*ejpmr, 2020,7(5), 407-415*

**SJIF Impact Factor 6.222**

**EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH**

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

# *SEMECARPUS ANACARDIUM* L.F. NUT OIL AS BIODIESEL FEED STOCK (ANACARDIACEAE –FAMILY)

***Dr. Vustelamuri Padmavathi**

Associate Professor, Department of Chemistry, Neil Gogte Institute of Technology, Kachavani Singaram, Hyderabad, India.

***Corresponding Author: Dr. Vustelamuri Padmavathi**

Associate Professor, Department of Chemistry, Neil Gogte Institute of Technology, Kachavani Singaram, Hyderabad, India.

**Article Received on 29/02/2020** **Article Revised on 19/03/2020** **Article Accepted on 09/04/2020**

**ABSTRACT**

As petrol is a fast depleting natural resource, it became a tremendous need for the scientists to search because another alternative renewable resource to petrol is a deemed necessity. Now serious efforts are being made on the production and utilization of biodiesel in India and other parts of the world. As an alternative invention of biodiesel from naturally growing herbal plants became the target. In this study, *Semecarpus anacardium* L.f. which grows naturally without any cost and care by the time, is analyzed and investigated as a proper feedstock in producing biodiesel for the first time. In order to prove its suitability, its seed and oil were experimented first. The tree is widely distributed through the hotter part of India. It is frequent in dry deciduous forests of Central India. Common in dry deciduous forests of Maharashtra spreading over Khandesi, Marathwada and East Maharashtra, in India. In the present study, biodiesel has been synthesised from *Semecarpus anacardium* L.f. oil. The acid value of this oil was found to be as 0.5 during these investigations, which leads us to convert it to biodiesel by the esterification followed by *trans*-esterification process. The methyl esters produced by these methods were analyzed and found that, some of them are suitable as biodiesel fuel to ascertain their suitability as diesel fuels.

**KEYWORDS:** *Semecarpus anacardium* L.f., Anacardiaceae Family; alkali *trans*-esterification; methyl ester; antimicrobial activity; alternative fuel.

**Abbreviations**

ASTM: American Society for Testing and Materials; EN: European Norm; CP: cloud point; PP: pour point; PM: particulate matter; PAH: polycyclic aromatic hydrocarbons; Sox: sulphur oxides; EU: European Union; FFA: free fatty acids.

## INTRODUCTION

Biodiesel which is derived from triglycerides by *trans*-esterification and also from the fatty acids by esterification has attracted considerable attention during the past decade as renewable, biodegradable, eco-friendly and non-toxic fuel. Recently biodiesel is gaining prominence in global warming and the consequential changes in weather pattern manifested in the form of widespread flooding, gully erosion, massive mudslide, environmental degradation and increasing cost of fossil fuel have given the necessary impetus to switch to vegetable oils as alternative fuels for diesel engines. Vegetable oils, however, are not suitable for direct use in diesel engines because of high viscosity, poor cold flow properties and low cetane number, It can however, be made useable by either blending with diesel fuel or *trans*-esterification with alcohol as to methyl ester is called biodiesel.

As a substitute for petroleum based diesel due to environmental considerations and depletion of vital resources like petroleum and coal, the possible use of renewable resources as fuels and as a major feedstock for the chemical industry is currently gaining acceptance. Further, as petroleum is a fast depleting natural resource, an alternative renewable route to petroleum is a deemed necessity. Now serious efforts are being made on the production and utilization of biodiesel in India. Methyl esters are clean burning fuel with no sulfur emission. Although its heat of combustion is slightly lower than that of the petro-diesel, there is no engine adjustment necessary and there is no loss in efficiency. Methyl esters are non-corrosive and are produced at low pressure and low temperature conditions. Concentrated (about 80%) glycerin is obtained as a byproduct during *trans*-esterification process.

### Plant History

*Semecarpus anacardium* L.f.[1-4] (Anacardiaceae) is a deciduous tree distributed in the forests of the Western Ghats of India. In the Indian system of medicine, the plant is well known as Bhallatak (Sanskrit) and commonly known as 'marking nut' (English) and Kaadu geru (Kannada). *Semecarpus anacardium* L.f (Anacardiaceae) is reported to possess many medicinal

properties. Trees: up to 25 m tall; young branches: terete, tomentose, watery latex present, which on drying it turns black. The black corrosive juice of the pericarp contains tarry oil consisting of 90% of oxyacid anacardic acid and 10% of higher nonvolatile alcohol called cardol, also contains catechol and a mono-hydroxy phenol called as anacardol. The most significant components of the *Semecarpus anacardium* L.f. oil are phenolic compounds on exposure to air; phenolic compounds get oxidized to quinones. The oxidation process can be prevented by keeping the oil under nitrogen. Many of the well-known properties of marking nut oils are easily explainable by the catechol half and lipoid-soluble $C_{15}$ chain. During exposure to air, the catechol ring might be oxidized to an orthoquinone which might impart the dark color and also implies polymerization. The vesicant nature and the indelible pigmentation due to the rapid formation of the orthoquinonoid intermediate. The absorption of the oil by the skin is obviously due to the lipoid-soluble $C_{15}$ chain.[5] In addition to this, Chemical and photochemical analysis of *Semecarpus anacardium* nuts revealed the presence of bhilawanol[5,6], Anacardic acid[7,8&9], I-4$^1$,II-3$^1$,4$^1$,I-5, II5,I7hexahydroxy [I3,II8]biflavanone,[10] I-4$^1$, II-4$^1$, I-5, II-5, I-7, II-7-hexahydroxy [I-3, II-8]biflavanone (3$^1$, 8-binaringenin)[10], I-4$^1$, II-4$^1$, I-7, II-7-tetrahexahydroxy [I-3, II-8] biflavanone (3$^1$8-billiquiritigenin)[10], Tetra hydrorobusta Flavanone[11], Tetrahydroamento flavanone[11] Amentoflavone[11], Semecarpuflavanone[12], Galluflavanone[13], Jeediflavanone[14,15], Semecarpetine[16], Anacarduflavanone[17], Nallaflavanone[18] Anacardoside[19] Bhilwanol analogs[20], Flavanoids.[21]

