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# Physico chemical properties of cotton seed oil methyl ester and its blends with conventional diesel and kerosene

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**ABSTRACT:** Fuel properties such as specific gravity, viscosity, gross calorific value, flash and fire point of Cotton seed oil methyl ester and its blends with conventional diesel oil in the proportions of 20:80 (B20), 40:60 (B40), and 60:40 (B60), 80:20 (B80) have been studied. It was found that the fuel properties were found to deviate more from those of diesel oil with the increasing in the percentage of methyl ester in the blend. It was also found that the properties of blend of B20 were found very close to those of conventional diesel oil. An attempt has also made to study the fuel properties of Cotton seed oil methyl ester blends with domestic kerosene oil and conventional diesel oil in the proportions (Methyl ester : Conventional diesel : Kerosene) of 20:75:5 (B20K5),40:50:10 (B40K10),60:25:15(B60K15),and80:0:20(B80K20)
**KEYWORDS:** Cotton **seed**oil methyl ester, conventional diesel oil, Cotton seed oil, transesterification, specific gravity, Heating value,

## I. INTRODUCTION

The energy play vital role in overall development of any country. Increase in population and economic growth in developing country like India has led huge increase in energy demand**.** India stands 4th position in consumer of primary energy at 24.7 quadrillion British thermal unit (BTU) s following China, United States and Russia. Despite notable fossil fuel resources India is increasingly dependent on energy imports. India is the third largest importer of oil followed by United states, China .in last four years import volume raised from 240 billion litres to 278 billion litres [1]. The highly fluctuating price of crude oil in international market gave negative impact on economy of oil importing nations like India[2]. There are many alternatives to energy sources, such as wind, solar, geothermal and biomass. Few of these meet the sustainability and few others satisfy the economic feasibility. But best option full filling the both the criteria is bio fuel obtained from the readily available biomass [3][4][5].Among the different available Biofuels biodiesel got more attention because of its similarity with conventional diesel with chemical structure, energy content.Neat vegetable oils cannot be used in IC engines due to high viscosity, this problems is associated with presenceof large triglyceride molecules[6].Dilution, micro emulsion, pyrolysis and transesterification are the methods available to reduce the viscosity of neat vegetable oils and among these the transesterification is most popular because it is simple and value added glycerol is obtained as by product which has commercial value.The current standards for regulating the quality of biodiesel on the market are based on a variety of factors which vary from region to region[7].

In this section characteristic fuel properties such as density, specific gravity, viscosity, flash point, and heating values of cotton seed oil, cotton seed oil methyl ester, B20K5, B40K10, B60K15,B80K20 were determined experimentally and compared with diesel and kerosene oil.

**Table 1** shows the fuel properties of cotton seed oil, cotton seed oil methyl ester (B100), diesel oil, B20K5, B40K10, B60K15,B80K20, and kerosene. **Table1** also indicates that density, viscosity, specific gravity and flash point of cotton seed oil is greater than Cotton seed oil methyl ester and diesel oil.

**Table 1 Properties of cotton seed oil, cotton seed oil methyl ester Diesel oil and kerosene blend (B20K5, B40K10, B60K15, B80K20)**

| Property | Cotton seed oil | Diesel | B20K5 | B40K10 | B60K15 | B80K20 | B100 | Kerosene |
|---|---|---|---|---|---|---|---|---|
| Density in kg/m$^3$ | 890 | 816 | 816.5 | 817.0 | 817.5 | 818 | 820 | 810 |
| Specific gravity | 0.890 | 0.816 | 0.816 | 0.817 | 0.817 | 0.818 | 0.820 | 0.810 |
| Viscosity at 40$^0$C in cSt | 9.5 | 4.3 | 4.181 | 4.062 | 3.943 | 3.943 | 4.5 | 1.12 |
| Flash point in $^0$C | 200 | 53 | 77.35 | 101.7 | 126.05 | 150.4 | 175 | 52 |
| Pour point in $^0$C | -6 | -8 | -9.95 | -11.9 | -13.85 | -15.8 | -7 | -51 |
| Heating value MJ/kg | 40 | 45.7 | 45.025 | 44.35 | 43.67 | 423 | 43.0 | 41.5 |

**Effect of specific gravity-**

The specific gravity of biodiesel varies with its fatty acid composition, and its glycerine content, A denser biodiesel has higher energy content and results in better mileage and increased power.The specific gravity of fuels is used as a precursor for a number of other fuel properties like heating value, viscosity and cetane number. Biodiesel fuel is having different properties compared to petroleumbased diesel fuel[8].

