Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 251-257, 2, 2024

Araştırma Makalesi

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 251-257, 2, 2024

Research Article

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

Soybean Oil as an Alternative Source of Biodiesel

Rafika HELAIMIA *

Departmentof English, University of Mohamed Cherif Messadia, Soukaharas, Algeria

Email of corresponding author: r.helaimia@univ-soukahras.dz

(Received: 03 March 2024, Accepted: 08 March 2024)

(4th International Conference on Innovative Academic Studies ICIAS 2024, March 12-13, 2024)

ATIF/REFERENCE: Helaıma, R. (2024). Soybean Oil as an Alternative Source of Biodiesel. *International Journal of Advanced Natural Sciences and Engineering Researches, 8(2), 251-257.*

Abstract: The world is fatigued by the devastating consequences of utilizing fossil fuels, which have a detrimental impact on the environment, economy, public policy, and human social interactions. In the pursuit of environmentally friendly alternatives to fossil fuels, various renewable energy sources have emerged. Among these, soybean oil has recently gained attention as a flagship prospect for the most promising energy source of the future. Currently, soybean is being used as a substitute for biodiesel production due to its abundant oil content and renewable nature. With the growing demand for renewable energy sources, soybean has become a viable choice for biodiesel production, providing a sustainable substitute for fossil fuels. The utilization of soybean as a feedstock for biodiesel production has gained popularity in recent years, as it offers a renewable and environmentally friendly solution to reduce greenhouse gas emissions. Consequently, agricultural sustainability will be promoted, and new job opportunities will be created. Soybean biodiesel has been found to exhibit similar performance characteristics to petroleum diesel, making it a practical and efficient alternative for transportation and other diesel-powered applications. This article aims to illuminate the significance of using soybean oil as a novel source of biodiesel by understanding its properties, conversion process, and addressing some challenges in adopting it as a renewable energy source.

Keywords- Soybean Oil, Properties, Coversion Processes, Challenges.

I. INTRODUCTION

A new trend has emerged in which crops are being utilized to produce fuel instead of fossil fuels. This shift is due to the environmental degradation caused by the use of fossil fuels, as they are becoming increasingly scarce and expensive. Bioenergy sources like soybeans, wheat, corn, and sugarcane can serve as alternatives to fossil fuels in oil production, particularly for biodiesel. Biodiesel is an effective substitute for compression-ignition engines, made from monoalkyl esters of long-chain fatty acids sourced from renewable feedstocks such as vegetable oils or animal fats. Soybeans, a widely grown crop globally, can be processed into biodiesel through methods like transesterification. This transition can help reduce reliance on fossil fuels and foster a sustainable future. Soybeans are renowned for their high oil and protein content, with global production reaching 340 million tons in 2017, primarily from America, Brazil, and Argentina. Additionally, 56 million tons of soybean oil were produced worldwide. Soybeans

contain polyunsaturated components that offer health benefits like lowering blood lipid levels, preventing blood clots, and enhancing immunity. Furthermore, soybean cultivation supports sustainable agricultural practices.

II. DEFINITION AND POPERTIES OF SOYBEANS

A significant crop in most of North America, South America, and Asia is soybean (Glycine max). With about 32% of the world's total production, the United States leads the world in soybean production, followed by Brazil with 28%.(3)

Soybeans were first domesticated in China around the eleventh century BC and originated in Southeast Asia. They were first planted in the United States in 1765 and by the mid-1800s, they had spread to the Corn Belt. However, their largest acreage was not observed until the 1920s when they were primarily grown for fodder (4).

Soybeans have a lower oil content compared to other oilseed crops like canola (40%) and sunflower (43%), containing only 18% to 20% oil (5). Soybean meal, which is used for both human and animal feed, is still one of the main products made from soybeans, weighing 48 pounds per bushel. Nowadays, soybean oil is one of the main feedstocks used to produce biodiesel (6).

