A COMPARATIVE ANALYSIS OF PHYSICOCHEMICAL PROPERTIES BETWEEN EDIBLE OIL BIODIESEL BLENDS AND CONVENTIONAL DIESEL FUEL

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Abstract Consumption of fossil fuels is increasing due to the rapid growth of the world's population, which is also responsible for pollutant emissions. This problem compelled mankind to search for an appropriate replacement for fossil fuel. Because of its renewable and environmentally favourable nature, bio-diesel is a potential substitute. Biodiesels produced from edible oils are known as first-generation biodiesels. In this article, A comparison of the physicochemical properties of edible oil biodiesels and their blends with diesel. The properties of edible oil biodiesels in their purest form are not close enough to diesel, but when different blends of biodiesel were mixed with diesel, it was found that biodiesel blends of up to 20% possess properties similar to diesel. PB10 blend of palm biodiesel possesses the density and kinematic viscosity of 850.9 Kg/m^3 and 2.66 mm^2/s respectively similar to diesel. Similarly, a flashpoint of CB10 and SOB10 blends of corn and soybean biodiesels are 71 ^{O}C and 72 ^{O}C which are very close to diesel (70 ^{O}C). As a result, the long-term energy requirement can be fulfilled by blending first-generation or edible oil biodiesel.

Keywords: First-generation biodiesel, First-generation feedstock, Edible oil biodiesel properties, Biodiesel blends properties

Nomenclature

CB100	Corn biodiesel	PB20	20% palm biodiesel + 80% diesel
CB20	20% corn biodiesel + 80% diesel	PB10	10% palm biodiesel + 90% diesel
CB10	10% corn biodiesel + 90% diesel	PP	Pour point
CFPP	Cold filter plugging point	RB100	Rapeseed biodiesel
CN	Cetane number	RB20	20% rapeseed biodiesel + 80% diesel
CP	Cloud point	RB10	10% rapeseed biodiesel + 90% diesel
CV	Calorific value	SOB100	Soybean biodiesel
FP	Flashpoint	SOB20	20% soybean biodiesel + 80% diesel
MB100	Mustard biodiesel	SOB10	10% soybean biodiesel + 90% diesel
MB20	20% mustard biodiesel + 80% diesel	SUB100	Sunflower biodiesel
MB10	10% mustard biodiesel + 90% diesel	SUB20	20% sunflower biodiesel + 80% diesel
PB100	Palm biodiesel	SUB10	10% sunflower biodiesel + 90% diesel

1. Introduction

Traditional energy sources such as petroleum, fossil fuels, methane and coal are not renewable. This is the primary source of energy at the moment, and scarcity is on the horizon as a result of increased use. Diesel fuel plays a vital part in each country's industrial economy. The industrialized world's high energy consumption and extensive usage of fossil fuels are causing rapid depletion of fossil fuel reserves as well as environmental deterioration [1]. Petroleum fuel is critical for industrial growth, transportation, agriculture, and meeting a variety of other fundamental human requirements. Nevertheless, the globe's energy consumption is fast growing because of the immense usage of fossil fuels. The Power generation increased from 6 to 15 Giga-tones between 1970 and 2015, with fossil fuel usage remaining high for the primary energy supply. In 1973, fossil fuels accounted for around 86 percent of primary energy output, but in 2015, the figure is approximately 78 percent. [2]. Petroleum, nuclear, wind, coal, solar, and other energy sources provide a significant portion of the energy for various industries (agriculture, transport, and industry) [3,4] In 1973, these industries consumed 42 percent of the total global oil consumption; in 2014, they consumed 64.5 percent. During the previous 41 years, the use of fossil fuels increased by 43.33 percent However, due to finite reserves, experts are seeking alternative fuels [1].

Another major issue linked to petroleum fuel usage is the discharge of toxic and hazardous gases, which increases pollution. These contaminated fumes are wreaking havoc on people's respiratory systems and neurological systems, causing a slew of dermatological disorders. These toxins also harm the health of livestock and have an impact on plants and trees [4].

All of these considerations need the continuing search for something and the development of ecologically acceptable renewable energy sources. biodiesels have received strong interest. They are renewable and hypoallergenic and can be manufactured locally using agricultural and plant resources [5,6]. The main features that an alternative fuel should have are that it is cost-effective, conveniently available, and has fewer environmental hazards than traditional fuels.

First-generation biodiesels met all these parameters. They are produced from edible oils [7]. Agricultural industries and rural people also benefit from the increase in demand for edible oil crops [1]. Biodiesels are now considered as renewable energy resources capable of completely replacing petroleum fuel, with a particular impact on the industrial and transportation sectors. It is made from a variety of edible oil feedstock, including sunflower, soybean, palm, rapeseed, coconut, and peanut [8]. The urge to fulfil clean air requirements and reduce carbon monoxide, hydrocarbon, and particle emissions from buses has prompted metropolitan regions around the world to examine and experiment with biodiesel mixes, or to at least consider doing so. Therefore, in this paper, we have described various physicochemical properties of first-generation biodiesels and their blends are also compared with diesel.

2. First-generation biodiesel

The bio-diesels which are synthesized from edible feedstock such as palm, soybean, corn, rapeseed, coconut, rice, olive, and mustard are known as First-generation biodiesels [8]. Fig. 1 Shows the plants first generation biodiesel feedstock. The edible feedstock was frequently employed in the production of biodiesel during the start of the biodiesel age. The abundance and accessibility of crops with relatively simple transition techniques are the primary advantages of first-generation feedstock [9]. For bio-diesel manufacturing, a variety of feedstock can be used. Crops for the generation of the first generation of biodiesel are easily available and their conversion into biodiesel is also cost-effective as compared to other generations. The quality of biodiesel derived from edible oils are acceptable and can be used as an alternative of diesel fuel. Food oils account for more than 94 percent of feedstock for the production of biodiesel. Sunflower and other edible oil crops such as coconut, olive, and mustard are used as feedstock for the extraction of first-generation biodiesels. The purity and content of biodiesel derived from diverse feedstock differ [8]. The initial stage in biodiesel manufacturing is selecting feedstock, which influences different parameters such as quality, cost, composition, and productivity [10].