The specific gravity of most of the vegetable oils and their methyl esters is higher than that of diesel fuel, it is because of presence of large molecular mass and chemical structures of vegetable oils [9][10].However, it helps in countering their low heating values in terms of brake specific fuel consumption. The specific gravity of a methyl ester is dependingupon its molecular weight, free fatty acid content,water content and temperature [11]. Specific gravity data is essential in modelling combustion process in IC engines and also to evaluate thermal efficiency of the fuel. Specific gravity is also one of the most basic and important property of the fuel because some important performance indicators which describes combustion quality of the fuel such as cetane number and heating value are correlated with this[12]**.**The specific gravity is also an important parameter during storage and transportation of the fuel. The variation of specific gravity with temperature for biodiesel has been evaluated for some fuels and it is concluded that the two important properties like density and viscosity of methyl esters varies linearly with temperature, taking an examples of studies on the densities and viscosities for the methyl esters of some n-alkanoic acidsand found that the densities of the methyl esters vary linearly with temperature for the range of 10 to 80°C[13].The same trend was also observed formethyl ester of soybean and methyl ester of yellow grease[14].

**Table 1** shows the specific gravity of cotton seed oil, B20K5, B40K10, B60K15, B80K20 and B100. Cotton seed oil has highest specific gravity (0.890) which is reduced to 0.820 after transesterification. Specific gravity of B20K5 is very close to that of conventional diesel which is 1.0006 times higher than conventional diesel oil. B100 has specific gravity of 0.820 which is 1.0049 times higher than the conventional diesel oil. **Figure 1** indicates that specific gravity value increases with the increase in percentage of methyl ester in the blend. Specific gravity of biodiesel, conventional diesel oil and kerosene blends increases with the increase in percentage of kerosene and corresponding decrease in conventional diesel oil in the given percentage of biodiesel.

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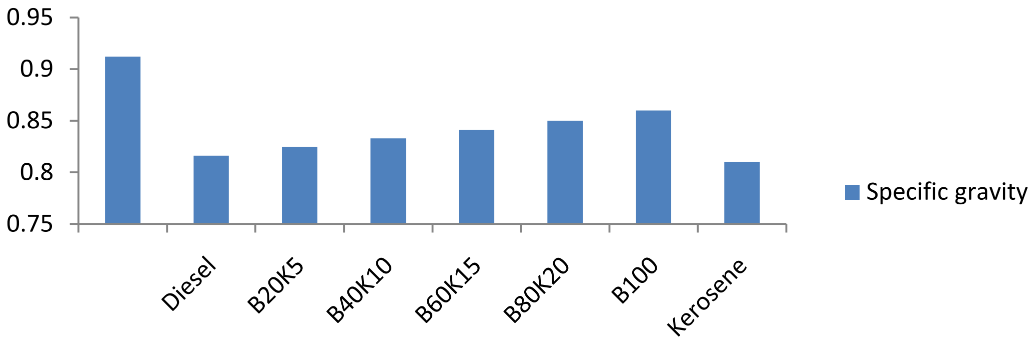