Between MY 2010-2011 and MY 2017-2018, the total supply of soybean oil in the United States increased from approximately 22.5 billion pounds to nearly 26.0 billion pounds. As a result, the amount of soybean oil used as a feedstock for biodiesel more than doubled, from around 15% to 30%. Soybean oil, along with other vegetable oils, can also be used as a feedstock for renewable diesel, which is being produced more frequently in petroleum refineries and standalone plants(7)

Soybeans are versatile crops that can be used to produce both ethanol and biodiesel (8). However, due to their high protein content, soybean hulls are usually preferred as animal feed. Nevertheless, soybean hulls still contain significant carbohydrates that can be used in the production of ethanol (9). Although biodiesel is usually blended with petro-diesel in different proportions, it can also be used as a standalone fuel source for compression ignition engines. Furthermore, engine emission tests have shown that using biodiesel alone results in lower emissions of smoke, CO, HC, and NOx compared to petro-diesel (10), according to Qi et al.'s findings in 2009.

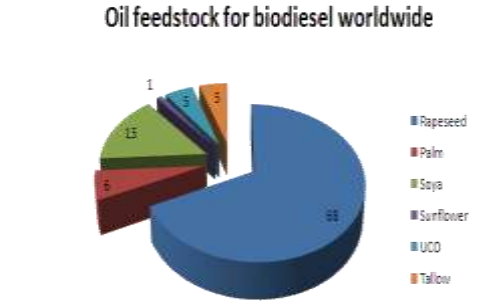

Fig.1Global Biodiesel oil feedstock (27)

III. METHODS OF CONVERTING SOYBEAN OIL TO BIODIESEL

These days, diesel can be blended with vegetable oil, especially soibean oil, by utilizing a variety of techniques to lower their viscosity (21).

The two primary methods have been used by researchers to extract biodiesel from soybeans: the mechanical extraction method and the chemical extraction method. While the second one concentrates on using solvent, the first one is based on using screw presses.(to be improved)

Mechanical Extraction Process :

Mechanical pressing of oil seeds is a popular technique for extracting oil worldwide (8). In mechanical extraction, 80-95% of the oil is recovered by applying force to extract the oil from the seeds . To prepare the soybeans for extraction, the most effective method involves using a high-shear dry extrusion process (11). This process involves heating, drying, and shearing the oilseeds using equipment such as the Anderson DoxTM Extruder, which eliminates hazardous enzymes and improves the proteins' effectiveness for pressing.Using an extruder is an effective method of supplying heat for enzyme neutralization. Extruders apply sufficient pressure and heat to render enzymes inactive on seeds.(12). Researchers have determined a high-temperature dry extruder to extract protein and oil. They found that higher extruder pressure enhanced the solubility of proteins in soybean oil (13).

Once the soybeans are prepared, they are ready to be used for extraction.oilseeds are fed into a screw press, such as the Anderson Oil Expeller®, where pressure and friction crush the seed material to extract the fats and solids (11).

Mechanical extraction has several advantages, which include the following (11) :

• It requires a lower initial investment, making it ideal for facilities that handle less than 1,000 tons per day.

• Chemical-free processing produces safer and higher-value products.

• It is easier to handle, but there are more oil losses, typically around 5-8%.

Fig.2 The process of extracting oil from soybeans to produce biodiesel (11).

Chemical Extraction :

IV. SOLVENT EXTRACTION PROCESS

Solvent extraction is a commonly used method in commercial soybean oil production to separate the oil from the soybean meal. During the preparation process, the soybeans are flaked to create a large surface area for the solvent extraction process. In this process, a solvent (typically hexane) is pumped through the soybean flakes to dissolve the oil in the solvent, resulting in the separation of 99.5% of the oil from the meal. Following extraction, the hexane is recycled for future use (14). Soybeans are typically processed for solvent extraction using a machine like the Anderson SolvexTM. This process is similar to preparing seeds for the Expeller by the Dox Extruder. However, the Solvex uses steam to cook the oilseeds instead of friction. The moisture inside the seeds expands due to a sudden pressure drop, creating soybean collets. These porous materials can be extracted more efficiently (11).

