Canola, Camelina, and Linseed Biodiesel: A Sustainable Pathway for Renewable Energy

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ABSTRACT

Biodiesel production from various feedstocks is gaining momentum as an alternative to fossil fuels, offering a more sustainable and environmental friendly energy source. This article explores the potential of canola, camelina, and linseed as biodiesel feedstocks. It provides an overview of their characteristics, benefits, and the impact they can have on reducing greenhouse gas emissions. By understanding the unique qualities of these oilseed crops, we can pave the way for a greener and more sustainable energy future.

Keywords: Canola, Camelina, Linseed, Biodiesel, Transesterification

1. INTRODUCTION

In today's world, the growing energy demand coupled with increasing environmental concerns has sparked a global search for sustainable alternatives to traditional fossil fuels. Biodiesel, a renewable and cleaner-burning fuel, has emerged as a promising solution. It is derived from various organic feedstocks and can reduce greenhouse gas emissions and promote energy independence [1].

Canola, camelina, and linseed are three oilseed crops that have attracted attention for their potential as sources for biodiesel production. These crops exhibit desirable traits, such as high oil content and favorable fatty acid composition, making them viable candidates for the production of eco-friendly fuel [1,2,3]

Canola, commonly known as rapeseed, is a versatile and widely cultivated crop with a significant oil content. Its oil is an excellent biodiesel production feedstock, exhibiting low greenhouse gas emissions and a biodegradable nature. With its remarkable oil yield and potential for reduced carbon footprint, canola biodiesel holds great promise as a renewable energy source [1].

Camelina, also referred to as false flax, is gaining popularity due to its adaptability to diverse growing conditions. This oilseed crop requires minimal water and can flourish in marginal lands, reducing competition with food crops. With its sustainable attributes and high oil content, camelina holds significant potential as a biofuel feedstock, contributing to a greener and more efficient energy landscape [4].

Linseed, known for its fiber and oil content, is recognized for its industrial applications. However, its feasibility as a biodiesel feedstock is now being explored. Linseed oil possesses a favorable fatty acid profile and exhibits high polyunsaturated fatty acid content. These characteristics make linseed biodiesel a promising option that not only offers a renewable and sustainable energy source but also presents favorable engine performance due to its excellent lubricity properties [5,6].

By leveraging the abundant resources and beneficial properties of canola, camelina, and linseed, the production and utilization of biodiesel can be significantly enhanced, reducing our carbon footprint and reliance on finite fossil fuels. This article aims to shed light on the potential of these oilseed crops, highlighting their unique qualities, benefits, and contributions toward a cleaner and more sustainable energy future. Through continued research and development, these biodiesel feedstocks can play a vital role in mitigating climate change and securing a greener and more sustainable planet for future generations.

Experimental

1. Feedstock Acquisition: Canola, camelina, and linseed seeds were procured from local agricultural suppliers. Seeds were selected based on their quality, ensuring high oil content and viability for biodiesel production [1,4,5].
2. Seed Cleaning and Preparation: Seeds were cleaned and rid of impurities using a seed cleaner machine. Any damaged or immature seeds were discarded. The cleaned seeds were then dried to a moisture content suitable for oil extraction [7].
3. Oil Extraction: The cleaned and dried seeds were subjected to oil extraction using an oil press machine. The seeds were crushed to release the oil, and the resulting oil was collected and stored in a suitable container [8].
4. Transesterification Reaction: The collected oil was then processed through transesterification to convert it into biodiesel. Methanol or methanol and a catalyst (such as sodium hydroxide or potassium hydroxide) were added to the oil in the presence of suitable agitation. The reaction was allowed to proceed for a specific duration, and the mixture was subsequently separated into biodiesel and glycerol phases [3,9].
5. Biodiesel Refining: The obtained biodiesel was further refined to remove any remaining impurities or contaminants. This included processes such as washing, drying, and filtration to achieve a high-quality final product [10].
6. Biodiesel Characterization: The produced biodiesel samples were characterized for key parameters, including density, kinematic viscosity, flash point, cetane index, acid value, and oxidation stability. These measurements helped evaluate the fuel quality and its potential application as a substitute for fossil diesel [11].

