Comprehensive Review on Properties and Generation of Biodiesel

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Abstract. Recently, biodiesel has become more attractive owing to its attractive properties such as positive environmental effects, non-toxic, biodegradable, derived from renewable resources. Hence, this paper aims to provide an overview on biodiesel production and generations of biodiesel produced from distinct feedstocks. Thereafter the comparison of fuel properties, oil yield for different edible and non-edible oil and feedstock cost in distinct countries is given. Finally, the properties of biodiesel developed from distinct feedstock are summarized. The outcome demonstrates that the various sources offered varying yields owing to the process factors. However, the yield of biodiesel varies w.r.t. feedstocks owing to the physical and chemical characteristics of the sources and the process factors. Among waste cooking oil, commercial diesel fuel, and biodiesel from waste cooking oil, waste cooking oil offered higher pour point (284K), density (0.924 kg/L), water content (0.42%), kinematic viscosity (36.4 mm^2/s) than commercial diesel fuel and biodiesel from waste cooking oil.

1. Introduction

The world's escalating energy needs are mostly met by non-renewable fossil fuels due to the fast-growing population and accelerating industrialization. Fossil fuel reserves are running out more quickly, and their overuse has caused significant environmental problems that make moving to renewable energy sources necessary. However, owing to its biodegradability, renewability, and ecologically friendly characteristics, biodiesel has attracted significant interest as a feasible and flexible fuel replacement to the currently used non-renewable fuels. Transesterification is the manufacturing method that is most frequently used to produce biodiesel from a variety of sources [1]. Around 9 billion people are projected to live on the earth by 2050 [2]. Natural energy sources are being depleted as a result of rising worldwide prices and increased energy consumption [3-5]. The combustion of fossil fuels has a number of negative effects on the environment, including a rise in the emissions of greenhouse gases (GHG), mainly CO_2 [6,7]. Global primary energy consumption has sharply expanded in recent decades as a result of rapid industrialization and rising living standards [3,8]. To maintain a reasonable quality of life, developing nations like South Africa, the South Asian area, and Brazil need 12–24 gigajoules (GJ) of energy per capita each year [9]. At the moment oil, coal, and natural gas make up over 80% of the world's energy supply, and nearly 98% of that energy is produced by carbon emissions from these fuels [9]. Through the 21st century, it is anticipated that droughts would last longer and be more intense, resulting in a five-fold reduction in water reserves [2].

Hence, this review paper discusses about the various aspects for biodiesel production from distinct feedstocks. Further, this paper includes the comparison of fuel properties, oil yield for different edible and non-edible oil and feedstock cost in distinct countries. Finally, the properties of biodiesel produced from distinct feedstock are summarized. Hence, this review paper will be useful for the futuristic scientists to get the properties of biodiesel produced from distinct feedstock.

2. Biofuels Types, Generation and Production

According to Figure 1, there are four generations of biofuels

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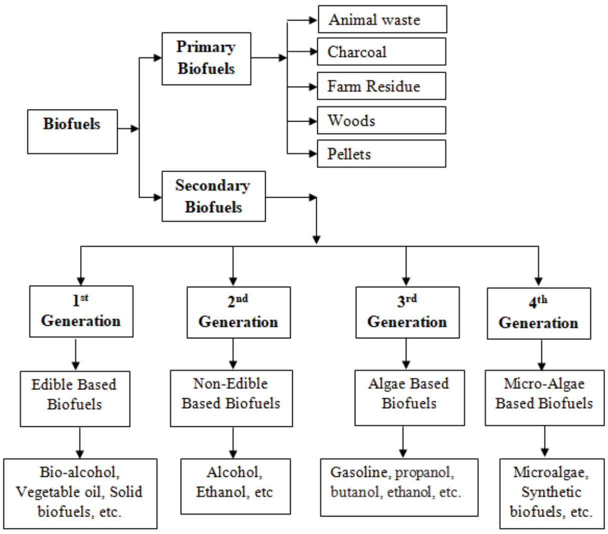

Figure 1. Types and generations of Biofuels [10]

2.1. 1st Generation

1st generation biofuels are traditional biofuels that are primarily produced from two categories of edible feedstock: starch-based feedstocks (such as potatoes, maize, wheat and wheat) and sugar-based feedstocks (such as sugar beet and sugarcane) [11, 12]. Crop availability and relatively easy conversion procedures are the primary benefits of 1st generation raw materials. However, there is a decreased food supply as a result of utilizing edible food crops for the manufacture of biodiesel [13–15]. The use of agricultural land for fuel generation is another issue. Environmental damage could result from using excessive amounts of insecticides and fertilizer for agricultural production [16].

2.2. 2nd Generation

Advanced biofuels known as second-generation biofuels are made from a variety of trees, grass, shrubs, and agricultural waste [10]. The second-generation biofuels include the Cellulosic Ethanol, Algae-Based Biofuels, Algae-Based Biofuels, Alcohol, Biosynthetic Natural Gas (Bio-SNG) etc. [17-20].