Fig.3 Process flow chart for extracting soybean oil using a solvent extraction method (23)

V. ELECTRIC FIELD EXTRACTION PROCESS

Producing biodiesel from soybean oil can be also done by applying the elctric field process. It has been discovered that NaCl salts can speed up the process of separating biodiesel and glycerin blends by causing gravity sedimentation (15). In addition to this, electrostatic techniques like field electrodes and fixed distance electrodes can also improve the process of glycerin transesterification in mixtures of biodiesel and glycerin. The yield of biodiesel can be increased by using the AC barrier discharge technique, which lowers the surface tension between alcohol and triglycerides(16) (17). Yongphet et al. employed the Response Surface Methodology to assess the impact of transesterification response on reaction parameters in the presence of electric fields (19). The most recent study explores the use of an electric field to increase the efficiency of separating glycerol-methyl esters in biodiesel and accelerate the transesterification process. It examines biodiesel samples post-purification, determines the kinetics of the transesterification reaction, and investigates how the strength of the electric field impacts the efficiency of the reaction and separation. The findings from this study will be utilized to develop technology for the cost-effective production of biodiesel (20).

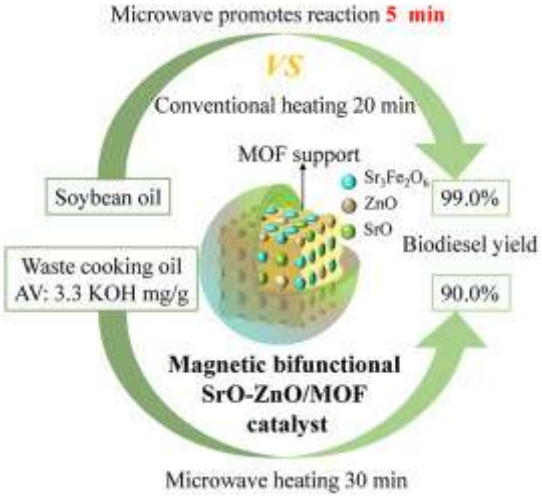

Fig.4 Soybean oil microwave heation process to produce biodiesel (24)

VI. SUPERCRITICAL FLUID EXTRACTION PROCESS

A new technique for extracting oil and isoflavones from soybeans involves the use of supercritical carbon dioxide (Mendes et al., 2002). Zaidul et al. (2007) used supercritical carbon dioxide (SC-CO2) to extract oil from palm kernels. Salgin (2007) extracted oil from jojoba oilseeds using a mixture of supercritical CO2 and supercritical ethanol, which increased the rate of oil extraction. Temperature and pressure were the two primary factors that influenced supercritical fluid extraction (SalgIn, 2007). In 2008, Kao and colleagues compared solvent extraction and supercritical carbon dioxide extraction and found that the latter produced more oil. Supercritical fluid extraction (SFE) is a popular green extraction technique nowadays, owing to its numerous benefits over traditional extraction methods. SFE's widespread adoption can be largely traced to its improved selectivity, higher yield, better fractionation capabilities, and reduced environmental impact(25).

VII. CHALLENGES

Although soybean crops, particularly soybean oil, are a valuable source of energy and nutrition, they face various challenges that require practical solutions. Like other crops, soybeans are vulnerable to weather-related problems, pests such as insects, and diseases. In recent times, there has been growing concern about a new disease caused by a fungus called soybean rust. This disease, which originated in Asia, has spread to South American soybean fields and eventually to American soybeans. Controlling rust can be expensive since it requires the use of fungicides that can significantly reduce yields. Moreover, the cost of producing soybeans can vary depending on the location, cropping system, and fluctuations in energy prices. Soybean production involves significant expenses such as seed, pesticides, planting, and harvesting. A rain-fed budget example for no-till soybeans in Nebraska in 2010 indicates that $115 per acre will be spent on field operations, supplies, and services. In addition, Soybean oil is widely used in various industries, including cooking oil, human food products, and industrial applications. In the US, at least 80% of the edible fats and oils come from soybeans. However, the increasing demand for soybean oil in various industries has made it challenging to use soybeans for biodiesel production. This competition has led to price increases in the soybean oil market, which has negatively impacted the profitability of soybean biodiesel. Wisner noted this concern in 2009 (3). Futhermore, There are a few challenges that make it difficult to produce biodiesel profitably, despite the increase in the price of diesel fuel. Firstly, the cost of feedstocks derived from reagent methanol and soybean oil has gone up. Secondly, the supply of feedstocks is scattered, making it hard to achieve economies of scale. Thirdly, the processing conditions require higher temperatures and pressures than ambient. To meet the ASTM specification D6751 limits for contaminants, several processing steps are necessary (26).