**Figure 1**
**Specific gravity of cotton seed oil and its blends with conventional diesel and kerosene**

**Effect of viscosity-** Viscosity is a measure of flow ability of a liquid at definite temperature, the viscosity of a fluid is a measure of its resistance to gradual deformation by share stress or tensile stress.viscosity is due to friction between neighbouring parcels of the fluid that are moving at different velocities, when fluid is forced through a tube, The fluid generally moves faster near the axis and very little near the walls, therefore some stress is needed to overcome the friction between layers and keep fluid moving for the same velocity patterns the stress is proportional to the fluid viscosity,the viscosity of the liquid also depends upon the size and shape of its particles and attraction between the particles.Viscosity is one of the most important properties of the fuel as it affects the operation of fuel injection equipment, particularly at low temperature. If the fuel viscosity is extremely high as in the case of vegetable oils there will be degradation of the spray in the cylinder causing poor atomisation, contamination of lubricating oil and the production of black smoke.Viscosity increases with chain length and with increasing degree of saturation. This also finding holds for the alcohol moiety[15].In case of unsaturated fatty compounds the kinematic viscosity is strongly dependent upon the nature and degree of unsaturation with double bond position which is affecting viscosity less. Presence of double bond at end position inaliphatic hydrocarbons can reduce the viscosity to smaller extent.Branching in alcohol will not affect viscosity much compared to straight chain alcohols. The viscosity of fatty acid compounds is more than that of hydrocarbons present in petro diesel. The viscosity of straight run vegetable oils or fats causes operational problems in engine.The viscosity of biodiesel more than that of petro diesel but less than that of the parent vegetable oil or fat [16][17] Biodiesel and its blends with petro diesel shows that viscosity is temperature dependent property same to that of neat petro diesel[18].Transesterificationreaction monitors the difference in viscosity between biodiesel and its parent oil or fat[19].Viscosity of fatty esters can be used to predict the viscosity of the mixture of fatty esters present in biodiesel [22].To determine viscosity of neat compound the viscosity contribution by mixture and several group is estimated[21].

Table 1 represents the viscosity of cotton seed oil, diesel oil, B20K5, B40K10, B60K15, B80K20 and B100, kerosene, cotton seed oil is possessing highest viscosity (9.5cSt at $40^0$C) which is about 2.20 times morethanthat of the conventional diesel oil after transesterification process viscosity has been decreased from 9.5 cSt to 4.5cStwhich is 1.046 times higher than that of diesel oil.From Figure 2 it is observed that, B20K5 has kinematic viscosity of 4.181cSt which is lower than conventional diesel oil (4.3cSt) viscosity of biodiesel, conventional diesel oil and kerosene blends decreases with the increase in percentage of kerosene and corresponding decrease in conventional diesel oil in the given percentage of biodiesel

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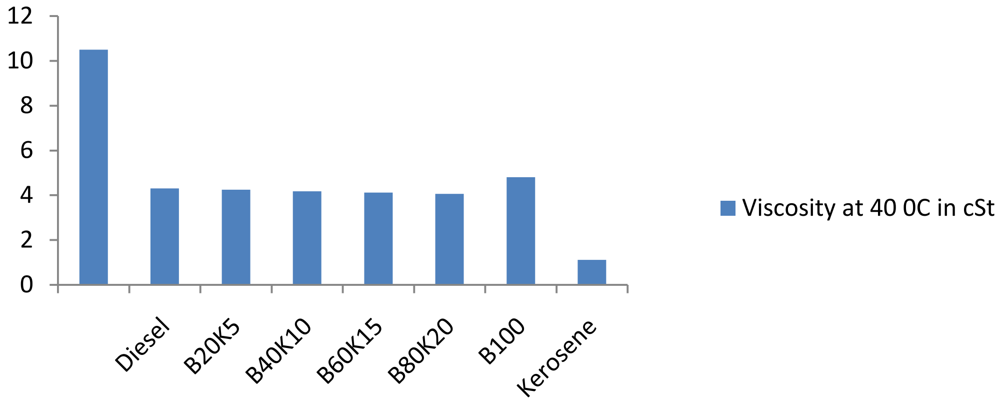


