A COMPREHENSIVE REVIEW: PROPERTIES COMPARISON OF SECOND-GENERATION BIODIESEL BLENDS AND CONVENTIONAL DIESEL

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Abstract: Diesel is one of the most significant contributors to global pollution problems. The current climatic conditions demand a better alternative fuel. Biodiesel is a fuel substitute for diesel engines. Because of the record utilization of first-generation (edible oils) as eatables, the usage of inedible plant oils is worthwhile. Second-generation / non-edible biodiesel feedstocks can be grown on degraded or infertile soils that are unsuitable for growing food crops, and they require less water. In addition to the environmental benefits, the production of biofuels from non-food crops also has the potential to create employment opportunities in rural areas. This study examines the properties of second-generation biodiesel blends, made from a variety of feedstocks including castor, cotton, jatropha and jojoba in comparison to conventional diesel fuel. In addition, the study compares the properties of the second-generation biodiesel blends to ASTM standards for biodiesel and assesses which blend produces the most optimal results, closely resembling those of diesel fuel. Based on findings, it is evident that there is a significant opportunity to utilize inedible oil biodiesel as a blend with diesel fuel, thereby optimizing the resulting properties of the biodiesel blend.

Keywords: Second-generation biodiesel, Second-generation feedstock, non-edible oil biodiesel properties, Biodiesel blends properties.

Nomenclature

ASTM D6751-10	Standard Specification for biodiesel fuel blends	CV	Calorific value
ASTM D975	Standard Specification for Diesel Fuel Oils	FP	Flash point
C10	10 % Castor biodiesel + 90 % diesel	HC	Hydrocarbons
C100	100 % Castor biodiesel	J10	10 % Jatropha biodiesel + 90 % diesel
C20	20 % Castor biodiesel + 80 % diesel	J100	100 % Jatropha biodiesel
CN	Cetane number	J20	20 % Jatropha biodiesel + 80 % diesel
CS10	10 % Cotton Seed biodiesel + 90 % diesel	Jo10	10 % Jojoba biodiesel + 90 % diesel
CS100	100 % Cotton Seed biodiesel	Jo100	100 % Jojoba biodiesel
CS20	20 % Cotton Seed biodiesel + 80 % diesel	Jo20	20 % Jojoba biodiesel + 80 % diesel

1. Introduction

Major research and development work in the last century was concerned with the creation of oil, petrol, and coal-based refineries for purpose of using easily accessible fossil feedstock [1]. These are the prime sources of energy and hold a significant portion of overall energy consumption. scarcity of these resources is on the way as a result of increased usage [2].

For the generation of primary energy, about 86% of fossil fuels were consumed in the year 1973. This consumption got reduced to 78% in the year 2015. During 2020, the oil production will reach its peak value, and would be increasing continuously, fueled mostly by India and China [3]. Due to increased industrialization, rising living standards, and a growing population, global energy consumption is estimated to rise [4]. To fulfill the future demands of energy, Biofuels are attracting experts' interest as a viable alternative to conventional fuel. other important aspects such as cost, environmental issues, and high cost of energy import have attracted researches towards biodiesel [3]. Biofuels obtained from the conversion of oils are found to have huge potential to be used as an alternative to conventional fuels. The properties of these oils get modified during the process of conversion and are found to be nearer to existing diesel fuel. Currently, the technology of transesterification of non-edible oils is utilized to create a renewable fossil fuel (Biodiesel). Some other major processes which are used for the production of second-generation biodiesels include micro-emulsification, pyrolysis, reactive distillation, dilution, etc [5]. Second Generation Biodiesels are formed from sustainable biological and energy resources and are non-toxic and easily degradable. The properties of biodiesel are similar to Petro-diesel fuel and sometimes even superior to it [1]. Production of biodiesel from edible food resources could be hurtful for the availability of the food. Thus, the non-edible feedstocks or second-generation biodiesels have evolved to deal with the food availability issue.

The various feedstocks for the generation of biodiesels are Pongamia glabra (koroch seed), Champaca, Hevea brasiliensis (Rubber seed), Jatropha curcas, Madhuca indica (mahua), Pongamia pinnata (Karanja), Simmondsia Chinensis (Jojoba), Ricinus communis L.(castor), Cerberaodollam (Sea mango), Sterculia feotida, Lesquerella fendleri, Salmon oil, Shorearobusta (Sal), Camellia, Rice bran, Asclepiassyriaca (Milkweed), Hingan (balanites), Radish Ethiopian mustard, Thevettia peruviana (yellow oleander), Sapindusmukorossi (Soapnut), etc. [2], [3], [6]

To further improve the properties of biodiesels, these can be along with the diesel fuel as blends. The researchers showed that the properties of blends are closer to that of existing fuel and are better for the performance of the engine. Different proportions of biodiesel and diesel such as 5%, 10%, 20%, etc. are made to get the desired properties.

This paper deals with the properties of second-generation biodiesels and their blends. The various properties of second-generation biodiesel, their blends and their effects are studied.