**Pharmalogical activities of Semacarpus anacardium**

Hypocholesterolemic activity[22], Anti-inflammatory[23-26], Immunomodulatory activity[27], Antioxidant[28-29], Adjuvant[30], Antimicrobial activity[31-36], Hypoglycemic and anti hyperglycemic[37], Breast cancer [38-43], Acetyl cholinesterase inhibitory activity[44], Acute and subchronic toxicity study[45], Anti mutagenic effect[46], Bioactivity[47-48], Renal cortical necrosis[49], Hair growth.[50]

## MATERIALS AND METHODS

*Semecarpus anacardium* L.f. nuts were collected from field area very nearer to the village Nandgaon, Kolhapur City, Maharashtra, India. All plant material specimen's were identified by Dr Vatsavaya S. Raju, Plant Systematic Laboratory, Department of Botany, Kakatiya University, Warangal (A. P. State) and conformed as *Semecarpus anacardium* L.f. (syn: *Anacardium latifolium* Lam., *A. orientale* Steud.) of Anacardiaceae and plant specimen deposited at Kakatiya University Herbarium, Warangal (KUW) with accession number 1874. It is locally known as 'nalla jeedi' and popularly known 'marking nut/dhobi nut.

### Material and plant source

### Extraction and purification

Plant material: *Semecarpus anacardium* L.f. 3 kg nuts were collected and shade dried and six psyphons (What are these?) were done for each step. The nuts were directly percolated with cold petroleum ether 5-6 times, filtered and concentrated by vacuum evaporation.

**STEP 1:** Then the nuts were made in to small pieces and percolated with petroleum ether 5-6 times, filtered and concentrated by vacuum evaporation.

**STEP 2:** Again the powdered nuts were percolated with hot petroleum ether 5-6 times, filtered, and concentrated by vacuum evaporation.

**STEP 3:** After that, the same powdered nuts were extracted with cold acetone by changing the solvent for 3 hours in three intervals, filtered and concentrated by vacuum evaporation.

**STEP 4**: After cold acetone percolation, nuts were subjected to hot acetone extract, and concentrated by vacuum evaporation.

The above four concentrates were then fractionated using silica gel column with appropriate solvent gradient and the oil obtained from the fraction of CAPE (cold acetone petroleum ether extract) 30, 31, 33, 34, 35, 36, 37 cape 38 last, the combined oil (named CAPE 30) was concentrated by vacuum evaporation and given for spectral analysis. Basing on UV, FT-IR[22], $^1$H NMR[23-26], $^{13}$C NMR[23], MASS, HPLC, LCMS, GCMS, GC[27-31] methods, it was found that it contains free fatty acids, triglycerides and others. Basing on spectral data and their physical properties *Semecarpus anacardium* L.f. nut oil was selected for biodiesel production.

### FT-IR: CAPE 30

The compound displayed bands at 3473.09 cm$^{-1}$ (O-H, hydrogen bonded alcohol, phenols), 3006.16 cm$^1$ (hydrogen bonded alcohol, phenols), 2925.05 cm$^{-1}$, 2855.42 cm$^{-1}$ (C-H, alkanes), 1746.10 cm$^{-1}$ (C=O, aldehydes, ketones, carboxylic acids, esters), 1460.52 cm$^{-1}$, 1376.09 cm$^{-1}$ (C-H, alkanes), 1221.47 cm$^{-1}$, 1163.38 cm$^{-1}$, 1118.88 cm$^{-1}$ (C-O, alcohol, acids, ethers, carboxylic acids, esters.), 770.90 cm$^{-1}$, 722.88 cm$^{-1}$ (C-H, alkanes).