VIII. CONCLUSION

In conclusion, while soybean has already shown promise as a feedstock for biodiesel production, further comprehensive research is warranted to fully unlock its potential. By optimizing cultivation and processing techniques, assessing environmental impacts, and evaluating economic feasibility, soybean can play a crucial role in meeting the increasing demand for renewable energy.One area of research that should be prioritized is developing soybean cultivars with higher oil content and improved fatty acid profiles, researchers can enhance the efficiency and quality of biodiesel production. Additionally, efforts should be made to enhance the tolerance of soybean plants to various environmental stresses, such as drought and pests, to ensure consistent and reliable yields.Furthermore, research should be conducted to optimize the cultivation practices of soybean, including the use of sustainable agricultural techniques. This includes exploring the potential of intercropping and crop rotation systems to improve soil health and reduce the need for synthetic fertilizers and pesticides. Additionally, the use of precision agriculture technologies, such as remote sensing and variable rate application, can help optimize resource use and minimize environmental impacts.In terms of processing techniques, further research is needed to develop more efficient and environmentally friendly methods for extracting oil from soybeans. This includes exploring alternative extraction methods, such as supercritical fluid extraction and enzymatic extraction, which can reduce energy consumption and solvent usage. Additionally, research should focus on developing innovative methods for converting soybean oil into biodiesel, such as enzymatic transesterification and microbial fermentation, which can improve the overall efficiency and sustainability of the biodiesel production process. Moreover, comprehensive life cycle assessments should be conducted to evaluate the environmental impact of soybean-based biodiesel production. This includes assessing the greenhouse gas emissions, energy consumption, and water usage associated with soybean cultivation, processing, and distribution. By identifying potential environmental hotspots and implementing mitigation strategies, the sustainability of soybean-based biodiesel production can be further improved. Lastly, economic feasibility studies should be conducted to assess the cost-effectiveness of soybean-based biodiesel production. This includes evaluating the profitability of soybean cultivation and processing, as well as analyzing the market demand and potential for biodiesel. By identifying potential barriers and incentives, policymakers and industry stakeholders can make informed decisions to support the growth of the soybean biodiesel industry.

REFERENCES

1. Sujan, S.A., S. Hirata and T. Minowa, (2009). An approach to produce biodiesel from non-edible Jatropha curcus oil through dual step process: Pre-esterification and transesterification. Bangladesh J. Sci. Ind. Res., 44, 347-352.
2. Weibin Konga , Jan Baeyensb , Kjerstin De Winterc , Andrés Reyes Urrutiad , Jan Degrèvec , Huili Zhanga, (2019). An energy-friendly alternative in the large-scale production of soybean oil, Journal of Environmental Management.
3. https://farm-energy.extension.org/soybeans-for-biodiesel-production/FARM-ENERGY, , APRIL 3, 2019.
4. Gibson L. and Benson G., (2005), Origin, History, and Uses of Soybeans (*Glycine max*), Iowa State University, Department of Agronomy, http://www.agron.iastate.edu.
5. Berglund D.R., McKay K., Knodel J., (2007), Canola Production, North Dakota State University, A-686 revised August 2007.
6. National Biodiesel Board (NBB), http://biodiesel.org.
7. https://www.eia.gov/todayinenergy/detail.php?id=39372, Soybean oil comprises a larger share of domestic biodiesel production,2019
8. A. Bulent Koc, Mudhafer Abdullah and Mohammad Fereidouni, (2011). Soybeans Processing for Biodiesel Production, Source: InTech,2011, uploaded by Daniel Fereidouni on 20 March 2014
9. Mielenz, J.R., Bardsley, J.S., Wyman, C.E., (2009). Fermentation of soybean hulls to ethanol while preserving protein value. Bioresource Technology, 100(14), 3532-3539.