2. Second Generation Biodiesel

ASTM defines biodiesel as the long-chain fatty acids of alkyl (methyl, ethyl, or propyl) esters produced from various non-edible oils that make up the fuel. Transesterification, as well as esterification, are chemical processes that produce biodiesel [7]. Generally, the expression 'generation of biofuels' is commonly used. As per the report of EASAC 2012, the classification of biodiesel is done mainly based on the origin i.e., first, second and third generation. while 4th generation biodiesel is artificial, it is derived from artificial biological devices and is in the early stages of research [5]. The first-generation biofuels are the ones that are easily obtainable from the edible feedstock. Similarly, second-generation biofuels are the ones that are obtained from the non-edible feedstock. while the third generation is obtained from waste cooking oil, Fate, algae and other microbes [8]

Nowadays, more attention is given to second-generation biodiesel or inedible vegetable oil as these feedstocks have a lot of potential for making biodiesel in the long run. Second-generation feedstock comprises various inedible oils some of them are Simmondsia Chinensis (Jojoba), Pongamia pinnata (Karanja), Jatropha curcas, Azadirachta indica (neem), Madhuca indica (mahua), etc. [6]. For the reason that the demand for edible oils as a food resource is enormous, the usage of inedible plant oils is particularly considerable in contrast to edible plant oils. these plants could be cultivated in places that are unsuitable for edible and cash crops and their raising price is also low [9]. The important features of second-generation biodiesel are that it is environmentally safe, has cheaper costs, lessens food inequity, and demands less space for growing [10]. Figure 1 shows the second-generation plants and Table 1 shows the uses, yield, and sources of some second-generation feedstock, Table 2 shows the ASTM specifications for diesel and Biodiesel and

shows the range of properties for different second-generation biodiesel and their blends.

2.1 Benefits of Non-consumable Feedstocks:

The various characteristics which make the non-consumable feedstocks a good alternative to other fuels are [2], [6], [11], [12]

- A huge potential for generating employment in rural areas, utilization of degraded lands, and the ability to fix up CO_2 emissions.
- Ease of cultivation of these feedstocks on non-agricultural and infertile regions and less need for moisture content.
- They are easily cultivable from the cuttings, stem parts, and seeds.
- They can be grown in poor regions and places that are not suitable for food crops.
- Reduces load on food resources demand as they are unsuitable for food consumption as they contain some toxic components.
- These feedstocks can be cultivated in regions of heavy rainfall as well as low rainfall areas.
- These are far better and more effective than previous generation feedstocks. The quality and method of production surpass first-generation feedstocks.
- Chief advantages of these feedstocks are low sulphur content, renewability, ease of portability, and bio-degradability.
- The by-products obtained by the trans-esterification process can be again reutilized. After oil extraction, the remaining part of the seeds can be utilized as fertilizers.
- These non-consumable feedstocks are pest and disease-resistant.
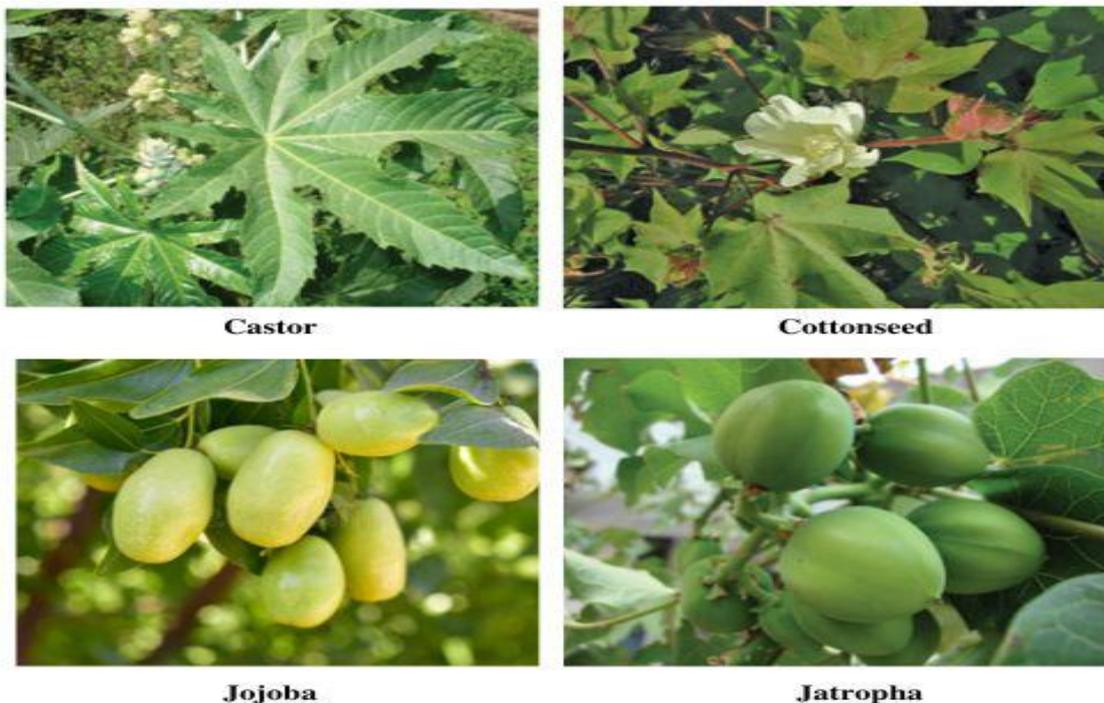

Figure 1. Second-generation feedstocks [13].