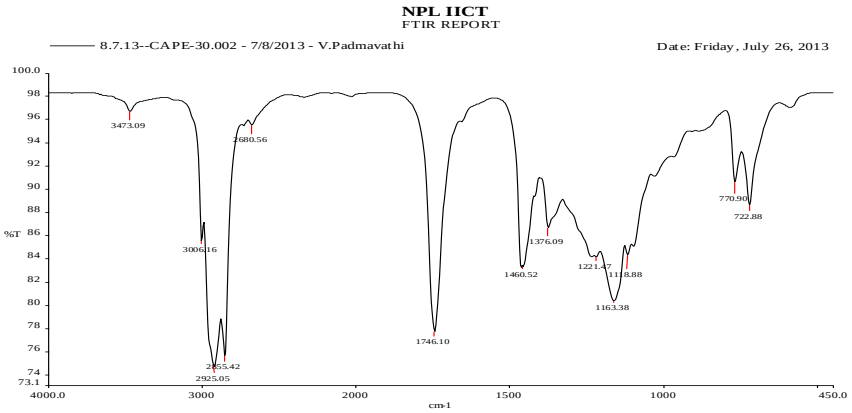



**Fig 1: FT-IR of cape 30.**

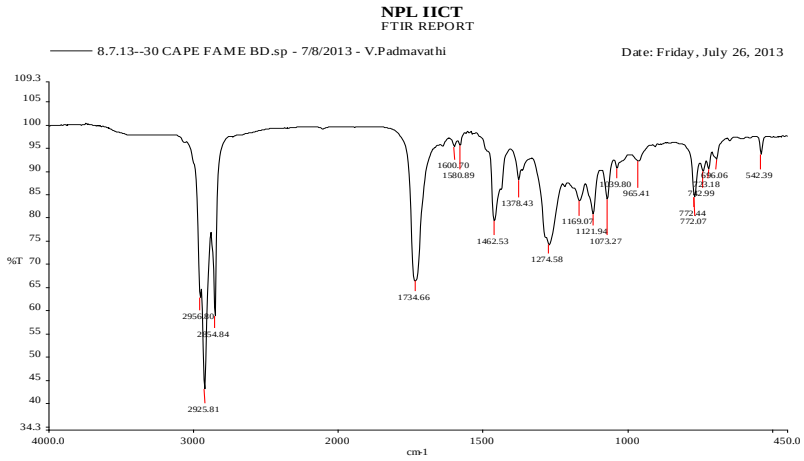



**Fig 2: FT-IR FAME of cape 30.**

**FIR: FAME CAPE 30**

FT-IR of the compound displayed bands at 2956.36 $cm^{-1}$, 2925.86 $cm^{-1}$, 2855.09 $cm^{-1}$ (C-H, alkanes), 1734.45 $cm^{-1}$ (C=O esters.), 1378.23 $cm^{-1}$, 1462.197 $cm^{-1}$ (C-H, alkanes), 1274.62 $cm^{-1}$, 1169.06 $cm^{-1}$, 1122.43 $cm^{-1}$, 1073.67 $cm^{-1}$ (C-O, esters.), 1039.67 $cm^{-1}$ (methylene > $CH_2$ stretch), 966.06 $cm^{-1}$, 772.30 $cm^{-1}$, 743.38 $cm^{-1}$, 723.85 $cm^{-1}$ (C-H, alkanes).

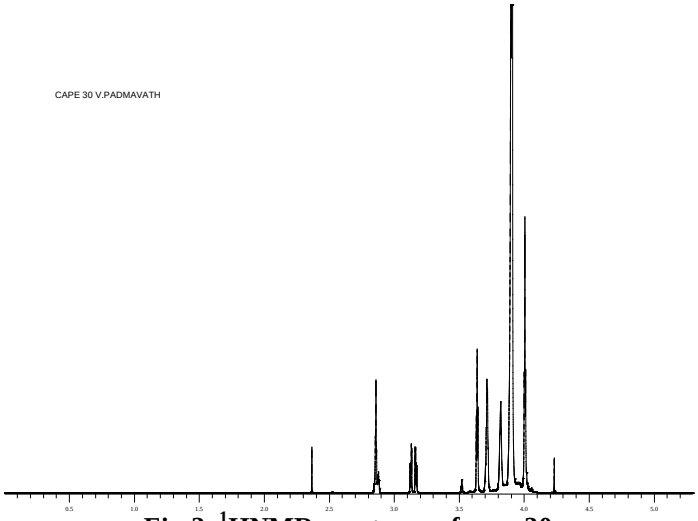
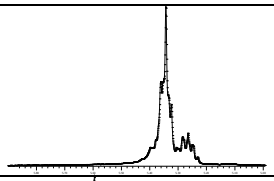
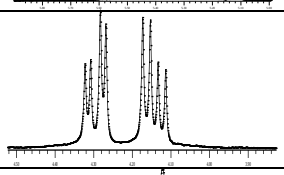
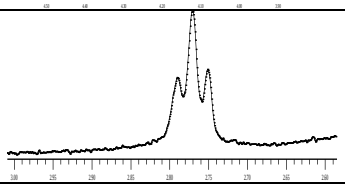
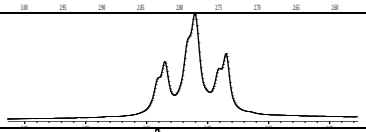
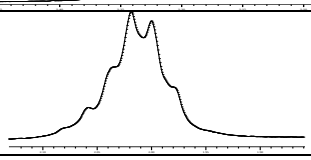
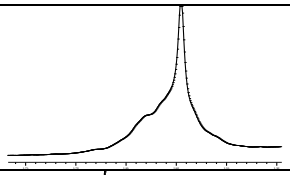
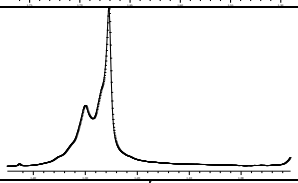
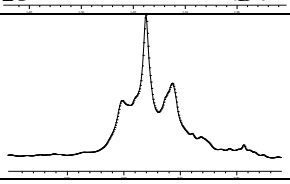