10. Qi, D.H., Geng, L.M., Chen, H., Bian, Y.Z., Liu, J., Ren, X.C,(2009). Combustion and performance evaluation of a diesel engine fueled with biodiesel produced from soybean crude oil. Renewable Energy, 34(12), 2706-2713.
11. https://www.andersonintl.com/exploring-the-potential-for-soybean-biodiesel/, OCTOBER 1, 2021
12. Gerpen, J.V., B. Shanks, R. Pruszko, D. Clements, Knothe, G., (2002). Biodiesel Production Techonlogy, National Renewable Energy Laboratory.
13. Jung, S., Mahfuz, A.A.,(2009). Low temperature dry extrusion and high-pressure processing prior to enzyme-assisted aqueous extraction of full fat soybean flakes. Food Chemistry 114, 947-954.
14. https://patents.google.com/patent/US7579492B2/en, Two-stage extraction of soybean oil, accessed on 12/12/2023
15. M.M.A. Shirazi , A. Kargari, M. Tabatabaei, B. Mostafaei, M. Akia, M. Barkhi, M.J.A. Shirazi,(2014). Separation of biodiesel-glycerol through NaCl-assisted gravitational settling, The 8 thInternational Chemical Engineering Congress& Exhibition (IChEC 2014) Kish,Iran, 24-27February, 2014
16. Susumu , Rusdianasari , Syahirman Yusi,(2018). Biodiesel Production from Waste Cooking Oil using Electrostatic Method, Indonesian Journal of Fundamental and Applied Chemistry.
17. Abbaszaadeh A., Ghobadian B., Reza M.O. and Najafi G., (2012). Current biodiesel production technologies: A comparative review. Energy Conversion and Management. Vol. 63, Nov. 2012, Pag. 138-148.
18. **:**
    Piyaphong Yongphet, Junfeng Wang, Wang Dongbao, (2021).Optimization of operation conditions for biodiesel preparation from soybean oil using an electric field, biomass conversion and biorefinery, published by Spronger Nature, 2021
19. Piyaphong Yongphet , Junfeng Wang , Tanongkiat Kiatsiriroat , Dongbao Wang , Thoranis Deethayat , Evans K. Quaye, Wei Zhang , Shijie Yang, (2020).Enhancement of biodiesel production from soybean oil by electric field and its chemical kinetics, Chemical Engineering and Processing - Process Intensification
20. T
21. Gerhard K, Jon VG, Jurgen K. *The Biodiesel Handbook*, (2005).AOCS Press: Champaign, IL, USA, .Search in Google Scholar
22. Dung Hoang , Samir Bensaid , Guido Saracco,(2013). Supercritical fluid technology in biodiesel production, Green Processing and Synthesis,.
23. https://www.doingoilmachine.com/FAQ/manufacture_soybean_oil_by_solvent_extraction_method_806.html,,2019.
24. Jian Yang , Wen-jie Cong, Zongyuan Zhu, Zheng-diao Miao, Yi-Tong Wang, Michael Nelles, Zhen Fang,(2023), Microwave-assisted one-step production of biodiesel from waste cooking oil by magnetic bifunctional SrO–ZnO/MOF catalyst, Journal of Cleaner ProductionVolume 395, 1 April 2023, 136182.
25. A.P. Sánchez-Camargo, M. Herrero, (2014). in Reference Module in Chemistry, Molecular Sciences and Chemical Engineering.
26. Vasudevan, P. T. & Briggs, M. (2008). Biodiesel production – current state of the art and challenges. Journal of Industrial Microbiology and Biotechnology, Vol. 35, No. 5, pp. (421-430), 1367-5435.
27. https://www.eubia.org/cms/wiki-biomass/biofuels/biodiesel/.