Table 1. Uses, yield, and sources of some second-generation feedstock.

Feedstock	Places	Plant	Plant part	Yield (Kg oil/ hectare)	Uses	References
Castor	United States, China, Central Africa, India, Brazil, and Australia	Tree / shrub	Seed	1188	Biodiesel, also used as lubricant and illuminant	[14]–[16]
Cottonseed	Northern India, China, Pakistan, Africa, Peru, Brazil, and South America	shrub	Seed	-	Biodiesel, skin ailments	[3], [17], [18]
Jatropha	Nepal, India, Thailand, Pakistan, Indonesia, Malaysia, and Philippines	Tree	Seed, kernel	1590	Biodiesel, Lubricant, Oil-illuminant	[1], [7], [8], [11], [13], [16], [19]
jojoba	Deserts of California, Mexico, and Arizona	Shrub	Seed	1528	Biodiesel, preventing desert growth	[11],[20], [21]

Table 2. ASTM specifications for diesel and Biodiesel. [22].

S. No.	Fuel property	Diesel Fuel standard ASTM D975	Biodiesel, No. 1-B grade ASTM D6751
1.	Kinematic viscosity, @ 40°C (mm^2/s)	1.3 – 4.1	4.0 – 6.0
2.	Density 15°C (g/cm³)	0.82 - 0.845	0.88
3.	Sulfur, wt % (ppm)	0.0015 max. (15 ppm max.)	0.0 – 0.0015
4.	Flash point, °C	60 – 80	100 – 170
5.	Cloud point, °C	(-35) – 5	(-3) – 15
6.	Pour point, °C	(-35) – (-15)	(-5) – 10
7.	Cetane number	40 – 55	47 – 65
8.	Carbon residue (10% dist. residue)	0.3	0.050

Table 3. Range of properties for different second-generation biodiesel and their blends

S. No.	Biodiesels	Blend	Flash point (°C)	Density (kg/m^3)	Kinematic viscosity (mm^2/s)	Calorific value (MJ/kg)	Cetane number	References
1	Diesel		50 - 70	824 - 850	2.3 - 2.7	42 - 46	40 - 55	[5], [7], [23]–[25]
2	Castor	C100	165 - 194	888 - 962.1	13.5 - 15.4	34.45 - 37.31	50	[16], [26]–[28]
		C10	85.9	832.4 - 849.1	2.74 - 3.14	43.59 - 45.75	-	
		C20	89.1	844 - 859.5	2.73 – 3.73	41.4 - 45.55	-	
3	Cotton seed	CS100	170	880.1 - 885	3.75 - 4.83	37.5 - 38.5	52.8	[29]–[31]
		CS10	75	838 - 843	3.45 - 4.26	45.75	-	
		CS20	81	847 - 853	3.29 - 4.87	41.9 - 43.2	51.2	
4	Jatropha	J100	128 - 148	861 - 873.5	4.23 - 4.35	38.5 - 40.204	58.6	[31]–[35]
		J10	64	831.5-835	3.39	44.728	48 - 52	
		J20	81.5 - 88	836.6 - 845	3.41 - 3.67	43.75 - 44.19	51 - 54	
5	Jojoba	Jo100	154	869.8	4.7	39.9	53	[36], [37]
		Jo10	81	852	3.01	42.157	49.2	
		Jo20	85	858	3.03	40.673	-	

3. Result & Discussion

3.1 Properties of Castor Biodiesel and blends:

Diesel has a very low flash point of 54 °C whereas flash point values for castor biodiesel were seen to be in the range of 165 – 194 °C. Flash point values for the C10 blend were seen to be 85.9 °C. B20 blend of castor had flashpoint values of 89.1 °C and 78 °C. According to ASTM D6751-07b standard flashpoint value for biodiesel should be a minimum of 93 °C. with proper blending it can be achieved. Refer Figure 2.

The density for castor biodiesel was seen to be 896 kg/m^3 and for diesel 824 kg/m^3. Density values for castor biodiesel was also seen to be 962.1 kg/m^3, 888 kg/m^3, 932.5 kg/m^3. Density values for the C10 blend were seen to be 832.4 kg/m^3 and 849.1 kg/m^3 and for the B20 blend of castor the values were seen to be 859.5 kg/m^3, 844 kg/m^3, and 856 kg/m^3. Therefore, we can say that density for castor biodiesel lies in the range of 888 - 962.1 kg/m^3, and for C10 and B20 blend of castor oil with diesel, density is in the range

of 832.4 - 849.1 kg/m^3 and 844 - 859.5 kg/m^3 respectively. According to the ASTM methods, the density value for biodiesel should be 880 kg/m^3 and castor biodiesel has a density near to the standard value. Refer Figure 3.

