# Production of Biodiesel from Milk Dairy Wash Water Scum and Study of its Characterisitics

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*Abstract* — **The Scenario of fuel consumption across the world is ringing alarm bells, urging us to find an alternative. The main source of fuel used today is fossil fuel. However with the rise in prices of crude oil and depletion of the resources, petroleum products are becoming increasingly difficult for an average man to afford, it has thus become inevitable to explore new possibilities in fuel production sector. Initiating from this view point various sources were looked at for production of alternative fuels .Most of the raw materials like seeds, grass, and bio mass have been in the line of successful experimentation. Hence a unique raw material that is the milk dairy wash water scum has been selected. By trans-esterification, methyl ester can be obtained from the scum which can be blended with diesel to get a new form of bio diesel. Further study of the properties of biodiesel developed and its performance characteristics when used to operate IC engines can open up new avenues in the research development and characterisation of bio fuels.**

*Keywords* — **Milk Scum, Transesterification, Methyl ester, biodiesel , fuel blends.**

## I. INTRODUCTION

With concerns over issues relating to global warming and depletion of fossil fuel reserves, the search for sustainable and renewable energy sources has become a matter of global interest [1]. To reduce the net contribution of green house gases (GHGs) to the atmosphere, biofuels has been recognized as one of the alternatives to petroleum-derived transportation fuels [2]. Biodiesel production from biomass has received major research attention due to their abundance and potential for biochemical conversion to fuels and chemicals [3].

Biodiesel is a cleaner fuel than petroleum diesel and an exact substitute for existing compression engines [4]. Scarcity of fossil fuel increases the searching of new biomass to trap renewable energy sources more attractive. Currently biodiesel is prepared from oil like soybean, canola, palm, sunflower etc. throughout the world [5,6]. It is now believed that the world food crisis will occur as the result of using food crops for producing biodiesel [7]. This lead to search for excavation of biodiesel feed stocks from unconventional, nonedible oil and fats like, waste grease, waste cooking oil, waste tallow, jatropha seed oil, tobacco seed oil, rubber seed oil, polanga seed oil, Milk Dairy wash water scum etc. Biodiesel is generally reported as being more costly than conventional diesel fuel. The cost of raw materials accounts for 75– 85% of the production cost of biodiesel [8, 9]. The higher price of biodiesel made researcher to look for newer ways to reduce cost to make newer biodiesel competitive [10].

Biodiesel can be obtained from milk scum by Trans-esterification process. The Milk Scum is a waste product (effluent) obtained from the wash water of the milk dairy. The Milk scum is produced by the sequential order of processes involving dairy wash water collection and its treatment in Effluent treatment plant (ETP) which can be transesterified with the help of suitable catalyst to obtain alcoholic esters such as methyl ester, ethyl ester etc.

Transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached.

Transesterification process involves the displacement of alcohol from an ester by another alcohol [11]. Overall transesterification reaction is given by three consecutive and reversible reactions which are believed to occur [12, 13]. These reactions are widely used to reduce the viscosity of triglycerides derived from renewable feedstock such as vegetable oil and animal fat for use in compression engine [14]. Catalyst is used to increase the transesterification reaction rate and yield. Excess alcohol used too, make possible to complete the reversible reaction [15]. When compared to other alcohols, methanol is preferred because of its low cost and its physical and chemical advantages (polar and shortest chain). It can quickly react with Triglycerides. Alkali catalyst such as Potassium Hydroxide (KOH) is easily get dissolved in methanol. In methanolysis, formations of emulsion were quick and easily break down to form glycerol rich bottom layer and Methyl ester rich upper layer [16]. Transesterification occurs approximately 4000 times faster in the presence of alkaline catalyst than the same amount of acid catalyst [17]. For alkali catalyst transesterification, the reactant must be anhydrous, large water makes the reaction partially change to saponification [18]. KOH is used as an

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alkali catalyst because it is used widely in large industrial scale biodiesel production. However the optimum conditions for biodiesel production strongly depend upon the properties of raw oil used [19].