Reaction of biodiesel production is shown in Figure 1.

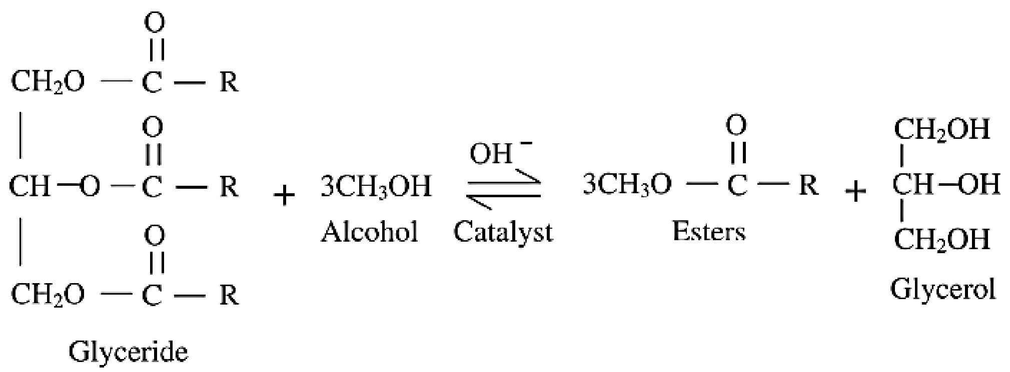

Figure 1. Reaction of biodiesel production [12].

Results and discussion

The findings of this study highlight the potential of canola, camelina, and linseed as biodiesel feedstocks. These oilseed crops possess unique characteristics that make them suitable for biodiesel production, offering a sustainable and renewable alternative to traditional fossil fuels [11,13,14].

With its high oil content and favorable fatty acid composition, Canola can serve as an excellent feedstock for biodiesel production. Its low greenhouse gas emissions and biodegradable nature make canola biodiesel an environmentally friendly option. Moreover, the wide cultivation of canola crops makes it a readily available and economically viable feedstock [11].

On the other hand, Camelina demonstrates promising adaptability to diverse environmental conditions and requires minimal water. Its high oil content and favorable fatty acid profile make it a suitable candidate for biodiesel production. The cultivation of camelina in marginal lands reduces the competition with food crops, making it an attractive option for sustainable biofuel production [4].

Although primarily known for its fiber and oil content, Linseed exhibits a favorable fatty acid profile and high polyunsaturated fatty acid content. These characteristics make linseed biodiesel a promising alternative fuel source. Its unique lubricity properties can contribute to favorable engine performance, ensuring smooth operation and reduced wear and tear [15,16].

Overall, the utilization of canola, camelina, and linseed as biodiesel feedstocks can significantly reduce greenhouse gas emissions, promote energy independence, and create a more sustainable energy future. Additionally, the cultivation of these oilseed crops has the potential to enhance the agricultural sector, providing farmers with diversified income sources and promoting rural development [4,5,11].

Many biodiesel of different types of resources are shown in Table 1.

In this article, many biodiesel are made from rapeseed, camelina, and linseed oil, and some helpful information about them is shown in Table 1.