Kinematic viscosity of castor biodiesel was seen to be 13.5 mm^2/s and when compared to kinematic viscosity of diesel i.e. 2.39 mm^2/s. A. Amin et al. reported the viscosity of the castor biodiesel to be 15.25 mm^2/s and S.T. Keera et al. reported that the kinematic viscosity of castor biodiesel was seen to be 15.40 mm^2/s. therefore, we can say that the kinematic viscosity of the castor biodiesel lies in the range of 13.5 - 15.40 mm^2/s. the C10 blend of castor had a kinematic viscosity of 2.74 mm^2/s and also S.T. Keera et al reported it to be 3.14 mm^2/s. B20 blend of castor and diesel had a kinematic viscosity of 3.73 mm^2/s. M. Arun Kumar et. al. reported the value for the B20 blend to be 2.73 mm^2/s. Values like 3.22 mm^2/s and 3.65 mm^2/s were also reported by various researchers. It can be seen that the kinematic viscosity of the B20 blend of castor and diesel lay in the range of 2.73 - 3.73 mm^2/s. According to ASTM D 6751-07b standards, the kinematic viscosity for good biodiesel lies in the range of 1.9 - 6 mm^2/s and we can see that kinematic viscosity of C10 and B20 blend of castor oil agrees with the given standards whereas values for castor biodiesel were way out of range. Refer Figure 4.

The calorific value of castor biodiesel is seen to be 37.31 MJ/kg which is lower than the calorific value of diesel which is 42 MJ/kg. the calorific value of 34.45 MJ/kg for castor was also seen. The calorific values of the C10 blend of castor with diesel were seen to be 45.75 MJ/kg and 43.59 MJ/kg. B20 blend of castor biodiesel with diesel was seen to be 45.55 MJ/kg, 43.44 MJ/kg, 41.4 MJ/kg, and 42.7 MJ/kg by different researchers. Therefore, we can see that the calorific value of castor biodiesel lies in the range of 34.45 - 37.31 MJ/kg which is very much lower than that of diesel fuel whereas calorific values for C10 and B20 blend of castor with diesel lies in the range of 43.59 - 45.75 MJ/kg and 41.4 - 45.55 MJ/kg respectively which is very much closer to diesel's value. Refer Figure 5 *and*

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3.2 Properties of Cottonseed Biodiesel and blends:

Flash point values for cottonseed biodiesel are seen to be 170 °C and 150 °C which is much higher than a flashpoint of diesel. The Flash point for the CS10 blend of cottonseed is seen to be 75 °C. S. Padmanabhan et. al. reported the flash point for the B10 blend of cottonseed to be 114 °C. the flash point for 20% blend of cottonseed, D80CBD20 was reported to be 81 °C. Refer Figure 2.

The density for cottonseed biodiesel was seen to be 880.1 kg/m^3 and 885 kg/m^3. According to the ASTM D 6751-07b biodiesel standards, the density of biodiesel should be around 880 kg/m^3 and cottonseed biodiesel satisfies the standards has a range of 880.1 - 885 kg/m^3. diesel has a density of 824 kg/m^3 and as we blend diesel with cottonseed biodiesel, the density values come near to the standard value. 10% blend of cottonseed, CS10, has a density of 838 kg/m^3. and another 10% blend B10 has a density of 843 kg/m^3. Density values for 20% cottonseed blend are seen to 847 kg/m^3, 852 kg/m^3, and 853 kg/m^3. Refer Figure 3.

Kinematic viscosity values for cottonseed biodiesel were seen to be 4.834 mm^2/s, 4.3 mm^2/s, and 3.75 mm^2/s. CS10 blend has a kinematic viscosity of 4.26 mm^2/s. B10 blend of cottonseed has a kinematic viscosity of 3.45 mm^2/s. D80CBD20 blend of cottonseed has a kinematic viscosity of 3.29 mm^2/s and another 20% blend, B20 has a kinematic viscosity of 4.87 mm^2/s. according to ASTM D6751-07b, the standard viscosity value for biodiesel should be in the range of 1.9 - 6.0 mm^2/s. Cottonseed oil has a viscosity of 28 mm^2/s, whereas cottonseed biodiesel and its blends have value well within the range. Refer Figure 4.

The calorific value for cottonseed biodiesel was seen to be 38.5 MJ/kg. the calorific value of cottonseed biodiesel lies in the range of 37.5 -38.5 MJ/kg. The calorific value for the C10 blend is 45.75 MJ/kg. D80CBD20 has a calorific value of 41.9 MJ/kg. B20 blend of cottonseed has a calorific value of 42 MJ/kg and the COT20 blend has a calorific value of 43.2 MJ/kg. The calorific value of cottonseed biodiesel is much less than the calorific value of diesel. 20% blends of cottonseed biodiesel with diesel have calorific value in the range of 41.9 - 43.2 MJ/kg which is very much identical to diesel's calorific value of 42 MJ/kg. Refer Figure 5 *and*

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3.3 Properties of Jatropha Biodiesel and blends:

Flash point values for jatropha biodiesel were seen to be 148 °C, 130 °C, and 128 °C. A blend of 10% jatropha biodiesel with diesel has a flash point of 64 °C which is very near to the flashpoint of diesel of 52 °C. A blend of 20% jatropha biodiesel was found to have flash point values of 82 °C, 81.5 °C, and 88 °C. According to the ASTM D 6751-07b biodiesel standard, the standard flash point value of biodiesel is a minimum of 93 °C. Jatropha biodiesel has flashpoints in the range 128 - 148 °C which is quite higher than the standard value. jatropha biodiesel blends have a lower value than the standard. 20% jatropha blend has a value very close to the given standards. Thus, with proper blending given standards can be met. Refer Figure 2.