The feedstock used in biodiesel manufacturing is greatly affected by geography. Before the selection of feedstock, the accessibility and financial aspects of the nation are first and foremost taken into account. In India, feedstock such as coconut, soybean, and corn is utilized. Canola oil is the main feedstock in Canada, whereas soybean is used in Brazil and the United States. Palm and coconut oils are utilized as biodiesel feedstock in Indonesia and Malaysia, whereas rapeseed oils are used as biodiesel feedstock in Finland, Italy, Germany, and Britain [11].

Fig. 1. First-generation feedstock's plants and seeds.

2.1 Biodiesel Properties Standards

Quality of biodiesel is regulated by different standards and methods. According to the European Commission, the development stage and climatic properties of the region where it is produced or used, and not least, the purpose and motivation for the use of biodiesel directly impact the quality of this fuel. Standards such as ASTM D6751 and EN14214 that are used to regulate the quality of biodiesel are typically based on characteristics of the existing diesel fuel standards. Table 1. Shows the comparison of biodiesel standard to petroleum diesel . [12]

Table *2*. and Fig. 2 – 7 shows the comparative study of first-generation biodiesel properties and their blends with diesel.

Table 1. Comparison of biodiesel standard to petroleum diesel. Source: https://www.biofuelsystems.com/standards.html

Biodiesel Standards		EUROPE	USA	Petroleum Diesel
Specification	**Unit**	**EN 14214:2012**	**ASTM D 6751-07b**	**EN 590:1999**
Applies to		FAME	FAAE	Diesel
Density 15°C	g/cm³	0.86-0.90		0.82-0.845
Viscosity 40°C	mm²/s	3.5-5.0	1.9-6.0	2.0-4.5
Distillation	% @ °C		90%, 360°C	85%, 350°C - 95%, 360°C
Flashpoint (FP)	°C	101 min	93 min	55 min
CFPP	°C	* Country-specific		* Country-specific
Cloud point	°C		* Report	
Sulphur	mg/kg	10 Max	15 Max	350 Max
Carbon residue	% Mass	0.3 max		0.3 max
Water	mg/kg	500 Max	500 Max	200 Max
Total contamination	mg/kg	24 Max		24 Max
Oxidation stability	hrs;110°C	8 hours min	3 hours min	N/A (25 g/m3)
Cetane number		51 min	47 min	51 min

Table 2 First-generation biodiesel properties and their blends comparison with diesel.

Properties		Cetane No.	Density	Kinematic Viscosity	Calorific Value	Flash Point	Pour point	Cloud point	References
Corn	CB100	45 - 58.5	874 - 877.9	3.39 - 4.30	39.74 - 39.977	119 - 171	-6.7 to -6	-5 to -2.5	[13],[14–17]
	CB20	44.9 - 52	860 - 863	3.34 - 3.65	41.256 - 42.266	73 - 90			
	CB10	43.95	855	3.09 - 3.34	41.895 - 41.914	68 - 74			
Mustard	MB100	52 - 56	864.1 - 878	5.3 - 5.76	38.9 - 40.40	105 - 169.16	-18 to -12	-6 to -1	[13,18–24]
	MB20			4.328	42.36	78			
	MB10			4.105	43.5	76			
Palm	PB100	60.21 - 62.5	859.2 - 880	4.42 - 4.6	34 - 37.26	174 - 176.7	8	10	[13,25–30]
	PB20	56.42	852.9 - 863.6	3.02 - 3.58	42.483 - 45.36	71.5 - 77.5			
	PB10		850.9	2.66	44.613 - 45.48	69 - 75.5			
Rapeseed	RB100	49.5 - 54.40	874 - 897.45	4.4 - 5.06	37 - 38.6	169.5 - 170	-12 to -10	-3.5 to -1	[13,23,28,31–34]
	RB20	54.94	863.8	3.2	43.8				
	RB10	-	-	-	-	-	-	-	
Soybean	SOB100	44.7 - 58	882 - 913.8	4.08 - 4.31	37.53 - 40	140.1 - 181	-9 to -3,	-3 to 5	[13,15,33]
	SOB20	52.3	864.16	3.4 - 3.47	42.85	70 - 76			
	SOB10			2.76	43.59	72			
Sunflower	SUB100	45.7 - 50.5	872.2 - 883	4.22 - 5	37.65 - 40.25	146 - 180.33	-6 to -2	-2 to 1.33	[13,15,16,30,35,36]
	SUB20			3.1 - 3.26	42.2 - 44.24	85 - 101.5			
	SUB10			2.79 - 3.21	43.6 - 45.21	75 - 76			
Diesel		40-55	850	2.6	42 - 46	60 - 80	-12	0	[13,29,30]

3. Result and Discussion - First generation biodiesel and their blends properties comparison

3.1 Corn biodiesel

From different studies, it was found that CN of corn biodiesel lies between 45 - 58.5 while CB20 and CB10 blends of corn biodiesel have the CN 44.9 - 52 and 43.95 respectively. The CN for petroleum diesel ranges 40 - 55 and by ASTM D 6751-07b, biodiesel should have a cetane index of 47. Density (at 40 ^{O}C) for pure corn biodiesel ranges 874 - 877.9 Kg/m^3 which is higher than that of diesel (850 Kg/m^3). But the density reduces to 860 - 863 Kg/m^3 for CB20 and 855 Kg/m^3 for CB10 blends. The value of kinematic viscosity (at 40^{O}C) for pure biodiesel was found in the range of 3.39 - 4.30 mm^2/s while diesel has a very low viscosity of 2.6 mm^2/s. However, CB20 and CB10 blends of biodiesel have a kinematic viscosity of 3.34 - 3.65 mm^2/s and 3.09 - 3.34 mm^2/s. All these values satisfy the standard set by ASTM D 6751-07b (1.9 - 6.0 mm^2/s). The diesel and corn biodiesel were found similar in terms of calorific value.