**Fig 3. $^{1}$HNMR spectrum of cape 30**

$^{1}$HNMR spectrum of cape 30: (5.50-5.20) (ppm) [due to unsaturated acids. CH=CH: olefinic protons, the SN-2 protons (attached to the centre carbon; CHO) of the glycerol backbone of the triacylglycerols causes the small cluster of peak at 5.25 ppm]; (4.20-4.10,4.40-4.20) (ppm) SN-1 OR SN-3 [unsaturated fatty acids -CH-OCOR, (attached to the two terminal carbons; $CH_2O$) of the glycerol back bone of the triacylglycerols]; (2.80-2.74) (ppm) [*bis*-allylic protons, *i.e*. protons attached to carbons situated directly next to two C=C double bonds, -CH=CH-$CH_2$-CH=CH-] (2.40-2.25) (ppm) [protons on the second carbon in the fatty acid chains -O-C(=O)-CH2-]; (2.10-1.90) (ppm) [allylic protons, *i.e*. protons attached to H=CH-. carbons next to C=C double bonds, -$CH_2$-$CH_2$-CH=CH-.] (2.10-1.90) ppm) [allylic protons, *i.e*. protons attached to H=CH-. carbons next to C=C double bonds, -$CH_2$-$CH_2$-CH=CH-.] (1.75-1.50) (ppm) [methylene protons: $(CH_2)$n-], (1.40-1.00) (ppm) [all fatty acids –$(CH_2)_n$-], (0.95-0.80) (ppm) terminal methyl protons -$(CH_2)_n$-$CH_3$; the small peaks. J = 6.043; J = 6.043; J = 5.288; J = 11.331; J = 7.554; J = 15.108.

**Table 1: Detailed $^{1}$HNMR spectrum of cape 30.**

| S.NO | PEAK | $\delta$(ppm) Values | Assignment of compound |
|---|---|---|---|
| 1 |  | (5.50-5.20) $\delta$(ppm) | unsaturated acids -CH=CH- olefinic protons, the SN-2 protons (attached to the centre carbon; CHO) of the glycerol backbone of the triacylglycerols causes the small cluster of peak at 5.25 ppm. |
| 2 |  | (4.20-4.10, 4.40-4.20) $\delta$(ppm) | SN-1 OR SN-3 unsaturated fatty acids -CH-OCOR, (attached to the two terminal carbons; $CH_2O$) of the glycerol back bone of the triacylglycerols. |
| 3 |  | (2.80-2.74) $\delta$(ppm) | *bis*-allylic protons, *i.e*. protons attached to carbons situated directly next to two C=C double bonds, -CH=CH-$CH_2$-CH=CH-. |
| 4 |  | (2.40-2.25) $\delta$ (ppm) | protons on the second carbon in the fatty acid chains -O-C(=O)-$CH_2$-. |
| 5 |  | (2.10-1.90) $\delta$ (ppm) | allylic protons, *i.e*. protons attached to H=CH-. carbons next to C=C double bonds, -$CH_2$-$CH_2$-CH=CH-. |

| | | | |
|---|---|---|---|
| 6 |  | (1.75-1.50) $\delta$(ppm) | methylene protons –$(CH_2)$n-. |
| 7 |  | (1.40-1.00) $\delta$(ppm) | fatty acids –$(CH_2)_n$- |
| 8 |  | (0.95-0.80) $\delta$(ppm) | terminal methyl protons -$(CH_2)_n$-$CH_3$; the small peaks |