The density of jatropha biodiesel was seen to be 873 kg/m^3. S. Imtenan et al. found it to be 861 kg/m^3. Harish Venu et al. found it to be 873.4 kg/m^3. Blend of 10% jatropha and 90% diesel, J10 was seen to have a density of 832.65 kg/m^3. Other researchers found the value of density to be 835 kg/m^3, 832.9 kg/m^3. and 831.5 kg/m^3. Blend of 20% jatropha and 80% diesel was found to have density values of 836.6 kg/m^3, 837 kg/m^3, and 845 kg/m^3. The density of jatropha biodiesel is higher and lies in the range of 861 - 873.5 kg/m^3. Whereas, a blend of jatropha has a similar density to that of diesel. The density of the 10% blend of jatropha lies in the range of 831.5 - 835 kg/m^3. Blend of 20% jatropha biodiesel was found to be in the range of 836.6 - 845 kg/m^3. Refer Figure 3.

The kinematic viscosity of jatropha biodiesel was seen to be 4.23 mm^2/s. S. Harish Venu et al. found that the kinematic viscosity of neem biodiesel was 4.35 mm^2/s. S. Imtenan et al. found it to be 4.27 mm^2/s. Therefore, we can say that the kinematic viscosity for jatropha biodiesel lies in the range of 4.23 - 4.35 mm^2/s. A blend of 10% jatropha has a value of 3.39 mm^2/s. 20% blend B20 has a kinematic viscosity of 3.41 mm^2/s. Other researchers also found the value to be 3.60 mm^2/s and 3.67 mm^2/s. According to the ASTM D 6751-07b biodiesel standard, the kinematic viscosity of biodiesel should be in the range of 1.9 - 6 mm^2/s. Kinematic viscosity of blend of 20% jatropha lies in the range of 3.41 - 3.67 mm^2/s which satisfies the given standard and has kinematic viscosity values relatively closer to that of diesel. Refer Figure 4.

Calorific values of jatropha biodiesel found by different researchers were seen to be 38.5 MJ/kg, 39.83 MJ/kg, and 40.204 MJ/kg. 10% blend of jatropha biodiesel has a calorific value of 44.728 MJ/kg. Blend of 20% jatropha, B20 was found to have calorific values of 43.759 MJ/kg and 44.191 MJ/kg. Jatropha biodiesel has a calorific value in the range of 42.563 - 42.67 MJ/kg which is very similar to that of diesel, whereas blends of jatropha biodiesel with diesel have a calorific value slightly higher but closer to that of diesel. Refer Figure 5 *and*

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3.4   Properties of Jojoba Biodiesel and blends:

The flash point of jojoba biodiesel is seen to be 154 °C which is very high when compared to the flash point of diesel of 54 °C. 10% blend of jojoba biodiesel JO10 has a flash point of 81 °C. B20 blend of jojoba has a flash point of 85 °C. D60JBD40 blend of 40% jojoba biodiesel and 60% diesel has a flash point of 91.8 °C. Refer Figure 2.

The kinematic viscosity of jojoba biodiesel is 4.7 mm^2/s which is pretty high when compared to diesel's kinematic viscosity of 2.39 mm^2/s. kinematic viscosity of jojoba biodiesel dropped to 3.01 mm^2/s when 10% jojoba biodiesel was blended with diesel. Kinematic viscosity of DBJ15, a 15% jojoba blend, was seen to be 4.42 mm^2/s by A.I. EL-Seesy, et al. B20 blend of jojoba biodiesel was seen to have a kinematic viscosity of 3.03 mm^2/s. Refer Figure 4.

Jojoba biodiesel has a calorific value of 39.9 MJ/kg and diesel has 42 MJ/kg calorific value. JO10 blend of jojoba has a calorific value of 42.157. A.I. EL-Seesy, et. al. reported that a 15% blend of jojoba and diesel, DBJ 15 has a calorific value of 44.756 MJ/kg. The calorific value of a B20 blend of jojoba and diesel is reported to be 40.673 MJ/kg. Refer Figure 5.