According to different authors, CB100, CB20, and CB10 have the calorific value in the range 39.74 – 39.977 MJ/Kg, 41.256 – 42.266 MJ/Kg, and 41.895 – 41.914 MJ/Kg. The calorific value of diesel is between 42 - 46 MJ/Kg. A huge variation can be observed in the flashpoint determined by different authors. Corn biodiesel has very high FP (119-171 ^{O}C) as compared to diesel (68 ^{O}C), whereas, FP for CB20 and CB10 is 73 - 90 ^{O}C and 68 - 74 ^{O}C. The FP between 60 – 80 ^{O}C is acceptable for diesel. CP for pure biodiesel were found to be (-5 to -2.5) ^{O}C.

CV of all the blends of corn biodiesel is not satisfied. However, the cetane index for CB20 and CB10 is close enough to diesel. CB10 blend has the closest FP to diesel. The cold flow properties of pure biodiesel are reasonably good.

3.2 Mustard biodiesel

The CN for mustard biodiesel ranges 52 – 56, which is higher than the specifications set by ASTM D 6751-07b. Nevertheless, it is close enough to diesel which has a CN of 40 – 55. The density (at 40 ^{O}C) of pure mustard biodiesel is 864.1 – 878 Kg/m^{3,} which is slightly higher than diesel (850Kg/m^{3}). MB100 possesses high viscosity of 5.3 – 5.76 mm^{2}/s. MB20 and MB10 blends of mustard biodiesel also have high kinematic viscosity of 4.328 mm^{2}/s and 4.105 mm^{2}/s respectively. The kinematic viscosity for diesel is 2.6 mm^{2}/s whereas, in accordance with ASTM D 6751-07b, the kinematic viscosity of biodiesel should be 1.9 - 6.0 mm^{2}/s. Calorific value for biodiesel was found in the range of 38.9 – 40.40 MJ/Kg. MB20 (42.36 MJ/Kg) and MB10 (43.5 MJ/Kg) blends have a similar calorific value to diesel (42 – 46 MJ/Kg). Mustard biodiesel also possesses a high FP of 105 – 169.16 ^{O}C which decreases after the blending of biodiesel. The FP of MB20 and MB10 is 78 ^{O}C and 76 ^{O}C respectively. For diesel, FP lies between 60 – 80 ^{O}C. CP for MB100 ranges from -6 to -1 ^{O}C. For diesel, CP values is 0 ^{O}C.

Mustard biodiesel is the most viscous fluid among all the biodiesels taken into study. After blending also, the viscosity of MB20 and MB10 is high enough than diesel. However, mustard biodiesel possesses very low CP.

3.3 *Palm biodiesel*

Palm biodiesel has a slightly high cetane index (60.21 – 62.5) than diesel (40 - 55). However, CN reduces to 56.42 for the PB20 blend. Density for pure palm biodiesel ranges 859.2 – 880 Kg/m^{3}. PB20 and PB10 blends have the density of 852.9 – 863.6 Kg/m^{3} and 850.9 Kg/m^{3} respectively. PB10 has the density closest to diesel (850 Kg/m^{3}). From different studies, it was found that PB100 has a kinematic viscosity in the range of 4.42 – 4.6 mm^{2}/s. A reduction is observed in the viscosity after blending; 3.02 – 3.58 mm^{2}/s for PB20 and 2.66 mm^{2}/s for PB10. According to ASTM D 6751-07b, kinematic viscosity of biodiesel is 1.9 - 6.0 mm^{2}/s. Diesel possesses a viscosity of 2.6 mm^{2}/s. CV for PB100, PB20, and PB10 ranges 34 – 37.26 MJ/Kg, 42.483 – 45.36 MJ/Kg, and 44.613 – 45.48 MJ/Kg respectively. PB20 and PB10 blends have the CV in the range of diesel (42 - 46 MJ/Kg). Like other biodiesels, Palm has also a high flash point of 174 – 176.7 ^{O}C, but for PB20 and PB10 blends, it reduces to 71.5 – 77.5 ^{O}C and 69 – 75.5 ^{O}C respectively. The FP of diesel ranges 60 – 80 ^{O}C. Palm biodiesel has a very high CP of 10 ^{O}C.

Palm biodiesel possesses poor cold flow properties with high density and viscosity. FP and CN of palm biodiesel are also very high. An improvement in the properties has been seen after the blending of biodiesel with diesel. PB10 blend has very low viscosity and density closest to diesel. It also has the highest calorific value among all biodiesel and biodiesel blends.

3.4 Rapeseed biodiesel

Rapeseed has a CN of 49.5 – 54.40 which is similar to diesel (40 - 55). Its RB20 blend has a CN of 54.94. According to ASTM D 6751-07b, the CN of biodiesel is 47. At 40 ^{O}C, RB100 and RB20 have density 874 – 897.45 Kg/m^{3} and 863.8 Kg/m^{3} respectively whereas diesel possess a comparatively lower density of 850 Kg/m^{3}. Similar to other biodiesels, rapeseed also has a higher kinematic viscosity in the range of 4.4 – 5.06mm^{2}/s. RB20 blend has a comparatively lower viscosity of 3.2 mm^{2}/s which is also higher than diesel (2.6 mm^{2}/s). However, all these values satisfy the standard set by ASTM D 6751-07b (1.9 – 6.0 mm^{2}/s). CV for pure biodiesel lies between 37 – 38.6 MJ/Kg which is lower than the CV of diesel (42 – 46 MJ/Kg). However, the CV of the RB20 blend of biodiesel is similar to diesel (43.8 MJ/Kg). Rapeseed biodiesel has a high FP (169.5 – 170 ^{O}C) than diesel (60 - 80 ^{O}C). CP of pure biodiesel are also similar to diesel; -3.5 to -1 ^{O}C.

