An Application of the Bibliometric Method to Analyze Research Development of Biodiesel

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Abstract

The current problem faced by Indonesia in the energy sector is the decline in oil reserves and production. It is aggravated by the increase in oil demand. Meanwhile, interest in using biodiesel from renewable energy sources continues to increase. In the last decade, the number of publications on this topic has shown an increase. This study aims to observe the research development of the conversion of vegetable raw materials into biodiesel fuel. In this study, the researchers conducted a bibliometric analysis of various publications on biodiesel to obtain information regarding the direction of research development and the novelty of studies addressing this topic. In total, the researchers collected and analyzed 679 relevant works of literature published between 2012 and 2022 from the Google Scholar database. The keywords used in the search were "biodiesel", "rapeseed", "corn", "cottonseed", "sunflower", "soybean", "sesame", and "coconut". Furthermore, the researchers employed Harzing's Publish or Perish and VOSviewer as tools to collect and analyze publications with the aforementioned keywords. The results showed that, from 679 publications related to biodiesel, the words with the highest frequency of occurrence were "Masjuki", "Sunflower Oil", and "USA" as the author, topic, and country, respectively. Based on the year of publication, the discussion of observing the properties of biofuel and vegetable oils is a relatively new issue. In addition, the number of papers discussing biodiesel tends to increase.

Keywords: Bibliometric Analysis; Biodiesel; Renewable Energy; Vegetable Oil; Research Development

1. Introduction

Biodiesel has several advantages over petroleum fuels. Biodiesel is a renewable energy that is clean from sulfur, is sufficient in quantity, has a relatively easier manufacturing process, and reduces greenhouse gas emissions (Tayari et al., 2020; Maheshwari et al., 2022). Biodiesel raw materials can be obtained from vegetable oils and animal fats (Putri & Supriyo, 2020). Raw materials from vegetable oils can be derived from soybeans (Koc et al., 2011; Pratigto et al., 2019; Colombo et al., 2019), corn (El Boulifi et al., 2010; Veljkovića et al., 2018), mustard (Alam & Rahman, 2013; Rana et al., 2019), jatropha (Mofijur et al., 2012; Folaranmi, 2013), rapeseed (Solis et al., 2017; Dworakowska et al., 2013), sesame (Ferdous et al., 2012; Dawodu et al., 2014), castor beans (Keera et al., 2018; González et al., 2020), cottonseed (Nabi et al., 2009; Sinha & Murugavelh, 2016), neem (Ali et al., 2013; Madai et al., 2020), algae (Scott et al. 2010; Medipally et al., 2015), coconut (Hossain et al., 2012; Rasyid et al., 2018), and peanuts (Oniya & Bamgboye, 2014; Habibullah et al., 2015).

The manufacture of oil from vegetable raw materials requires pre-treatment, extraction, and purification as illustrated in Figure 1. The pre-treatment includes cleaning, drying, stripping, and milling processes (Koc et al., 2011). In addition, the extraction steps may need mechanical compressors, solvents, supercritical fluids, microwave-assisted tools, and/or ultrasound-assisted devices (Koc et al., 2011).

After extraction, a purification step is required. There are several different purification methods in this step, such as mechanical purification (i.e., separation, filtration, or centrifugation), chemical purification (i.e., degumming, neutralization, or bleaching), and physical purification (i.e., drying or heating). The presence of phospholipids is removed by a degumming process, namely the addition of hydrating agents, precipitation, and sedimentation. After that, the removal of fatty acids is carried out by a neutralization process. Moreover, the bleaching step is conducted to remove the color. Furthermore, the clay is separated by centrifugation. To remove moisture, we carry out the drying or heating process (Schmutzler, 1993; Li et al., 2014; González et al., 2020).

Figure 2 shows a general biodiesel production scheme. Three important elements needed to make biodiesel are vegetable oil, alcohol, and catalyst. The alcohols used are methanol (Putri & Supriyo, 2020; Tayari et al., 2020; Habibullah et al., 2015), butanol, ethanol, propanol, and amyl alcohol (Koc et al., 2011). Meanwhile, the catalysts used are CaO (Putri & Supriyo, 2020), KOH (Tayari et al., 2020), NaOH, and H2SO4 (Habibullah et al., 2015). A catalyst is needed to trigger the reaction between oil and alcohol (Britannica, 2022).