Henceforth in the present investigation it has been intended to effectively develop and optimize a process methodology to produce biodiesel from milk scum and critically evaluate the biodiesel produced for its properties such as viscosity, flash point, fire point, kinematic viscosity, density, specific gravity.

## II. MATERIAL AND METHODS

### *A. PROCESSING OF MILK SCUM*

The sequential treatment of wash water used for cleaning milk silos and other container in Effluent Treatment plant and other units such as screening chambers, fat removal unit, acid phase reactor, anaerobic sludge banker, Aerobic tank and clarifier yields Milk scum. 10 kg of overall Milk scum thus processed was collected from KMF Mother Diary, Yelahanka and heated to 100$^{o}$C to drain all the moisture content away. The milk scum was then filtered to remove coarse and floating impurities. Finally after filtration process, around 6.2 litres of scum oil was obtained.

### *B. TRANSESTERIFICATION OF MILK SCUM*

One litre of scum oil was taken for tranesterification process, which involved two major steps. In the first step known as the acid catalyzed esterification process, the scum oil was acid catalyzed to reduce its FFA (free fatty acid content) to about 2%. While in the second step, known as base catalyzed transesterification process, the products of first step were converted to its mono esters and glycerol.

In acid catalyzed esterification process, 1 litre of scum was heated to 75 degree centigrade and transferred to the round bottom flask of the esterification setup. 350ml of methanol and 10ml of sulphuric acid was mixed thoroughly and added into a beaker in the setup and slowly allowed into the flask containing scum. This mixture of milk scum, methanol and sulphuric acid was stirred continuously until the FFA formed a separate top layer. Once FFA's formed a separate top layer, the mixture was allowed to settle for around 12 hours and the FFA, Impurities floating on the top surface was removed.

In base catalyzed esterification process, the products of acid esterification process was once again heated to 75$^{o}$C , the heated scum was then transferred to the round bottom flask of esterification setup and to this mixture, 8 g of NaOH pellets dissolved in 300 ml of methanol in beaker was added by slowly opening the valve. The mixture was then stirred until glycerine formed a separate layer, once glycerine formed a separate top layer; the mixture was allowed to settle for around 12hours and the glycerine floating on the top surface was removed.

Finally 850 ml of esterified scum oil, which is nothing but biodiesel was obtained after the removal of glycerine.

### *C. WATER WASH*

The biodiesel obtained was washed 4 times with water to remove the catalyst. Finally the clear wash water was obtained after four successive wahses thereby confirming that the catalyst is not present in the biodiesel. This was later heated to 100 degree centigrade to get dry biodiesel which was completely free from moisture .Thus neat bio diesel was obtained.

### *D. BLENDING OF FUEL*

The bio diesel was then blended with the fossil diesel in different percentages as shown in table 1.The blending process was carried out with the help of a measuring jar and beaker. The appropriate percentages of diesel and biodiesel were added to the beaker and then transferred to the bottle. The bottles were agitated well and were allowed to stay upside down to ensure proper mixing of fuels. The bottles were stored in dry place and kept still for the next 24 hour. Blends were checked for every 6 hours time intervals for any layer formation. All the blends were stable and passed the 24 hrs stability test and were ready to be used on engine.

**Table-1**

| Sl.No. | Biodiesel Percentage | Diesel percentage | Notation |
|---|---|---|---|
| 1. | 10% | 90% | B10 |
| 2. | 20% | 80% | B20 |
| 3. | 30% | 70% | B30 |

*Blends of different biodiesel – diesel percentage*

### *E. PROPERTIES OF MILK SCUM*

The blended fuel samples and biodiesel were tested for different chemical and physical properties. The first test conducted was the flame test for the produced biodiesel to make sure that it is in anhydrous form. This test was conducted with the help of a spirit lamp to check whether it burns without sparks and with a blue flame.