Rapeseed biodiesel is an ideal alternative in terms of cold flow properties. However, it has high values of density, viscosity, and FP with a lower calorific value. There is a need for the blending of biodiesel because the RB20 blend has improved properties.

3.5 Soybean biodiesel

CN for SOB100 and SOB20 blend is 44.7 – 58 and 52.3 respectively. By ASTM D 6751-07b, the cetane index for biodiesel should be 47 while CN of pure diesel ranges 40 – 55 at 40 ^{O}C, soybean biodiesel has a very high density of 882 – 913.8 Kg/m^{3} which reduces to 864.16 Kg/m^{3} for its SOB20 blend. Diesel has a lower density of 850 Kg/m^{3}. Soybean biodiesel is more viscous than diesel with a kinematic viscosity of 4.08 – 4.31 mm^{2}/s. It reduces to 3.4 – 3.47 mm^{2}/s for SOB20 and 2.76 mm^{2}/s for SOB10 blends. The viscosity of the SOB10 blend is closest to petroleum diesel (2.6 mm^{2}/s). CV of pure biodiesel lies between 37.53 – 40 MJ/Kg which is lower than diesel (42 - 46 MJ/Kg). However, it has been observed from different studies that calorific value increases after blending. SOB20 and SOB10 blends of biodiesel possess the CV of 42.85 MJ/Kg and 43.59 MJ/Kg respectively. The FP for soybean biodiesel ranges 141.1 – 181 ^{O}C, which is higher than the FP of pure diesel (60 - 80 ^{O}C). Nevertheless, FP for SOB20 (70 - 76 ^{O}C) and SOB10 (72 ^{O}C) blend is close to diesel. Cloud point value for SOB100 lies between -3 to 5 ^{O}C and the cloud point value for diesel is 0 ^{O}C.

Soybean biodiesel has a very high density than diesel. Its kinematic viscosity is also slightly high. However, the SOB10 blend possesses a very low viscosity and FP close to diesel. Improvement is observed after blending for the other properties too.

3.6 Sunflower biodiesel

The cetane index of pure sunflower biodiesel (45.7 – 50.5) is similar to that of diesel (40 – 55). It also satisfies the specification set by ASTM D 6751-07b. Sunflower biodiesel is denser than diesel with a density of 872.2 – 883 Kg/m^3 whereas, diesel has a density of 850 Kg/m^3. Like other biodiesels, SUB100 also possesses high viscosity of 4.22 - 5 mm^2/s, while diesel has a lower kinematic viscosity of 2.6 mm^2/s. However, it decreases to 3.1 – 3.26 mm^2/s for SUB20 and 2.79 – 3.21 mm^2/s for SUB10 blends. According to ASTM D 6751-07b, the kinematic viscosity of biodiesel ranges 1.9 – 6.0 mm^2/s. Sunflower biodiesel has a slightly lower CV in the range of 37.65 – 40.25 MJ/Kg whereas, SUB20 and SUB10 blends have the CV of 42.2 – 44.24 MJ/Kg and 43.6 – 45.21 MJ/Kg respectively, which is similar to diesel (42 – 46 MJ/Kg). Similar to other biodiesels, SUB100 possesses a high FP of 146 – 180.33 ^{O}C, however, it reduces to 85 – 101.5 ^{O}C for SUB20 and 75 - 76 ^{O}C for SUB10 blends. The flashpoint of diesel is found to be in the range of 60 – 80 ^{O}C. Sunflower biodiesel possesses cloud point between -2 to 1.33 ^{O}C which is close to diesel (0 ^{O}C).

The CN for pure sunflower biodiesel is very close to diesel but its density is very high. SUB10 blend has a calorific value very close to diesel and a reasonable viscosity too. On the other hand, cold flow properties for sunflower biodiesel are not up to the mark.