Type	Conditions	Conclusions and Optimum Conditions
Rapeseed oil [1]	Method of conversion: transesterification, reaction time: 20-180 min reaction temperature: 30-65 °C stirring rate: 0-360 rpm solvent: methanol, molar ratio of methanol to oil: 9:1 catalyst name: γ-Al_2O_3 loaded with KOH and K (K/KOH/ γ-Al_2O_3), catalyst concentration: 0.5-7.0 wt%	Maximum conversion: 84.52% at reaction time: 60 min reaction temperature: 60 °C stirring rate: 270 rpm molar ratio of methanol to oil: 9:1 catalyst concentration: 4 % wt
Camelina oil [2]	Method of conversion: transesterification, reaction time: 4-16 h reaction temperature: 60-120 °C agitation speed: about 1,000 rpm solvent: methanol, molar ratio of methanol to oil: 10-50: 1 catalyst: $Na_{0.1}Ca_{0.9}TiO_3$ Nanorods, catalyst concentration: 1-9 % w/w,	Maximum conversion: 93% at reaction time: 8 h reaction temperature: 60 °C molar ratio of methanol to oil: 36:1 catalyst concentration: 6 %w/w
Linseed oil [3]	Method of conversion: transesterification, reaction time: 60 min reaction temperature: 30 °C stirring rate: 650 rpm co-solvent: Di-ethyl ether, tetrahydrofuran, biodiesel, n-hexane methanol to oil: 4-12, co-solvent to methanol: 0.5-2 catalyst name: CaO, catalyst concentration: 0.3-3 wt.% hydrogel: Absent & Present	Maximum conversion: 98.77% co-solvent: Di-ethyl ether methanol to oil: 9.41:1 co-solvent to methanol: 1.11:1 catalyst concentration: 0.98 wt.% hydrogel: Present
Camelina oil [4]	Method of conversion: non-catalytic transesterification, reaction time: 2- 30 min reaction temperature: 245- 320 °C solvent: ethanol, ethanol to oil molar ratio: 25:1, 35:1, 45:1, 55:1 co-solvent: hexane, molar ratio of co-solvent to oil: 0,0.05, 0.1, 0.2, 0.3 (v/v% of oil)	Maximum conversion: 85% at reaction time: 20 min, reaction temperature: 295 °C, ethanol/oil molar ratio: 45:1, hexane/oil ratio: 0.2 v/v
Linseed oil [5]	Method of conversion: transesterification, reaction time: 50-300 min reaction temperature: 55-70 °C methanol to oil: 3-12:1 catalyst name: TiO_2- $C_4H_5KO_6$ & TiO_2, catalyst concentration: 3-12 wt%, TiO_2 to $C_4H_5KO_6$: 1:0.25, 1:0.5, 1:0.75 and 1:1	Maximum conversion: 98.5% reaction time: 180 min reaction temperature: 60 °C methanol to oil: 6:1 catalyst: TiO_2- $C_4H_5KO_6$ TiO_2 to $C_4H_5KO_6$: 1:0.5 catalyst concentration: 6 wt%
Linseed oil [6]	Method of conversion: transesterification, reaction time: over 180 min reaction temperature: 30 °C co-solvent: diethyl ether (DEE) co-solvent: Absent & Present DEE to methanol: 0.5, 1.25, 1.65, 1.7, 2:1, methanol to oil: 3, 4.82, 7.5, 10.18, 12:1 catalyst name: CaO, catalyst concentration: 160 grams flow rate: 1, 1.2, 1.5, 1.8, 2 ml/min	Maximum conversion: 98.08% co-solvent: DEE, DEE to methanol: 1.19:1 methanol to oil: 9.48:1 flow rate: 1.37 ml/min
Linseed oil [9]	Method of conversion: transesterification, reaction time: 90-150 min reaction temperature: 40-60 °C agitation speed: 600~900 rpm co-solvent: tetrahydrofuran, co-solvent: Absence & Presence, solvent to solid ratio: 1~15 (v/w), co-solvent to solvent ratio: 0.25~2.25 (v/v) catalyst name: KOH, catalyst concentration: 1~13 wt.%	Maximum conversion: 93.15% at reaction time: 90 min reaction temperature: 40 °C agitation speed: 700 rpm solvent to solid ratio: 10 (v/w) co-solvent to solvent ratio: 0.3 (v/v) catalyst concentration: 6.80 wt. %