Second test was to find out calorific values of the blended fuel samples and also for regular diesel. This was done by testing 50 grams of fuel in a bomb calorimeter and directly obtaining the calorific value of the fuel. The next test conducted was the viscosity test with the help of a Red Wood Viscometer for the blended fuel samples as well as regular diesel to check whether they hold good for ASTM fuel standards. The fuel samples were also tested for the flash points. The results have been furnished in table 2.

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**Table - 2**

| FUEL BLENDS | FLASH POINT $^0$C | CALORIFIC VALUE (kJ/kg) | DENSITY (kg/m$^3$) | VISCOSITY (cP) |
|---|---|---|---|---|
| DIESEL | 75 | 44515 | 844 | 3.8 |
| B10 | 76 | 43632 | 833 | 3.3 |
| B20 | 76 | 43193 | 834 | 3.35 |
| B30 | 77 | 42745 | 836 | 3.38 |
| B100 | 79 | 40188 | 868 | 3.8 |

*Results of Various tests carried out to determine properties of different blends of fuel*

## III. RESUSLTS & DISCUSSIONS

In our study, the characteristics of fuel were analysed by plotting a number of graphs; some of the important properties like kinematic viscosity; density and calorific value of different blends on the addition of biodiesel were also studied by comparing the results with that of the fossil diesel and 100% biodiesel. The results obtained pertaining to the Kinematic Viscosity, Specific Gravity, Density and Calorific Value is discussed one by one with the help of graphs.

### *A. KINEMATIC VISCOSITY*

The test for kinematic viscosity is carried out at a temperature of 400$^o$C in redwood viscometer (ASTM standard) and a critical comparison of kinematic viscosity of Diesel, Biodiesel and various blends is done by plotting a graph as shown in Fig 2. From the graph it can be observed that the viscosity of diesel-biodiesel blends are less compared to fossil diesel and as the percentage of biodiesel in the blends increases, the viscosity of the blends also increases slightly from 3.3 to 3.8.