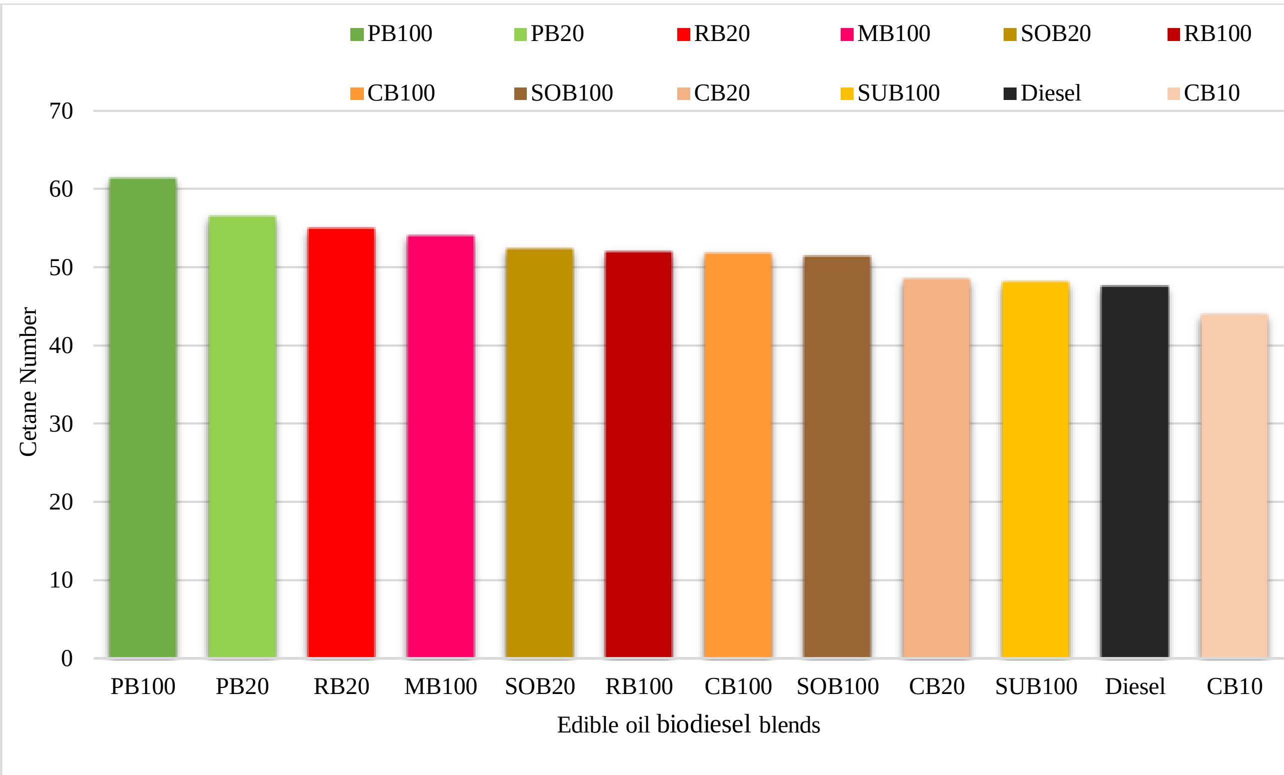

Fig. 2. Comparison of Cetane Number of first-generation biodiesel blends.

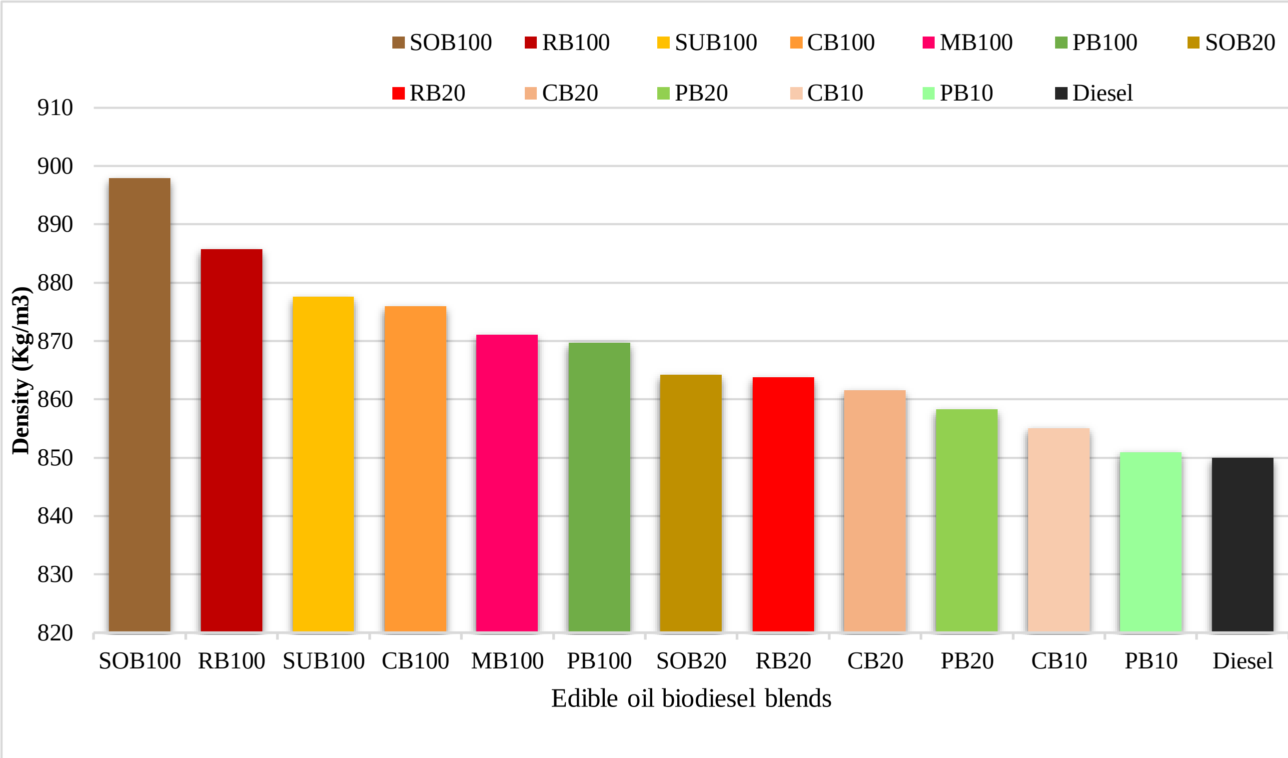

Fig. 3. Comparison of Density of first-generation biodiesel blends.

