (HSD) and pure biodiesel (GOE). This shows that higher calorific value gives less fuel consumption resulting in complete combustion of GOED 10% blend.

Pure ester of groundnut oil (the so called 100% biodiesel) is also a substitute to diesel because it has nearer calorific value compared to diesel.

Table-2 shows that basic fuel tests were done on pure diesel (HSD) and pure biodiesel (GOE) and its blend GOED 10%, *i.e.*, cetane number is enhanced from 50 to 53 and even pure biodiesel (GOE) has an excellent ignition quality with high self-ignition temperature. Sulphur content is low in GOE and GOED 10% compared to diesel which avoids sulphur dioxide formation during the combustion of fuels. Due to less carbon residue (0.19, 0.18), GOE and its blend emit little soot (particulate matter); There is smooth running of engine because its oil derivative nature acts as a lubricant.

Table-3 indicates 20–22% improvement in mileage in using GOE and GOED 10% fuels compared to diesel (HSD) due to their high calorific value.

Table-7 indicates that the use of GOE and GOED 10% fuel put on heavy duty results in 73–74% improvement in smoke reduction.

This shows that as the blends are used, green house gas (GHG) emissions are significantly reduced due to their high thermal efficiency. The FT infrared spectra of GOE and GOED 10% (Figs. 1 and 2) show the presence of moisture content ranging from 3700–3200  $\text{cm}^{-1}$  spectrum range of wave number, presence of (C=O) functional group in the range of 1750–1700  $\text{cm}^{-1}$  in all spectra. This blend has a property of absorbance of moisture.

Tables 4–6 denote Manatec diesel smoke metre reports, indicating the smoke emission level results in terms of opacity % using pure HSD, pure GOE and GOED 10% on training vehicle of heavy duty. If opacity % of the vehicle is greater than 65%, the results fail and the vehicle is seized in order to avoid pollution and keep the air clean and the environment green; by using biodiesel GOE and GOED 10%, the emission level is 19.4%, 17.2% compared to 29.1% in diesel (HSD).

Biodiesel GOE and GOED 10% give less soot and carbon leading to white smoke emission.

Fig. 3 indicates a comparative % improvement in smoke reduction and mileage, as the analysis of variance indicates that in HSD there is 63.6% smoke reduction with 16.94% improvement in mileage as compared to 73–74% in biodiesel and its blend. As the blend increases, smoke reduction increases with linear clean burning of fuels, output is high with significant reduction of smoke emission particulates and shows % improvement of mileage from 20–22%.

### Conclusion

- Fuel quality upgradation by preparing biodiesel GOE and its blend GOED 10%.
- Fuel savings, environment conservation
- Improves the economic rural agriculturists.
- Potential advantages for vehicle manufactures.
- Improves economy of the sugar industry by excess production of ethanol which in turn helps production of biodiesel.
- Substantial availability and utilizing agricultural feedstock, less fuel cost.
- High engine performance in terms of mileage and smoke reduction improving urban air quality.
- Alternate green fuel improves the economy of the transport sector.
- Biodiesel production improves Indian economy reducing imports.
- Life cycle cost is less.
- Utilisation of unfertile land for production of edible oil seed plants or trees.

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