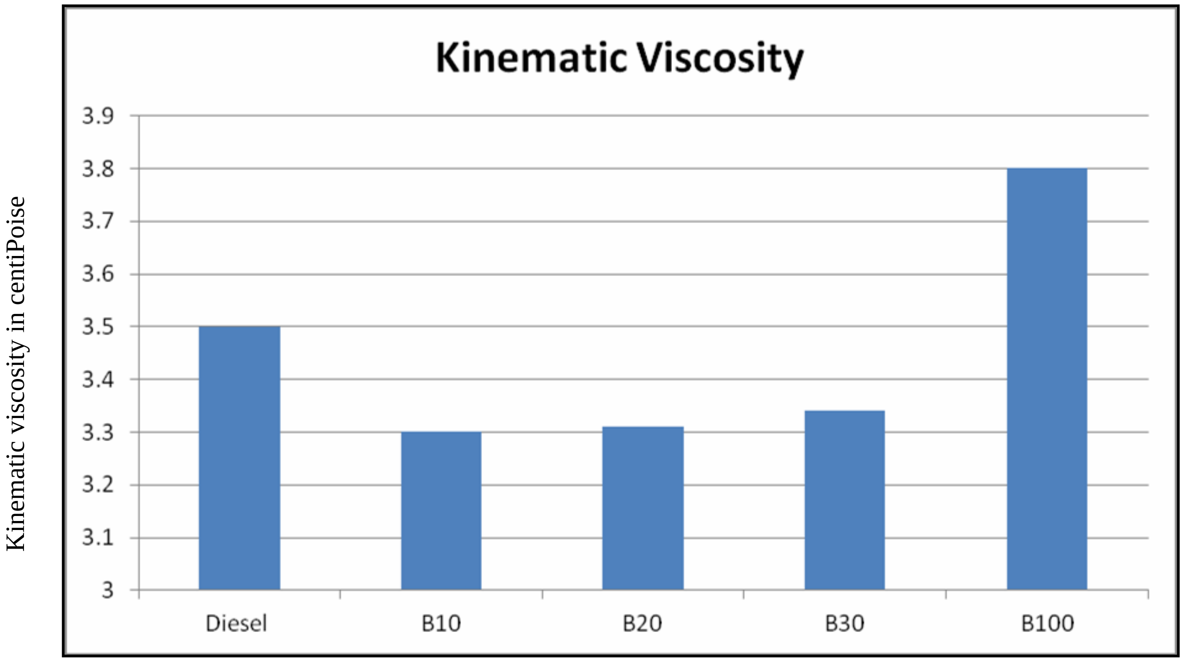


Fig 1 Kinematic Viscosity of different Blends



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*B. SPECIFIC GRAVITY*

The test for specific gravity is carried at a temperature of 250$^o$C as per ASTM standard and a comparative evaluation of specific gravities of Diesel, Biodiesel and blends are done by plotting a graph as shown in Fig 2. From the graph we can conclude that the specific gravities of the blends increase with the increase in percentage volume of biodiesel. The specific gravity of biodiesel is 0.855 and it is more than fossil diesel (0.815).

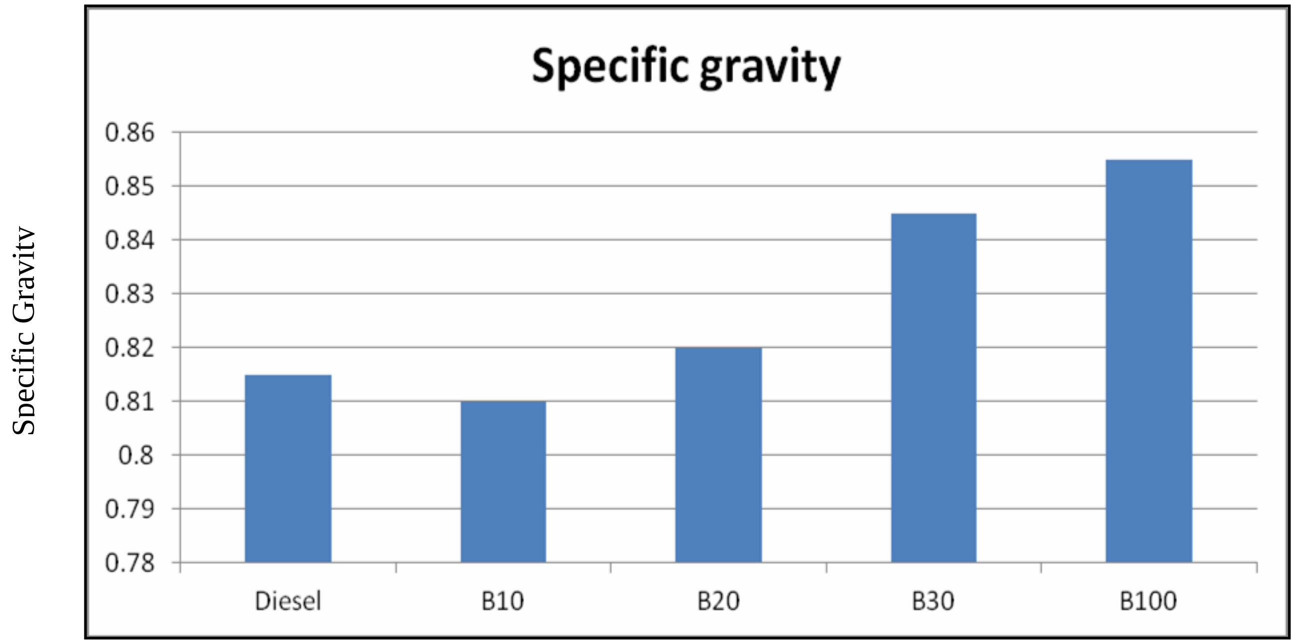


Fig 2 Specific Gravity of different Blends

*C. DENSITY*

The density of Diesel, Biodiesel and blends are plotted graphically on a bar chart as shown in Fig 3. This test is carried out at a temperature of 150$^o$C (ASTM standard). From the graph we can conclude that the densities of the blends are less compared to fossil diesel and as Percentage of biodiesel increases, the density also increases slightly from 833 to 836 kg/m$^3$. The density of biodiesel is 868 kg/m$^3$ and it is more than fossil diesel (844 kg/m$^3$).