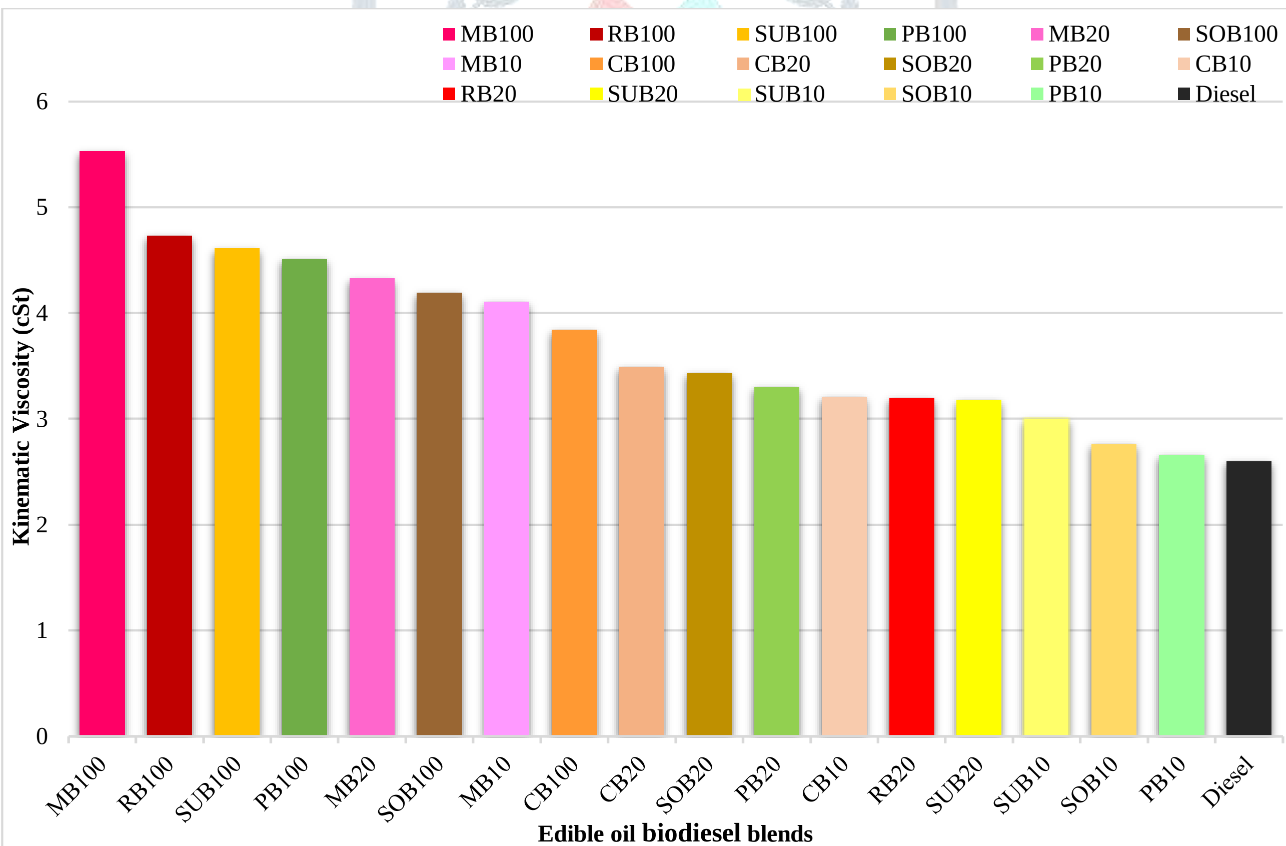

Fig. 4. Comparison of Kinematic Viscosity of First-generation biodiesel blends.

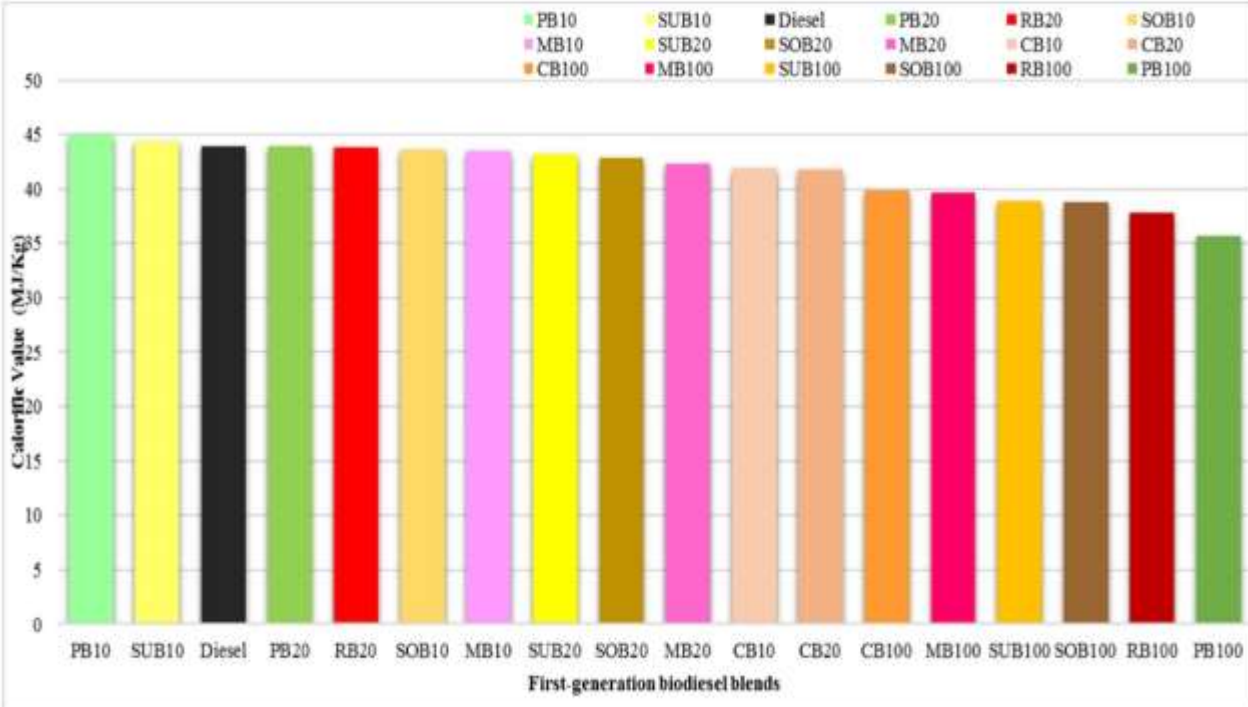

Fig. 5. Comparison of Calorific Value of first-generation biodiesel blends.