cetane number of jojoba biodiesel is seen to be 53 and that of diesel was 47. It is seen that as we blend 10% jojoba with diesel to form the JO10 blend, the cetane number becomes 49.2. DBJ15 blend has a cetane rating of 51.5. The density of jojoba biodiesel is 869.8 kg/m^3 and that of diesel is 824 kg/m^3. The density of jojoba biodiesel reduces to 852 kg/m^3 when 10% jojoba is blended with diesel to form JO10.DBJ15 blend has a density of 857 kg/m^3. B20 blend has a density of 858 kg/m^3. Refer Figure 6 *and*
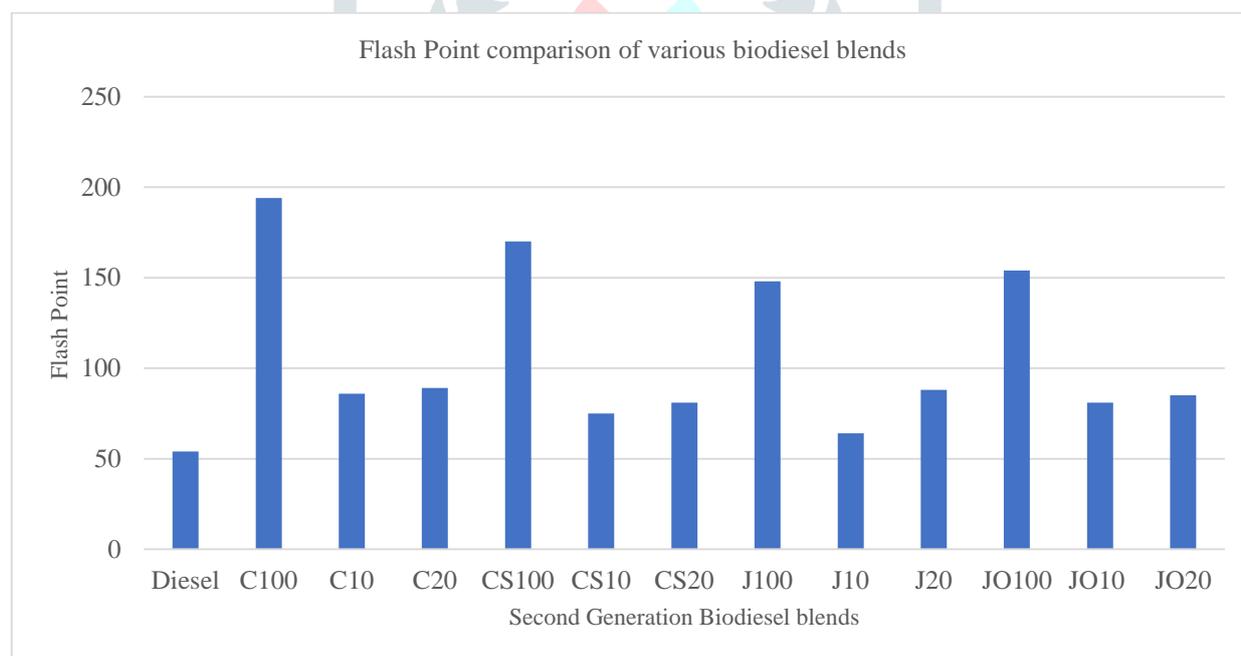
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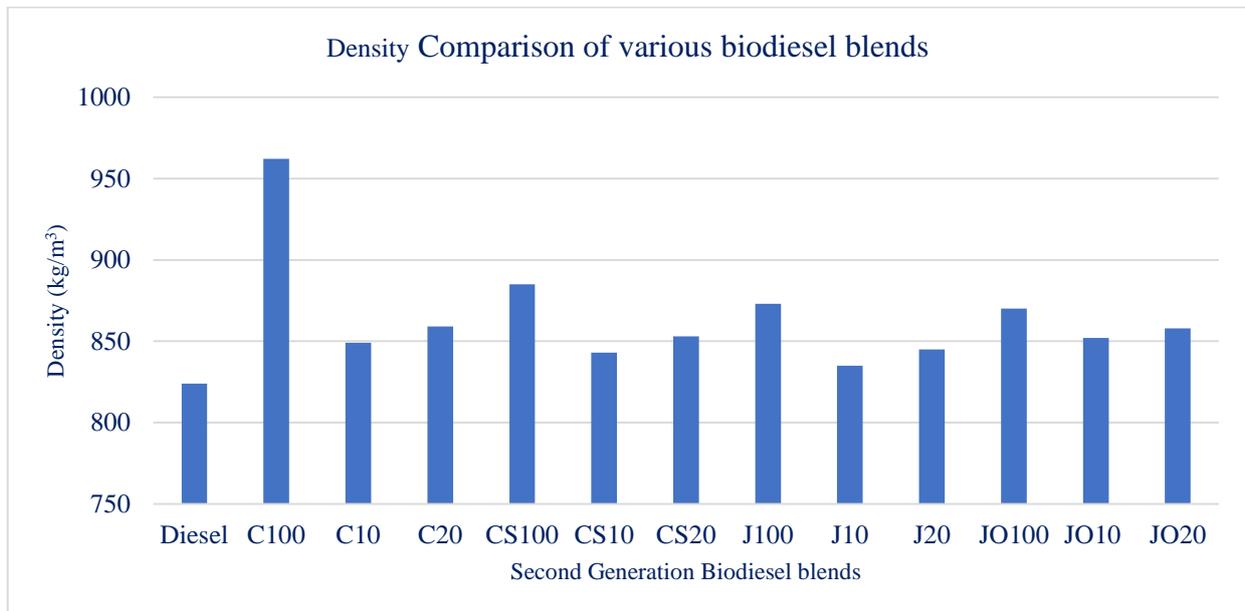Figure 2. Comparison of flash point of various biodiesel and their blends.