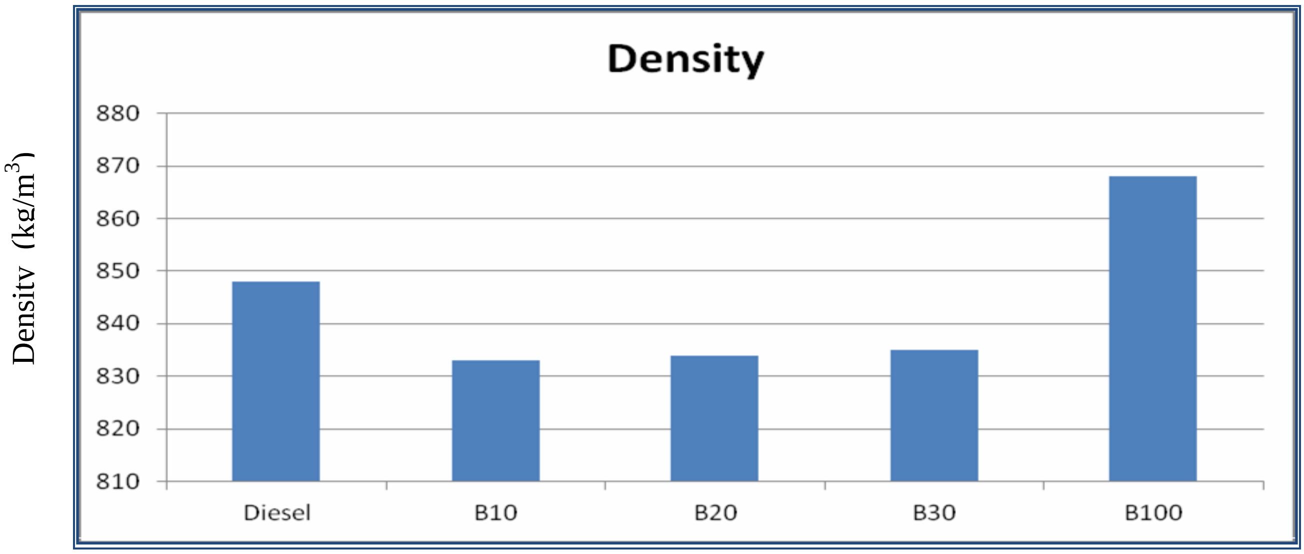


Fig 3 Density of different Blends

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*D. CALORIFIC VALUE*

The calorific Value of Diesel, Biodiesel and blends are graphically represented on a bar chart as shown in Fig 4. The Calorific value of B100 is found to be 40188.58 kJ/kg and the Calorific values of different blends are also determined using a Bomb Calorimeter as per ASTM Standards. The Calorific values of blends are found to be less than the fossil diesel (44515.6 kJ/kg).