2.3. 3rd Generation

Algal biomass and used cooking oil are used to create 3rd generation biofuels. These biofuels have the benefits of greater growth and productivity, using less agricultural land, having more oil, and having less of an influence on the food supply. The main sources of 3rd generation biodiesel feedstocks include microalgae, animal fat, fish oil and used cooking oil [21].

2.4. 4th Generation

The biofuel produced by such a method is referred to be a fourth-generation biofuel since it uses Molecular biology, transdisciplinary physicochemical methods, and genetic engineering, including the utilization of “CRISPR/Cas9” with guided RNA for genetic change in algae [22]. In order to increase biofuel yield, genetically altered algae that accumulate high lipid and carbohydrate content are used in the manufacturing of 4thgeneration biofuels [23-25]. The Edible & non-edible vegetable oils developed by distinct countries is given in **Table 1.**

Table 1. Vegetable oils, both edible and not, by nation of production [26].

Countries: Edible oil	Countries: Non-Edible oil
China, USA: Corn	USA: Jojoba
Thailand, Malaysia, Indonesia: Palm	South Asia: Neem, Karanja
Canada: Canola	China, Canada, Russia: Linseed
France, Finland, Germany: Rapeseed	Asia: Silk cotton
Thailand, Philippines: Coconut	India, China, Brazil: Tobacco, Cotton seed
Sweden, Russia, Italy, UK: Soybean	India, Australia, Sri Lanka: Sandalwood
India, China: Groundnut	China: Cotton seed
Argentina, China, Brazil: Sunflower	India: Mahua, Polanga
Canada, China, Europe: Mustard	India, China, Thailand, Philippines, Indonesia: Jatropha
Russia, USA: Sunflower	Malaysia: Rubber seed

The feedstock comes in three generations. Vegetable oils that can be consumed, like sunflower oils, and soybean are first generation feedstocks [27]. **Table 2** lists the second-generation feedstocks, which are derived from non-edible sources including jojoba oil, used cooking oil, animal fats and jatropha etc. [28].

Table 2. Second-generation biodiesel production feedstock types [29].

2nd generation biodiesel production from distinct feedstock		
Non-edible oil seed	**Waste materials**	**Animal fats**
Jatropha	Acid oils	Pork lard
Kusum	pomace oil	Beef tallow
Karanja	Vegetable oil soap stocks	chicken fat
Botryococcusbraunii	dried distiller’s grains (DDG),	yellow grease
Mahua	tall oil	By-products from fihi oil
Ethiopian mustard		waste salmon
Linseed		sorghum bug
Tomato seed		melon bug
Cotton seed, Tobacco, Neem, etc.		

High costs, ineffectiveness, and sustainability are constraints on the development of these feedstocks [30–34]. Number of distinct seed oils were evaluated as a possible fuel source for the diesel engine, with the third-generation feedstock, microalgae, receiving the majority of attention. **Figure 2** compares the characteristics of several fuels.

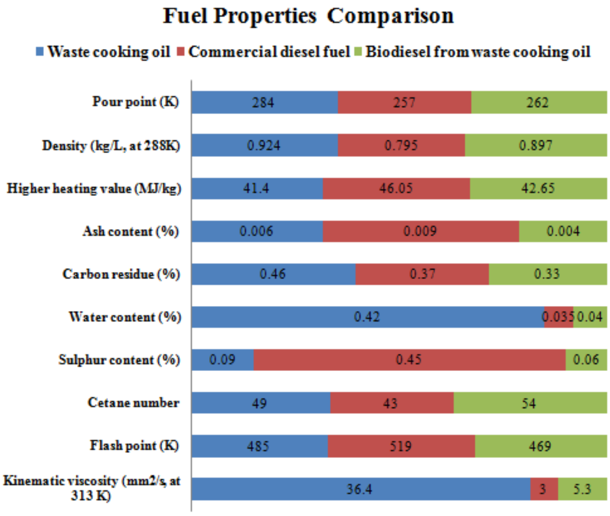

Figure 2. Distinct fuel properties comparison [35].

Further, the comparison of oil yield (%) in case of edible and non-edible oil source is shown in **Figure 3.**

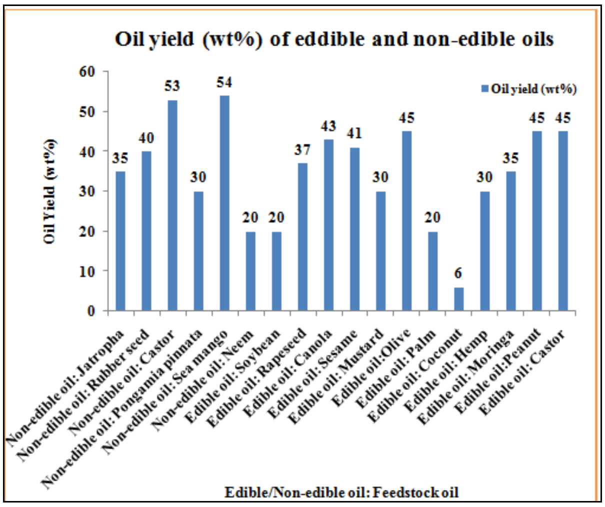

Figure 3. comparison of oil yield for edible and non-edible oil [35-37]