**Fig 2**
**Viscosity of cotton seed oil and its blends with conventional diesel and kerosene**

**Effect of flash point**

Flash point is the temperature in which a combustible liquid must be heated to give off sufficient vapours to form momentarily a flammable mixture with air when a small flame is brought near the surface of the liquid under specified condition.The minimum temperature at which anoil gives off sufficient vapour which when ignited continues to burn for at least five second is known as fire point. Flash point varies inversely with volatility of the fuel. The biodiesel is having higher flash point which is usually above $150^0$C**[22][23][24].**Flash point of the biodiesel decreases rapidly with increase in unreacted alcohol (residue) increases in the biodiesel.The flash point does not affect the combustion directly; higher value of flash point makes the fuel safer with respect to storage, fuel handling and transportation. The flash point and fire point are not sufficient as the sole factors to decide fire hazard nature of the fuel but they have used to compare fire hazard potential of different flammable liquids

Table 1 shows the flash point of cotton seed oil, cotton seed oil methyl ester, diesel oil, kerosene, B20K5, B40K10, B60K15 and B80K20.Figure 6.15 shows that flash point increases with the increase in percentage of methyl ester in the blend. From Figure 3 it is observed that, biodiesel has higher flash point than conventional diesel oil but kerosene has lower flash point than conventional diesel oil. B20K5 has flash point of $77.35^0$C which is higher than conventional diesel oil ($53^0$C). Flash point of biodiesel, conventional diesel oil and kerosene blends increases with the increase in percentage of kerosene and corresponding decrease in the percentage of conventional diesel oil in the given percentage of biodiesel.

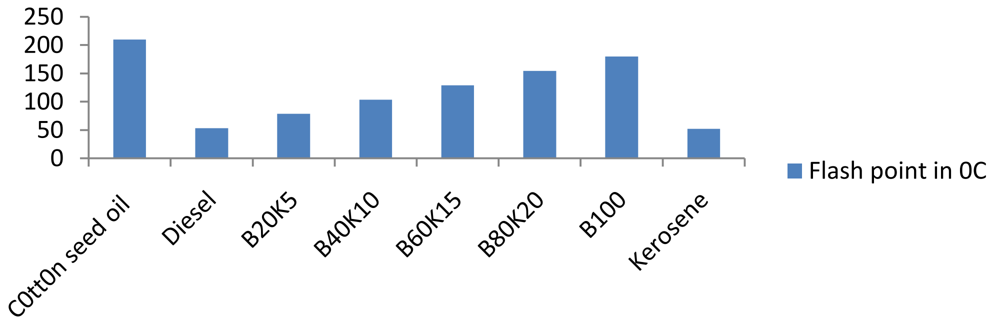


**Figure 3**
**Flash points of cotton seed oil and its blends with conventional diesel and kerosene**

**Effect of heating value**

The heating value or heat of combustion represents the quantity of heat liberated when a unit quantity of fuel is burnt in presence oxygen in an enclosure of constant volume.The product may be gaseous $CO_2$,$NO_x$,$SO_2$ and $H_2O$.The heating value of a fuel are of two types as higher heating value or gross calorific value and lower heating value or net

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calorific value.The higher heating value (HHV) represents the heat removed from fuel combustion with the original and generated water in a condensed statewhile the lower heating value is based upon gaseous water as a product.

The higher heating values (HHVs) included the latent heat of the vaporisation of water because the water vapour is allowed to condense to liquid water. A low heating value (LHV) is the correction to HHV due to moisture in the fuel (biomass) or water vapour formed during combustion of hydrogen in the fuel.

The heating value of a fuel can be determined experimentally by using calorimeter, which measures the enthalpy change between reactants and products. However, the measurement is a complex and time-consuming process that requires the set-up, measurement and calculation procedures.

The analyses of fuels are necessary for their efficient and clean utilization while the HHV of fuels determine the quantitative energy content of fuels. There exists a variety of correlations for predicting HHV from ultimate analysis of fuel [25][26]. The presence of oxygen in ester molecule decreases the heating value of biodiesel compared to diesel.The diesel fuel with higher aromatics tends to have higher high energy content per litre even though the aromatics have lower heating value per kilograms. A fuel with lower energy content per litre such as biodiesel will cause the engine to produce less peak power.Biodiesel fuels do not contain aromatics but they contain methyl ester with different levels of saturation,unsaturated esters have lower energy content on weight basic but because of high density they have more energy per unit volume for example methyl state has a higher heating value of 40.10MJ/Kg which is 0.41% more than the methyl ester of oleate(39.93 MJ/Kg)However on volume base the at 40 0C methyl state is having 34.07MJ/Kg which is 0.7% less than that of methyl oleate.[27][28]

Table 1 shows the heating value of cotton seed oil, cotton seed oil methyl ester, diesel oil, B100, kerosene, B20K5, B40K10, B60K15 and B80K20.Figure 6.16shows that heating value decreases with the increase in percentage of methyl ester in the blend.