Figure 3. Comparison of density of various biodiesel and their blends.
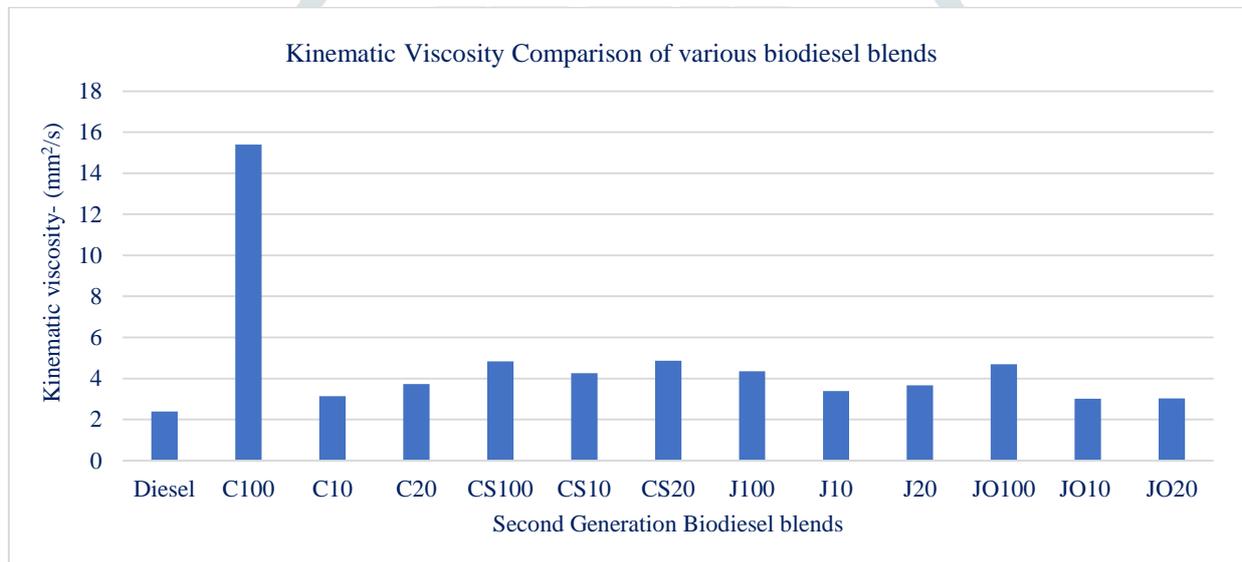

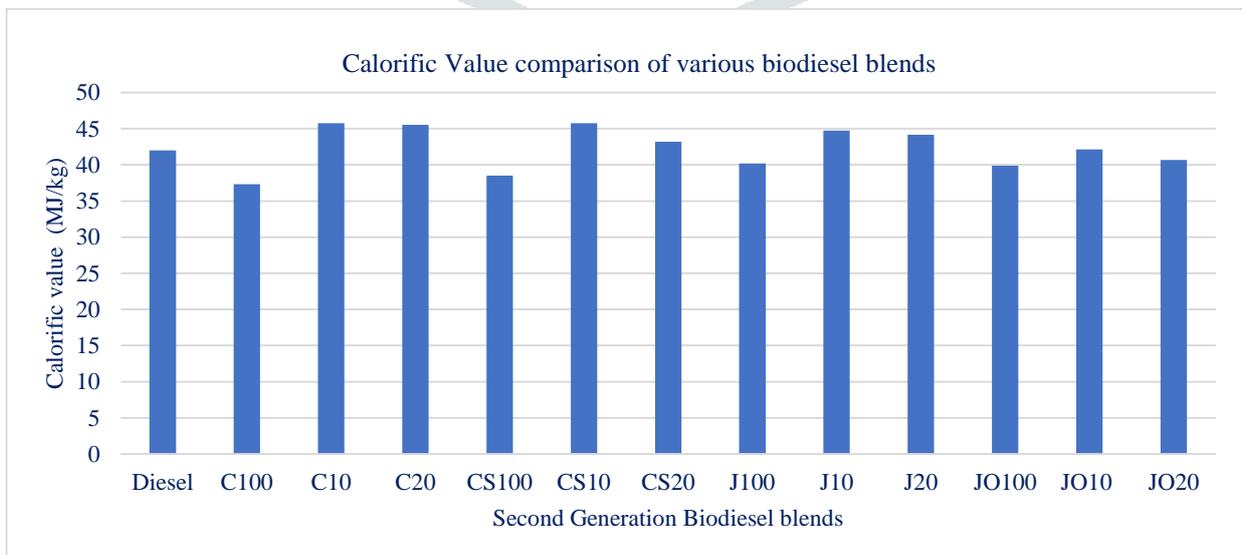Figure 4. Comparison of kinematic viscosity of various biodiesel and their blends.