Further, the cost of distinct biodiesel feedstock in distinct countries is represented in **Figure 4.**

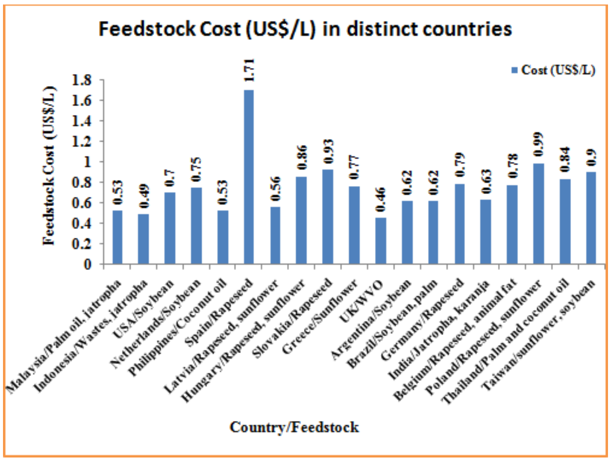

Figure 4. Cost of biodiesel feedstocks in distinct countries [35, 38]

Researchers and scientists have created many processes for producing biodiesel from various biofuels. The majority of academics and experts claimed that using a catalyst increased the production of biodiesel. To create biodiesel, Ahn et al. [39] used a 2-step reaction procedure. By employing, potassium hydroxide, sodium hydroxide as catalysts, canola methyl ester (CME), rapeseed methyl ester (RME), beef tallow ester (BTE) and sunflower methyl ester (SME) were all produced. Cold-pressed rapeseed oil and methanol are transesterified in two stages at low temperatures to produce biodiesel [40-45].

3. Properties of Biodiesel

Fatty acid methyl ester (FAME), sometimes referred to as biodiesel, is created by combining methanol with any triacylglycerol-carrying substance, including vegetable oil, animal fat, or both. The value of FAME's properties is greatly altered by variations in feedstocks [46, 47]. The cetane number, viscosity, calorific value, pour temp., iodine number, cloud temp, flashpoint, specific gravity, and cold filter plugging point are only a few of the attributes that are closely linked to the composition of FAME. However, the FAME characteristics of bio-diesel fuel are impacted by its handling and production procedures in addition to its intrinsic characteristics [48–54]. The water content, acid number, cold soak filtration, ash content, metals, sediment, and methanol concentration are some of these characteristics [47, 55]. Table 3 provides a summary of the main physic-chemical characteristics of biodiesel

Table 3: Distinct characteristics of biodiesel developed from distinct feedstock [55-64]

Feedstocks	Density at 15°C (kg/m³)	Heating Value (MJ/kg)	Cloud Point (°C)	Flash temp. (°C)	Pour Temp. (°C)	Viscosity at 40 °C (mm²/s)	Cetane Number	Iodine Number	Sulfur Content (wt.%)	Ad Value mg/g
Babassu	872	31.8	4	117	-	4.2	63.25	-	-	0.425
Bitter almond	884	-	4.5	169	-6	4.60	45.18	117.2	-	0.27
Camelus dromedaries	871	39.52	12.7	158	15.5	3.39	58.7	65.3	0.031%	-
Canola	878	-	-3.25	172.36	-8	4.42	54	113.6	2 ppm	0.49
Chicken fat	883	40.17	-7	172	-	4.98	48	-	23.45	0.22
Variabilis	867	38.7	-	157	-	4.8	58.6	-	0	-

Cotton seed	887	39.7	1.7	210	-12.5	4.19	48.1	120	-	0.5
Groundnut	920	39.8	8	132	3	4.4	59.85	71.8	1.31ppm	-
*J. curcas*L.	865	40.7	5.6	175.5	6	4.52	55.43	95.75	0.008	0.24
Karanja	889	36.56	13.3	157.4	6.4	4.79	56.55	89	0.003%	-
Lard	877	36.50	-	143.5	7	4.84	-	77	-	0.12
Mahua	895	36.9L, 39.4H	4.33	129.5	4.33	4.77	55	74.2	-	0.41
MicheliaChampaca	870	39.5	-	158	-	5.11	50.28	104	-	0.44
Neem	929	-	19	214	10	38.8	41	75.2	-	-

4. Conclusion

According to the literature, biodiesel from sources including sunflower, rapeseed, palm, and jatropha has enormous potential. It has been established that base catalysts outperform acid catalysts and enzymes, and that biodiesel combustion properties are comparable to those of diesel. The usage of vegetable oil/diesel blend is also implied to have resulted in worse engine performance since the high viscosity oil contaminated the lubricating oil and caused coking of the injectors. The literature study led to the conclusion that there is a significant area for research in the manufacturing of biodiesels, as well as in performance improvement and emission reduction. Additionally, there are significant opportunities for study in the field of increasing biodiesel output.

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