Camelina oil [13]	Method of conversion: transesterification, reaction time: 25-180 min reaction temperature: 40, 60, 80, 100, 130 °C solvent: methanol, molar ratio of methanol to oil: 3-15:1 catalyst: SrO, CaO, MgO, and BaO, catalyst concentration: 0.25, 0.5, 1, 1.5, and 2 (%w/w of oil)	Maximum conversion: (for BaO, SrO) about 80%, (for CaO) about 30%, (for MgO) about 20% reaction time: for BaO, SrO, CaO, and MgO: 180, 120, 90, and 90 min, at reaction temperatures of 100, 60, 100, and 80 °C, respectively; molar ratio of methanol to oil: (for BaO) 9:1, (for SrO) 12:1, (for CaO and MgO) 15:1 catalyst concentration: for BaO, SrO, CaO, and MgO are 1, 0.5, 0.5, and 1%, respectively
Linseed oil [14]	Method of conversion: transesterification, reaction time: 0-8 min solvent: methanol and ethanol, alcohol to oil molar ratio: 41:1 supercritical temperature: 503 K, 523 K	Maximum conversion: 98% reaction time: 8 min solvent: methanol supercritical temperature: 523 K
Linseed oil [15]	Method of conversion: transesterification, reaction time: 40 min reaction temperature: 40, 50, 60 °C stirring rate: 750 rpm solvent: methanol, methanol to oil molar ratio: 6:1 and 9:1 catalyst name: NaOH, catalyst concentration: 0.5, 1.0 wt.%	Maximum conversion: 95.99% reaction temperature: 60 °C methanol to oil molar ratio: 9:1 catalyst concentration: 0.5 wt.%
Linseed oil [16]	Method of conversion: transesterification, reaction time: 0-300 min reaction temperature: 200, 250, 300, 350°C solvents: methanol and ethanol, alcohol to oil molar ratio: 10-70:1 pressure: 200 bar catalyst name: Novozym 435, enzyme loading: 5-60 mg	Maximum conversion: ≈ 100% reaction time: ≈ 40 min reaction temperature: 350°C solvent: methanol, methanol to oil molar ratio: 40:1 enzyme loading: 10 mg
Rapeseed oil [17]	Method of conversion: transesterification, reaction time: 0.5, 1, 3, 4 h reaction temperature: 50, 55, 60, 65 °C solvent: methanol, methanol to oil molar ratio: 3:1, 5:1, 10:1, 15:1, 20:1, 30:1 catalyst name: CaO, catalyst concentration: 1, 2, 5, 10 %wt	Maximum conversion: 96.1 % at reaction time: 3 h reaction temperature: 65 °C methanol to oil molar ratio: 30:1 catalyst concentration: 5 % wt
Refined rapeseed oil [18]	Method of conversion: noncatalytic transesterification, reaction time: 0, 5, 10, 15, 20 min reaction temperature: 300, 325, 350, 375, 400 °C reaction pressure: 100, 150, 200, 250, 300 bar solvent: methanol, methanol to oil molar ratio: 30, 40, 50, 60, 70: 1 stirring rate: 500 rpm	Maximum conversion: 93.6% at reaction time: 16 min reaction temperature: 313 °C reaction pressure: 250 bar methanol to oil molar ratio: 60: 1

Continued research and development in optimizing cultivation techniques, oil extraction methods, and transesterification reactions will further improve the efficiency and viability of canola, camelina, and linseed biodiesel production. Additionally, exploring the potential of blending these biodiesels with other feedstocks or fossil diesel can offer customized fuel solutions with improved performance and reduced emissions.

Conclusions

Canola, camelina, and linseed are oilseed crops with significant promise as biodiesel feedstocks. Their abundance, advantageous fatty acid profiles, and various environmental benefits make them attractive options for a greener, more sustainable energy future. By harnessing the potential of these crops and investing in further research and development, we can continue to expand the use of biodiesel and reduce our dependence on fossil fuels.

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