Figure 5. Comparison of calorific value of various biodiesel and their blends.
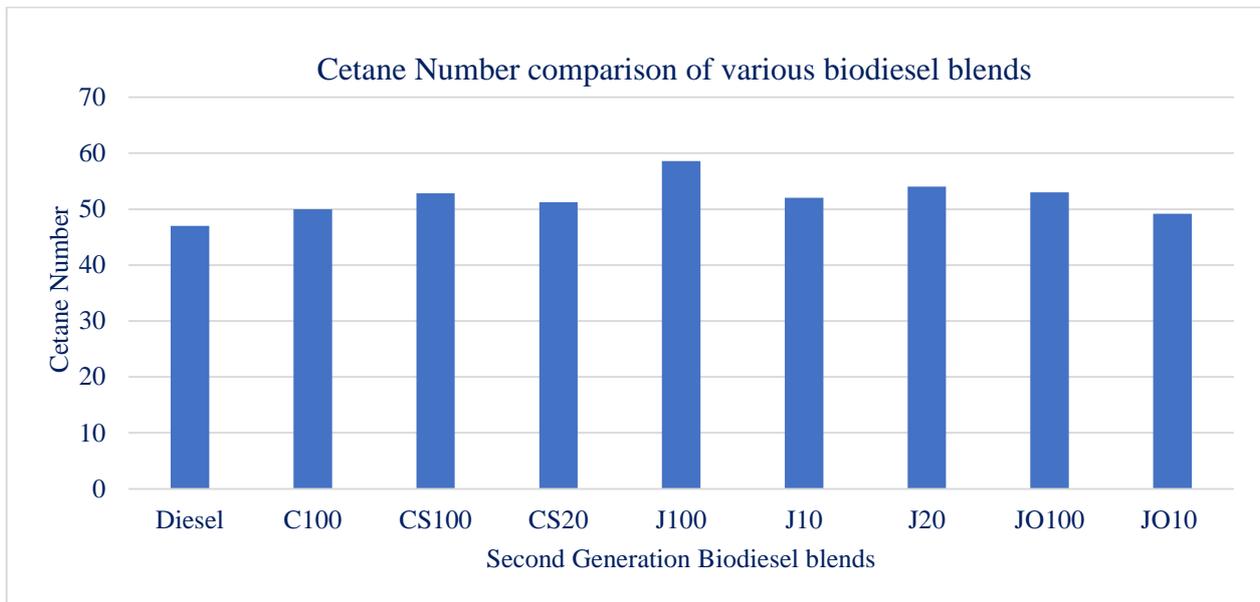
Figure 6. Comparison of cetane number of various biodiesel and their blends.

4. Conclusion

In this study, we discussed various properties second generation biodiesel, and their blends, After the study following points is find out.

- Kinematic viscosity of C10 and B20 blend of castor and diesel lied in the range of 2.74 – 3.14 mm^2/s and 2.73 – 3.73 mm^2/s respectively which agrees with the given standards whereas values for castor biodiesel were way out of range. C10 and B20 blends of castor and diesel lie in the range of 43.59 - 45.75 MJ/kg and 41.4 - 45.55 MJ/kg respectively which is very much closer to diesel's value when compared to the calorific value of castor biodiesel. According to the ASTM methods, the density value for biodiesel should be 880 kg/m^3 and castor biodiesel has a density near to the standard value.

- The Flash point for the 10% blend of cottonseed biodiesel with diesel was seen to be 75 °C and 81 °C for 20% blend. diesel has a density of 824 kg/m^3 and as we blend diesel with cottonseed biodiesel, the density values come near to the standard value. Cottonseed oil has a viscosity of 28 mm^2/s, whereas cottonseed biodiesel and its blends have value well within the range. The calorific value for the C10 blend is 45.75 MJ/kg and the 20% blend of cottonseed has a calorific value in the range of 41.9 - 43.2 MJ/kg which is very much identical to diesel's calorific value of 42 MJ/kg.

- The density of jatropha biodiesel is higher and lies in the range of 861 - 873.5 kg/m^3. Whereas, a blend of jatropha has a similar density to that of diesel. The density of the 10% blend of jatropha lies in the range of 831.5 - 835 kg/m^3. Blend of 20% jatropha biodiesel was found to be in the range of 836.6 - 845 kg/m^3. Kinematic viscosity of blend of 20% jatropha lies in the range of 3.41 - 3.67 mm^2/s which satisfies the given standard and has kinematic viscosity values relatively closer to that of diesel. Jatropha biodiesel has a calorific value in the range of 42.563 - 42.67 MJ/kg which is very similar to that of diesel, whereas blends of jatropha biodiesel with diesel have a calorific value slightly higher but closer to that of diesel. jatropha biodiesel blends have lower flash points than the standard. 20% jatropha blend has value very close to the given standards. Thus, with proper blending given standards can be met.

- the pour point of jojoba biodiesel has seen a drastic decrease when a 10% jojoba biodiesel is blended with diesel, JO10 has having a pour point of -4.3°C. The kinematic viscosity of jojoba biodiesel is 4.7 mm^2/s which is pretty high when compared to diesel's kinematic viscosity. kinematic viscosity of jojoba biodiesel dropped to 3.01 mm^2/s when 10% jojoba biodiesel was blended with diesel. It was seen that as we blend 10% jojoba with diesel to form the JO10 blend, the cetane number of jojoba biodiesel becomes from 53 to 49.2. The density of jojoba biodiesel reduces to 852 kg/m^3 when 10% jojoba is blended with diesel.

- Biodiesel has many advantages like reduced exhaust gas emission, higher cetane numbers, reduced toxicity, safety due to higher flashpoints. Biodiesels have the potential of becoming a great fuel, but they cannot be used in their pure forms because of poor cold flow properties and higher viscosity. Therefore, it is necessary to mix biodiesel with diesel in different proportions and make a blend.

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