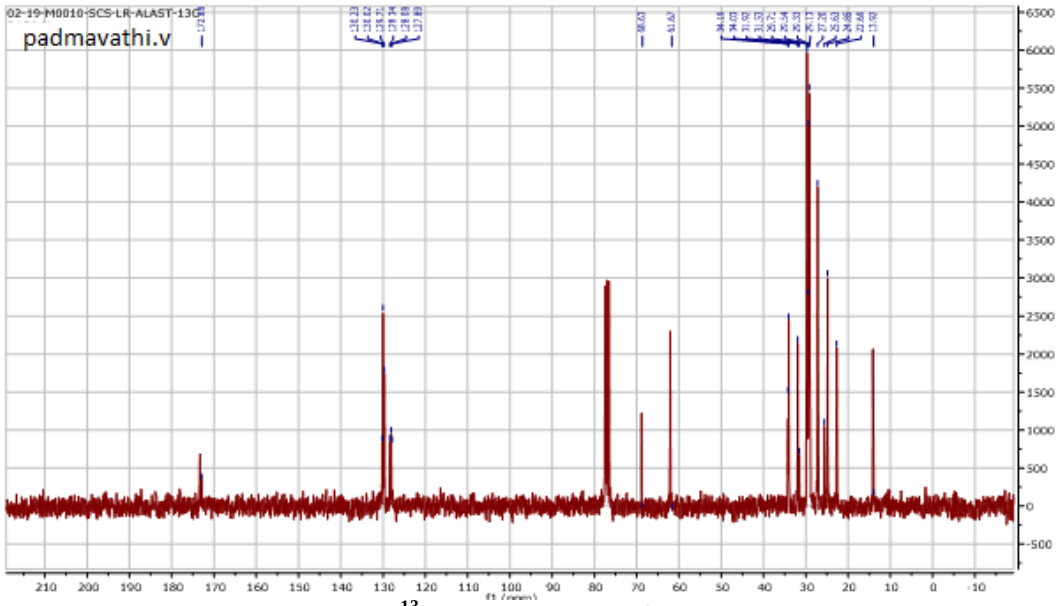



**Fig 4: $^{13}$CNMR spectrum of cape 30.**

$^{13}$CNMR($CDCl_3$): 172.88, 130.23, 130.02, 129.71, 128.34, 128.08, 127.89, 68.63, 61.67, 34.19, 34.03, 31.92, 31.53, 29.71, 29.54, 29.33, 29.13, 27.20, 25.63, 24.65, 22.69, 13.92.

**GC**

The fatty acid composition was determined by GC and the results are given below, the acid value and it was found that it is varied from 0.52-0.31.

For the analysis, the method followed for gas chromatography (GC) is as follows:

GC apparatus: Agilent Technologies, USA., Model no →6890 N, Column → DB-225 [(50% cyanopropylphenyl)-dimethylpolysiloxane, 30M × 0.250mm 1D × 0.25µm film thickness. inlet temperature → 230$^0$C, oven prog → 160$^0$C (2min) - 5$^0$C/min-230$^0$C (20min), detection temperature → 270$^0$C, HY → 30ml/min, air → 300ml/min, inlet type → split/split less, detection type → FID, soft ware → GC chem. station, A.10.02 (1757). The fatty acid composition was determined by GC and the results are given below, the acid value and it was found that acid value varied from 0.52-0.31 (Fig. 5).

**Fig. 5: GC of fatty acids in *S. a* L.f nut oil.**

**Table 2: Fatty acid composition of *Semecarpus anacardium* L.f. nut oil.**

| Fatty acid | 12:0 | 14:0 | 15:0 | 16:0 | 16:1 | 17:0 | 18:0 | 18:1 | 18:2 | 18:3 | 18.3 | 20:0 | 20:1 | 20:2 | 20:3 | 22:0 | 22:1 | 24:0 | 24:1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wt% | 0.54 | 1.08 | 0.4 | 16.1 | 0.4 | 0.2 | 9.8 | 45.8 | 0.8 | 7.3 | 0.5 | 3.1 | 0.4 | 0.6 | 3.2 | 4.0 | 1.03 | 0.95 | 2.6 |

**Table 3: Properties of *Semecarpus anacardium* L.f.nut oil cape 30.**

| Properties | *Semecarpus anacardium* L.f. nut extracted oil |
|---|---|
| acid value (mg KOH/g) | 0.52 |
| iodine value | 80.5 |
| density(mg/Lit) | 0.872 |
| kinematics/viscosity | 4.8 capillary suction time (cst) |
| peroxide value | 1.2 |
| saponification value (KOH/g) | 165 |
| unsaponification value | sterols |
| Phosphorous content | 9.8 |

After knowing the above acid value,s the sample was submitted for physical propertie.

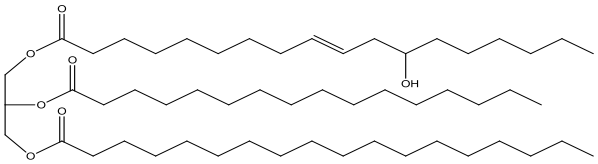



**Fig. 6: (E)-2-(Palmitoxy)-3-(stearoyloxy)propyl 12-hydroxyocadec-9-enoate.**

(**18:1** 45.8%, **16:0** 16.2% and **18:0** 18.99%). Basing on this lipid % and FT-IR, $^{1}H$ NMR, $^{13}C$ NMR, MASS, GC and GC-MS, CHN analysis.name of the compound is (E)-2-(palmitoxy)-3-(stearoyloxy)propyl 12-hydroxyocadec-9-enoate, chemical formula: $C_{55}H_{104}O_7$, m/z 876.78, elemental analysis C,75.3; H,11.9; O,12.8.

**Trans esterification process**[27-31]

In our investigation, *Semecarpus anacardium* nut oil cape 30 had found to have a free fatty acid (0.52) hence, alkaline *trans* esterification was done by using anhydrous methanol at a molar ratio of 6:1 and 3g/Liter of sodium hydroxide as catalyst.[22,23] The processor was stirred at 600 rpm and at a temperature of $60^{0}$ C for 2 hours, after which the mixture was poured into a decanter and allowed to settle for 3 hours so that the reaction can be driven to completion. By following mechanism as in Figure 2 and found that the mixture has been separated in to its corresponding methyl ester.