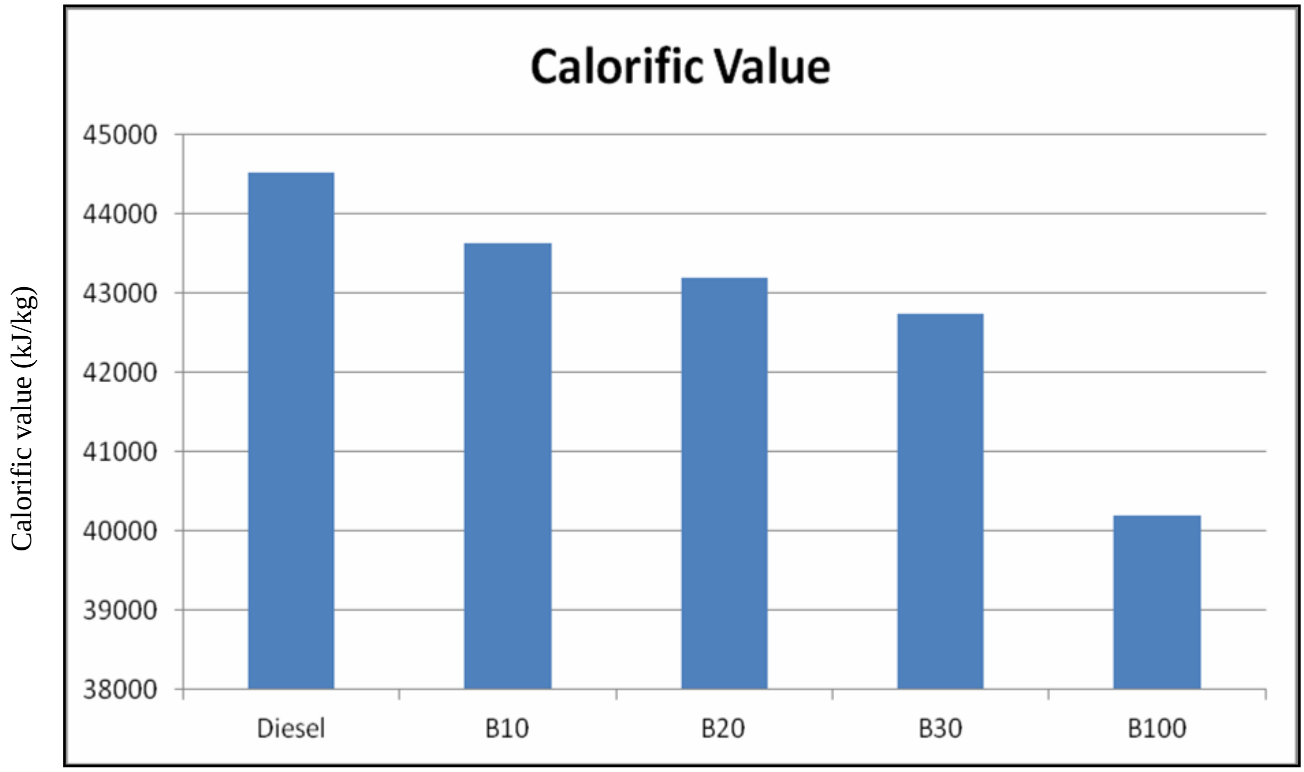


Fig 4 Calorific value of Different Blends

*E. FLASH POINT*

The flash point of B100 is 79$^{o}$C, while the flash point of fossil diesel is found to be 75$^{o}$C. The flash point of blends is less when compared to the biodiesel and slightly more in comparison to the fossil diesel with the values of flash point of different blends other than B100 ranging from 76$^{o}$C to 77$^{o}$C

## IV. CONCLUSIONS

The overall studies based on the production and fuel characterization of Scum biodiesel and its blends B10, B20, B30 yields the following conclusions.

- The production of Scum biodiesel methyl esters is a two stage transesterification process.
- Approxmimately 150 ml of methanol can be recovered
- The time required to produce 900ml of biodiesel is 6 hours and the blending stability time is 24 hours
- The density of biodiesel is 868 kg/m$^3$ and it is more than fossil diesel (844 kg/m$^3$).
- The Calorific value of B100 is found to be 40188.58 kJ/kg and the Calorific values of different blends are also determined according to ASTM standards. The Calorific value of blends is found to be less than the fossil diesel (44515.6 kJ/kg).
- The specific gravity of biodiesel B100 is 0.855 and it is more than fossil diesel (0.815).

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