From Figure 4 it is observed that, biodiesel, conventional diesel oil and kerosene blends have lower heating value than conventional diesel oil. B20K5 has heating value of 45.025MJ/kg which is lower than conventional diesel oil (45.7 MJ/kg). Heating value of biodiesel, conventional diesel oil and kerosene blends decreases with the increase in percentage of kerosene and corresponding decrease in conventional diesel oil in the given percentage of biodiesel.

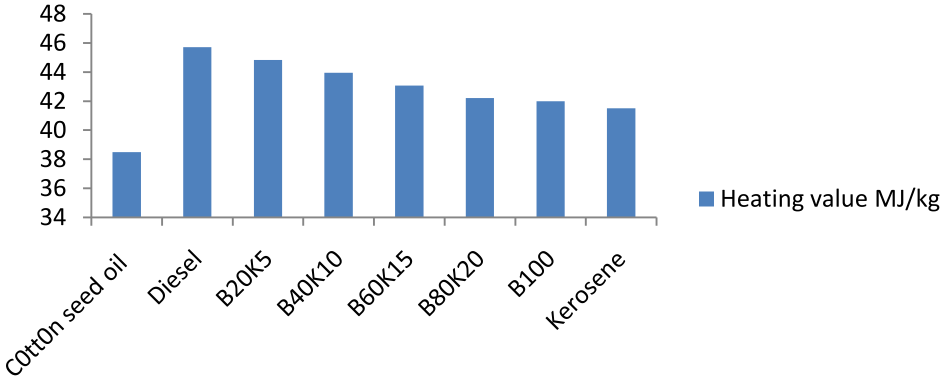


**Figure 4**
**Heating values of cotton seed oil and its blends with conventional diesel and kerosene**

## II. CONCLUSION

From the study it is observed that the fuel properties like viscosity, specific gravity, flash point and heating values of the biodiesel changes with changes with changein percentage of methyl esters with diesel and kerosene blends.

Specific gravity of biodiesel, conventional diesel oil and kerosene blends increases with the increases in percentage of kerosene and corresponding decrease in the conventional diesel in the given biodiesel. Kinematic viscosity of biodiesel, conventional diesel oil and kerosene blends decreases with the increase in percentage of kerosene and corresponding decrease in conventional diesel oil in the given biodiesel. Flash point value increases with the increase in the percentage of methyl ester in the blends. Flash point of biodiesel, conventional diesel oil and kerosene blends increases with increase in percentage of kerosene. Heating values of Biodiesel, conventional diesel oil and kerosene blend decreases with increase in percentage of kerosene and corresponding decrease in conventional diesel oil in the given percentage of biodiesel.

## REFERENCES


[1]. Ma, F.R. and Hanna, M.A., Biodiesel production: a review. Bio-resource Technology, 70, pp 1-15,1999.

[2]. Dermibas A., Progress and recent trends in biodiesel fuel, energy conversion and management 50,pp 14-34,2009

[3]. Gui,MM, Lee KT,BhatiaS,Feasibility of edible oil vs waste edible oil as biodiesel feed stock, Energy 33, pp 1646-1653,2008

[4]. Lam MK,Tan KT, Lee KT, Mohamed AR , Malaysian palm oil: surving the food versus fuel dispute for a sustainable future, Renewable sustain energy 13 pp 1456-1464,2009

[5]. Kerutzer, U.R., Manufacture of fatty alcohols based on natural fats and oils, Journal of American Oil Chemists Society, 61 (2), pp 343-348, 1984.