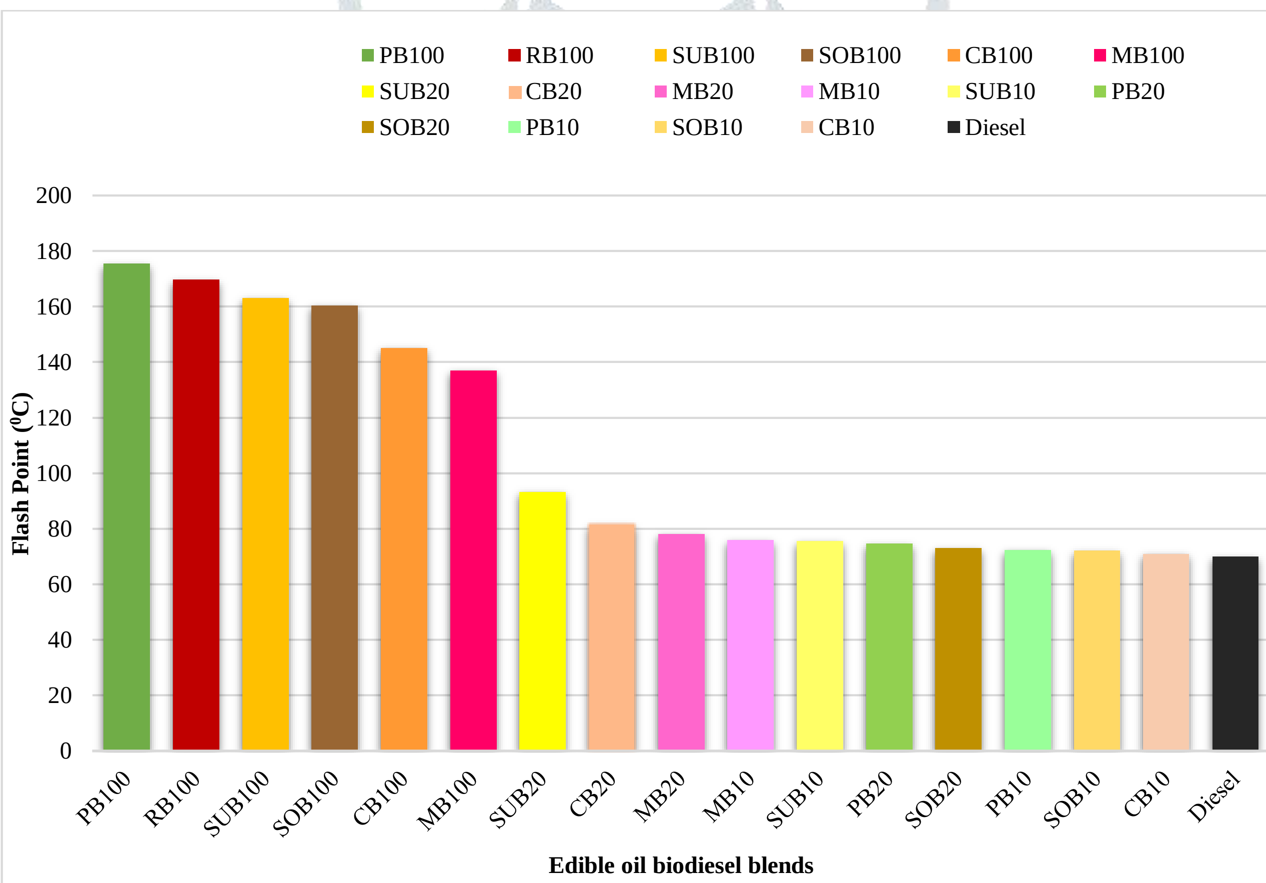

Fig. 6. Comparison of Flash Point of first-generation biodiesel blends.

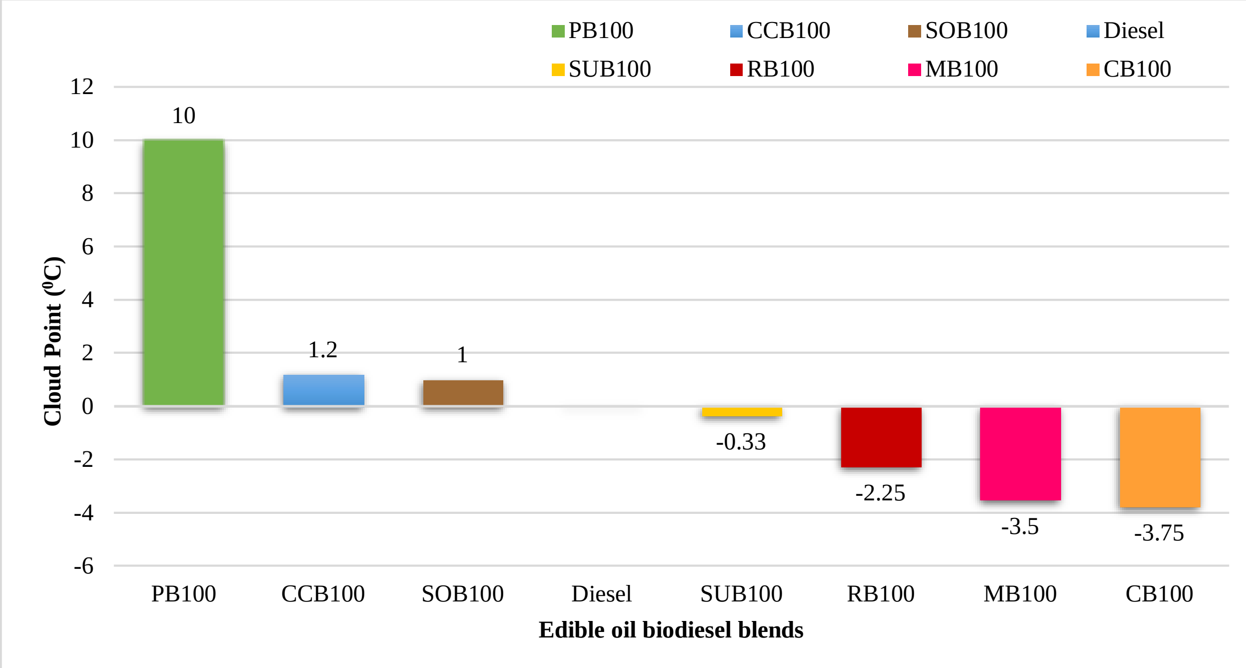

Fig. 7. Comparison of Cloud Point of first-generation biodiesel blends.