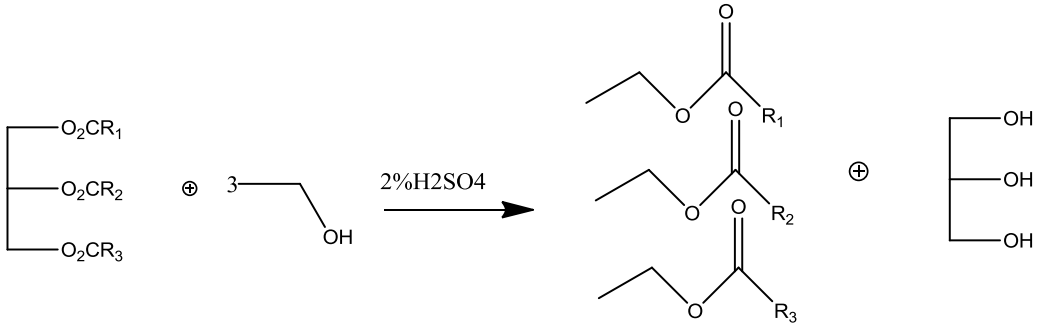
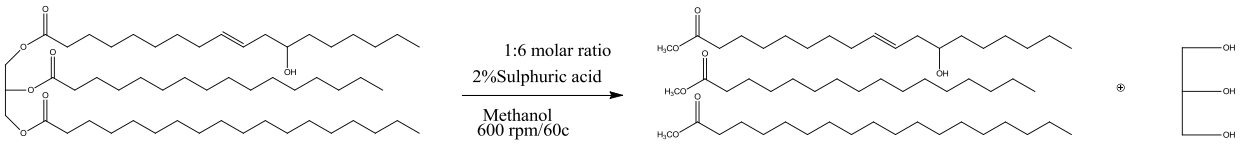



**Figure 7: Mechanism of *trans*-esterification process.**




(E)-2-(palmitoxy)-3-(stearoyloxy)propyl methyl ester glycerol 12-hydroxyocadec-9-enoate.

The glycerol at the bottom was drained off by gravity. The excess methanol in the ester was removed by using a flash rotary evaporator. The impurities were removed from the methyl ester by washing with distilled water of volume ratio 3 to 1 three times. Finally, the washed methyl ester was dried by passing it through anhydrous sodium sulphate ($Na_2SO_4$).

**Table 4: Comparison of *Semecarpus anacardium* L.f. nut extracted biodiesel with the standard diesel values.**

| Test property | Fatty acid methyl esters of *S.a* nut oil | Diesel (B100) blend stock ASTM[1)] D6751 |
|---|---|---|
| methyl ester conversion | 99.010349% | 94.5 - 100% |
| acid value (mg KOH/g) | 0.31 | 0.50 max mg KOH/g |
| iodine value | 80.5 | 115 max |
| density(mg/Lit) | 0.8720 | 0.875 - 0.90 |
| viscosity (cst) @40$^0$C | 5.96 cst | 1.9 - 6.0 mm$^2$/S |
| saponification value(KOH/g) | 165 | |
| unsaponification value | sterols | not more than 1.5% |
| phosphorous value | 0.001 max | 0.001 max |
| kinematics η 40$^0$C | 5.96 cst | 1.9 - 6.0 mm$^2$/S |
| copper strip corrosion 3 h 5$^0$C at max | 1 a | 1a |
| flash point | 140 | 130 - 170$^0$C |
| pour point | -5 | -15 to 10 |
| cloud point | -7 | -3 to 12$^0$C |
| heating value | 37.12 | 42.9 |
| cetane number | 48.99 | 47 to 65. |

1) ASTM: American Society of Testing Materials.

## RESULTS AND DISCUSSION

As the production of biodiesel from edible oils is currently much more expensive than diesel fuels due to relatively high cost Renewable energy such as biodiesel has the potential to replace petroleum derived transportation fuel in the future. The production s of Semecarpus anacardium L.f nuts were discussed by the transesterification of triglycerides of SA Nut Oil to yield Fattyb Acid Mthyl ester, and glycerine as a by-product and the Spectral Datas of Semecarpus anacardium L.f Nut Oil Which was presented in Table 1,2and Figs 1-5 and and their Deravative (FAME)Determine by Trans esterification process (fig 7) compared with the Varous Oil Spectral data & Various properties of Semecarpus anacardiun L.f. nut oil were determined by using standard methods and results are presented in Table 3.Properties of Semecarpus anacardium L.f. nut oil methyl esters were determined experimentally to ascertain their suitability as diesel fuel. The properties of Semecarpus anacardium L.f. nut oil methyl esters have been compared with the properties of biodiesel and petro diesel in table4. The fuel properties of Semecarpus anacardium L.f. nut oil methyl esters were within specifications. The properties of its oil, such as its saponification value, iodine value, and the amount of its free fatty acid content were 165, 80.5 and 0.52, respectively. Eventually, the methyl ester of its crude oil, which was produced through alkali transesterification reaction with methanol alcohol and NaOH as catalyst was experimented and its physicochemical properties were determined. All of the determined characteristics, namely, density (0.8720 g/mL), kinematic viscosity (5.96 mm 2/s at 40 ºC), flash point (140ºC), cloud point (-7ºC), pour point (-5ºC), cetane index (48.99) meet the two accepted biodiesel standards (*i.e.* ASTM D6751 and EN 142140). Therefore, according to the results, *Semecarpus anacardium* L.f. which was not reported earlier[31-38], and feedstock in producing biodiesel for the first time. Among the very few resent investigations then on this field ours is the first report on the FAME *Semecarpus anacardium* L.f. nut oil (biodiesel).