[6]. Schwab, A.W., BagbyM.O., and Freedman B., Preparation and properties of diesel fuels from vegetable oils, Fuel, 66(10), pp1372-1378, 1987

[7]. Kurt Marcel,Biodiesel hand book Clanrye International 2015, https://www.researchgate.net/publication/228589856

[8]. Pramanik K. Properties and use of JatrophaCurcas oil and diesel fuel blends in compression ignition engine. Renewable Energy. 28(2): 239-248. 2002. Elsevier Science Ltd.

[9]. McCormick R.L., M.S. Graboski A.M. Herring and T.L. Alleman.. Impact of biodiesel source material and chemical structure on emissions of criteria pollutants from a heavy-duty engine. Environmental Science and Technology. 35(9): 1742-1747. 2001

[10]. Saed B., Mohamed K. A., Abdul A.A.D,.NikMeriam..Prediction of Palm Oil-Based Methyl Ester Biodiesel Density Using Artificial Neural Networks. Journal of Applied Sciences. 8(10): 1938-1943. 2008,.

[11]. Tat M.E. and J.H. Van Gerpen. The specific gravity of biodiesel and its blends with diesel fuel. J. Am. Oil Chem. Soc. 77(2): 115-119. 2000.

[12]. Liew K. Y., C.E. Seng., L.L Oh., Viscosities and densities of the methyl esters of some n-alkanoic acids

[13]. Journal of American oil Chemists Society(JAOCS),69(2),155-158, 1992.

[14]. Y. Yuan, A. Hansen, and Q. Zhang. “The Specific Gravity of Biodiesel Fuels and Their Blends With Diesel Fuel”. Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Manuscript EE 04 004. Vol. VI. September, 2004

[15]. Gerhard Knothe, JurgenKrahl, Jon Van Gerpen,. Biodiesel Hand book 2nd Edition AOCS press,2010,.

[16]. F D Gunstone, R J Hamilton Oleochemical manufacture and applications. Academic Press;. p. 106–63. 2001,.

[17]. Robert O.Dunn,. Gerhard Knothe,.Alternative diesel fuels from vegetable oils and animals fats. Journal of Oleo Science;50(5):415-26,.2001,.

[18]. Tat ME, Van Gerpen JH. The kinematic viscosity of biodiesel and its blends with diesel fuel. Journal of American oil Chemists Society(JAOCS),. 76(12): 1511–1513. 1999

[19]. De Filippis P, Giavarini C, Scarsella M, Sorrentino M. Transes-terification processes for vegetable oils: a simple control method of methyl ester content Journal of American oil Chemists Society(JAOCS),;71(12): 1399–404. 1995,.

[20]. Allen CAW, Watts KC, Ackman RG, Pegg MJ. Predicting the viscosity of biodiesel fuels from their fatty acid ester composition. Fuel 1999;78(11):1319–26.

[21]. Poling BE, Prausnitz JM, O’Connell JP. Viscosity. 5th ed. The properties of gases and liquids. New York: McGraw-Hill; p. 9.1–9.97.2001,.

[22]. Song C. Introduction to chemistry of diesel fuels. In: Song C, Hsu CS, Mochida I, editors. Chemistry of diesel fuels. New York, London: Taylor and Francis; p. 1–60. 2000,.

[23]. Sanford SD., White JM,.Shas PS, Wee C, Valverde MA, Meier GR, Feed stock and biodiesel characteristics report :2011

[24]. UriarteF.A.j Biofuels from plant oils : 2019

[25]. Parikha J, Channiwalab SA, Ghosal GK. A correlation for calculating HHV from proximate analysis of solid fuels, ;84:487-494,.2005

[26]. Channiwala SA, Parikh PP. A Unified correlation for estimating HHV of
[27]. Solid, liquid and gaseous fuels.Fuel; 81:1051–1063,. 2002,.
[28]. Freedman. B.M.O Bagby,.Heat of combustion of fatty acids and triglycerides. Journal of American oil Chemists Society (JAOCS), 66, 1601-1605,. 1989,.
[29]. WeastR.C.,Handbook of chemistry and physics, 51st edn,:Chemical Rubber Company Cleveland, 1972,.

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