7. Conclusion

First-generation biodiesel is a renewable and sustainable energy solution for the world's growing energy demand. Sunflower, Soybean, and Corn are among the most abundantly grown oilseed crops across the globe. Sunflower ranks fifth in the most widely grown crop of the world, whereas, the production of corn is increasing every year. In the Indian context, coconut, rice bran, rapeseed, and soybean are the most suitable feedstock for biodiesel, since India is among the major contributors of these crops. Moreover, coconut and palm have maximum oil yield of 63 – 65% and 30 – 60% respectively followed by rapeseed and mustard.

Enzymatic oil extraction technique is the best method to extract oil from oil seeds since it is non-hazardous to nature, however, it requires longer processing time. The solvent extraction technique is cost-effective at large scale only. Extraction by the mechanical press is the cheapest method but the quantity of oil extracted by this method is lower than other techniques and requires additional treatments. However, pre-processing of the seeds can enhance oil production. Another drawback of this method is that different extractors are required for different kind of seeds.

For biodiesel synthesis, transesterification is the most preferred technique because the high quality of biodiesel is produced with high yield. Through this method, triglycerides are converted into biodiesel with improved physicochemical properties. Soybean and mustard biodiesels synthesized by the transesterification process have high biodiesel yield of 86 – 88% and 81 – 83% respectively.

Biodiesel yield depends upon the catalyst used for biodiesel synthesis. Alkali, acid, and enzyme catalysts can be used. Alkali catalysed transesterification yields a high conversion level of triglycerides to corresponding methyl esters in a short time. However, alkali catalysts have some drawbacks such as alkaline wastewater requires treatment, and recovery of glycerol is also difficult. These limitations are overcome by enzyme catalyst but the high cost is an issue again. For oils having a high amount of free fatty acids and water content, acid catalysed transesterification is suitable. Biodiesel yield is also influenced by the molar ratio of alcohol to triglycerides. Initially, yield increases with the increase of molar ratio up to a certain limit and then start decreasing. It was also found that high temperature (up to 60 ^{O}C – 70 ^{O}C) is most suitable. Biodiesel yield decreases at a lower temperature.

This article also covers the different physicochemical properties of biodiesel and its blends. Some observations are made out of them:

- CV of all the blends of corn biodiesel are not satisfied. However, the cetane index for CB20 is 44.9 - 52 and CB10 is 43.95, close enough to diesel. CB10 blend has the closest FP (68 - 74 ^{O}C) to diesel. The cold flow properties of pure biodiesel are reasonably good.
- Mustard biodiesel with the viscosity of 5.3 – 5.76 mm^2/s is the most viscous fluid among all the biodiesels taken into study. After blending also, the viscosity of MB20 (4.328 mm^2/s) and MB10 (4.105 mm^2/s) are high enough than diesel. However, mustard biodiesel possesses very low PP and CP of -18 to -12 ^{O}C and -6 to -1 ^{O}C respectively.
- Palm biodiesel possess poor cold flow properties with high density and viscosity. FP and CN of palm biodiesel are also very high. An improvement in the properties has been seen after the blending of biodiesel with diesel. PB10 blend has very low viscosity (2.66 mm^2/s) and density (850.9 Kg/m^3) closest to diesel. It also has the highest calorific value of 44.613 – 45.48 MJ/Kg among all biodiesel and biodiesel blends.

- Rapeseed biodiesel is an ideal alternative in terms of cold flow properties. It has PP of (-12 to -10) ^{O}C, CP of (-3.5 to -1) ^{O}C and CFPP of (-10 to -4) ^{O}C respectively. However, it has high values of density, viscosity, and FP with a lower calorific value. There is a need for blending of biodiesel because the RB20 blend has improved properties.
- Soybean biodiesel has a very high density (882 – 913.8 Kg/m^3) than diesel. It has a kinematic viscosity of 4.08 – 4.31 mm^2/s which is also slightly high. However, the SOB10 blend possesses a very low viscosity (2.76 mm^2/s) and FP (72 ^{O}C) close to diesel. Improvement is observed after blending for the other properties too.
- The CN for pure sunflower biodiesel is 45.7 – 50.5 that is very close to diesel but its density is very high (872.2 – 883 Kg/m^3). SUB10 blend has the calorific value of (43.6 – 45.21 MJ/Kg) which is very close to diesel and has a reasonable viscosity (2.79 – 3.21 mm^2/s) too. On the other hand, cold flow properties for sunflower biodiesel are not up to the mark.

From the above observations, we can conclude that biodiesel blends of different feedstock are similar to diesel in terms of different properties. The cetane index of SUB100 and CB20 is 48.1 and 48.45 respectively which is close enough to diesel (47.5). PB10 blend is found to be best in terms of density (850.9 Kg/m^3) and kinematic viscosity (2.66 mm^2/s), whereas PB20 blend along with SUB10 has calorific values of 43.92 MJ/Kg and 44.4 MJ/Kg closest to diesel. Density, viscosity, and calorific value for diesel are 850 kg/m^3,2.6 mm^2/s, and 44 MJ/kg respectively. The Flashpoint of CB10 is 71 ^{O}C and SOB10 is 72 ^{O}C which is almost similar to diesel (70 ^{O}C). So, it is clear from the present study that the properties of pure biodiesel are not close enough to diesel. However, the properties of biodiesel blends of up to 20% are similar to that of diesel.

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