## ACKNOWLEDGMENT

We would like to thank Sri Dr. R.B.N. Prasad Chief Scientist and Head of the Department of Lipid Research, CSIR-IICT, Hyderabad, Dr. M.S.L Karuna, A. Tirupathi, for the kind cooperation and help during the tenure of this research.

## REFERENCES

1. Madhavachetty K, Sivaji K, Tulasi Rao K (2008). *Flowering Plants of Chittor District*. A.P, India, 76: 131.
2. Singh NP (1998). *Flora of Estren Karnataka*. 46, 61, 81, 98, 100, 117, 121, 207, 210.
3. Maheshwari JK (1963). *The Flora of Delhi*, 104.

4. Maheshwari JK (1996). *Addition to the Flora of Delhi*, Department of Botany, University of Delhi, 48.
5. Naidu DS 1925. Constituents of the marking-nut: emecarpus anacardium Linn. Journal of Indian Institute of Science, 8: 129-14.
6. Pillay P and Siddiqui S(1931). J. Indian em. soc., 8: 1517.
7. Chattopadyaya MK & Khare RL(1969). The Indianjournal of Pharmacy, 31(4): 104-105.
8. Govindachary TR, Joshi BS, Kamal VM(1971). Phenolic constituents of Semecarpus anacardium. ndian J Chem, 9: 1044.
9. Prakasa Rao NS, Ramachandra Row L and Brown RT(1973). Phytochemistry, 12: 671.
10. Gedam PH, Sampathkumaran PS, Sivasamban MA (1974). Composition of bhilawanol from Semecarpus Anacardium. Indian J Phytochem, 3: 513–5.
11. Ishatulla K, Ansari WH, Rahman W, Okigawa M, Kawanon N(1977). Bioflavanoids from *Semecarpus anacardium* linn. Indian J Chem., 15: 617–22.
12. Murthy SSN(1983). A biflavanoid Semcarpu flavanone, from *Semecarpus anacardium*. Phytochemistry, 22: 1518-1520.
13. Murthy SSN (1983). Naturally occurring Biflavonoid, Galluflavanone, a new biflavonoid from *Semecarpusanacardium*. Phytochemistry, 22: 2636.
14. Murthy SSN (1984). A biflavanoid Semcarpu flavanone, from *Semecarpus anacardium*. Phytochemistry, 24: 1065-1069.
15. Murthy SSN(1984). Confirmation of the structure of Jeediflavonone: A biflavonane from *Semecarpus anacardium*. Phytochemistry, 23: 925–7.
16. Murthy SSN(1988). Semicarpetin: A bifl avonoid From *Semecarpus anacardium*. Phytochemistry, 27: 3020–2.
17. Murthy SSN(1992). New n biflavonoid from Semecarpus *anacardium* linn. Clin Acta Turcica, 20: 30.
18. Murthy SSN(1987). New dimeric flavone from *Semecarpus anacardium*. Proc Indian Natl Sci Acad., 57: 632.
19. Ramakumar M, Ramesh, Appa Rao(1995). Anacardoside from Semecarpusanacardium, Phytochemistry, 3,9,2, 405-407.
20. Nagabhushanaa KS, Umamaheshwari S, Tocolic FE, Prabhu SK, Green IR and Ramadoss CS (2002). Inhibition of soybean and potato Lipoxygenases by Bhilawanols from Bhilawan (*Semecarpus anacardium*) nut shell liquid and some synthetic Salicylic acid analogues. *Journal Enzyme Inhib. Medical Chemistry*, 17(4): 255-259.
21. Selvam C, Sanjay Jachak M and Bhutani KK(2004). Cyclooxygenase Inhibitory Flavonoids rom the Stem Bark of Semecarpus anacardium Linn, PHYTOTHER. Res, 18: 582-584.
22. Sharma A, Mathur R, Dixit VP (1995). Hypocholesterolemic activity of nut shell extract of *Semecarpus anacardium* Bhilawa) in cholesterol fed rabbits. Indian J Exp Biol., 33: 444–8.
23. Ramprasath VR, Shanthi P, Sachdanandam P(2006). Immunomodulatory and ntiinflammatory effects of *Semecarpus anacardium* LINN. Nut milk extract in experimental inflammatory conditions. Biol Pharm Bull, 29: 693–700. [PubMed]
24. Selvam C, Jachak SM(2004). A cyclooxygenase (COX) inhibitory biflavonoid from the seeds of *Semecarpus anacardium*. J Ethnopharmacol, 95: 209–12. [PubMed]
25. Bhitre MJ, Patil S, Kataria M, Anwikar S, Kadri H(2008). Antiinflammatory activity of the fruits of *Semecarpus anacardium* Linn. Asian J Chem., 20: 2047–50.
26. Satyavati GV, Prasad DN, Das PK, Singh HD(1969). Antiinflammatory activity of *Semecarpus anacardium* Linn. A preliminary study. Indian J Physiol Pharmacol, 3: 37–45.
27. Singh D, Aggarwal A, Mathias A, Naik S(2006). Immunomodulatory activity of semecarpus anacardium extract in mononuclear cells of normal individuals and rheumatoid arthritis patients. J Ethnopharmacol, 108: 398–406.
28. Premalatha B, Sachdanandam P(2000). Potency of *Semecarpus anacardium* Linn. Nut milk extract against aflatoxin B(1)-induced hepatocarcinogenesis: Reflection on microsomal biotransformation. Pharmacol Res., 42: 161–6. [PubMed]
29. Ramprasath VR, Shanthi P, Sachdanandam P(2005). Semecarpus anacardium Linn. Nut milk extract, an Indigenous drug preparation, modulates reactive oxygen/nitrogen species levels and antioxidative system in adjuvant arthritic rats. Mol Cell Biochem, 276: 97–104.
30. Mythilypriya R, Shanthi P, Sachdanandam P(2008). Therapeutic effect of Kalpaamruthaa, a herbal preparation on adjuvant induced arthritis in wistar rats. Inflammopharmacology, 16: 21–35.
31. Verma N, Vinayak M(2008). Bioscience Reports Immediate Publication, p. 20080035.
32. Sahoo AK, Narayanana N, Sahanaa S, Rajanb SS, Mukherjee PK(2008). In vitro antioxidant potential of *Semecarpus Anacardium* L. harmacologyonline, 3: 327–35.
33. Periasamy VS, Subash-Babu P, Muthukumaran VR, Akbarsha MA, Alshatwi AA(2012). Advanced Science Letters, 6: 75-79(5).
34. Farooq SM, Alla TR, Rao NV, Prasad K, Shalam K, satyanarayana S(2007). A study on CNS effect of nut milk extract of *Semicarpus anacardium*. Pharmacologyonline, 1: 49–63.
35. Mohanta TK, Patra JK, Rath SK, Pal DK, Thatoi HN(2007). Evaluation of antimicrobial activity and phytochemical screening of oils and nuts of *Semecarpus anacardium*. Sci Res Essay, 2: 486–90.
36. Nair A, Bhide SV(1996). Antimicrobial properties of different parts of *Semecarpus anacardium*. Indian Drugs, 33: 323–8.

37. Arul B, Kothai R, Christina AJ(2004). Hypoglycemic and antihyperglycemic effect of *Semecarpus anacardium* Linn in normal and streptozotocin- induced diabetic rats. Methods Find Exp Clin Pharmacol, 26: 759–62.
38. Veena K, Shanthi P, Sachdanandam P(2006). The biochemical alterations following administration of Kalpaamruthaa and *Semecarpus anacardium* in mammary carcinoma. Chem Biol Interact, 161: 69–78.
39. Mathivadhani P, Shanthi P, Sachdanandam P(2007). Apoptotic effect of *Semecarpus anacardium* nut extract on T47D breast cancer cell line. Cell Biol Int., 31: 1198–206.
40. Arulkumaran S, Ramprasath VR, Shanthi P, Sachdanandam P(2007). Alteration of DMBA-induced Oxidative stress by additive action of a modified indigenous preparation--Kalpaamruthaa. Chem Biol Interact, 167: 99–106.
41. Sugapriya D, Shanthi P, Sachdanandam P(2008). Restoration of energy metabolism in leukemic mice treated by a siddha drug: *Semecarpus anacardium* Linn.nut milk extract. Chem Biol Interact, 173: 43–58.
42. Raja Latha[a], Santhi P[b] (2012). Biomedicine & Preventive Nutrition, 2(3): 210–214.
43. Sharma A, Verma PK, Dixit VP(2003). Effect of *Semecarpus anacardium* fruits on reproductive function of male albino rats. Asian J Androl, 5: 121–4. [PubMed]
44. Vinutha B, Prashanth D, Salma K, Sreeja SL, Pratiti D, Padmaja R(2007). Screening of selected Indian medicinal plants for acetylcholinesterase inhibitory activity. J Ethnopharmacol, 109: 359–63. [PubMed]
45. Choudhari CV, Deshmukh PB(2007). Acute and subchronic toxicity study of *Semecarpus anacardium* on heamoglobin percent and R.B.C. count of male albino rat. J Herb Med Toxicol, 1: 43–5.
46. Choudhari CV, Deshmukh PB(2008). Effect of *Semecarpus anacardium* pericarp oil extract on histology and some enzymes of kidney in albino rat. J Herb Med Toxicol, 2: 27–32.
47. Prabhu D, Rajwani LS, Desai PV(2005). The antimutagenic effect of *Semecarpus anacardium* under in vivo condition. Asian J Chem., 12: 13–6.
48. Krishnarajua AV, Rao TV, Sundararajua D, Vanisreeb M(2005). Assessment of bioactivity of Indian medicinal plants using brine shrimp (*Artemia salina*) lethality assay. Int J Appl Sci Eng., 3: 125–34.
49. Matthai TP, Date A(1979). Renal cortical necrosis following exposure to sap of the marking-nut tree (*Semecarpus anacardium*) Am J Trop Med Hyg., 28: 73–4.
50. Semalty M, Semalty A, Joshi GP, Rawat MS (2008). Herbal hair growth promotion strategies for alopecia. Indian Drugs, 45: 689–700.