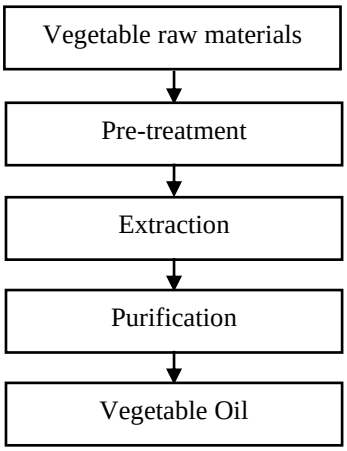

Fig. 1. The process of making vegetable oil

Four methods can be used for the reaction, namely pyrolysis, dilution with mixed hydrocarbons, microemulsion, and transesterification (Tweddell et al., 1998; Shimada et al., 1999; Watanabe et al., 2002). Transesterification is a method commonly used to produce biodiesel from vegetable oils. Principally, this transesterification process aims to convert (tri, di, mono) glycerides contained in vegetable raw materials into methyl esters or alkyl esters of fatty acids (biodiesel) and glycerol (Suleman et al., 2019). In this process, the oil and alcohol react with each other for 15 minutes to two hours at an ambient temperature of 50-75°C (Chitra et al., 2005; Tayari et al., 2020; Putri & Supriyo, 2020). The by-product of the transesterification process is glycerol. In this process, biodiesel is separated from glycerol by gravity or centrifugation (Ramadhas et al., 2005; El-Mashad et al., 2008).

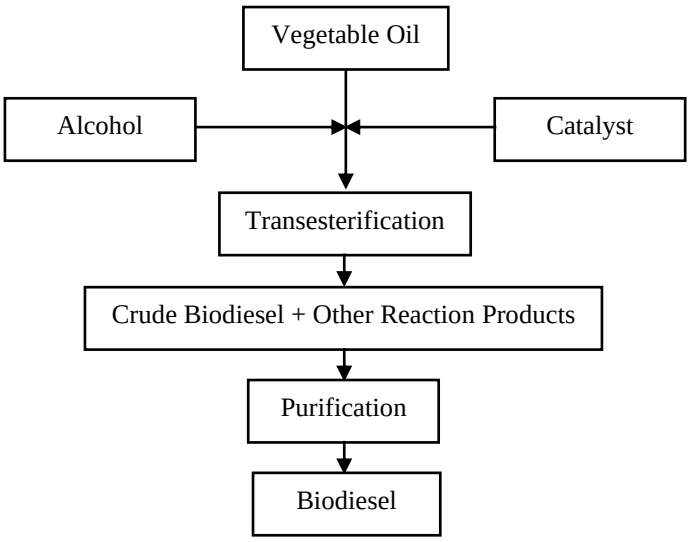

Fig. 2. The process of making biodiesel

The increase in science and technology intensively encourages scientists to examine the current direction of research development in certain fields of science, such as biodiesel or briquettes. The study of research trends may allow researchers to inspire themselves with the latest findings, compare the scope of research, and observe trends for future research. Bibliometric analysis can be used in analyzing research trends (Nugraha et al., 2022). In this study, the researchers applied a bibliometric approach to analyze the available works of literature on biodiesel technology at Google Scholar. Those works were published from January 2012 to December 2021. In addition, this analysis particularly emphasized biodiesel from vegetable raw materials.

2. Methods

The researchers used Harzing's Publish or Perish software for gathering articles addressing the topic of biodiesel. The keywords used in the search were "biodiesel", "rapeseed", "corn", "cottonseed", "sunflower", "soybean", "sesame" and "coconut". In total, the researchers successfully collected 679 relevant works of literature published between 2012 and 2022 from the Google Scholar database. Furthermore, the researchers employed VOSviewer software to map the obtained articles. Mapping was made based on keywords and things related to keywords. In addition, mapping was also carried out based on the author of the literature. The resulting keyword map was based on co-occurrence to position nodes (in this case: the appropriate keywords) on the map. The researchers also utilized Microsoft Excel for mapping the year of publication for both individual and whole keywords.

3. Results and Discussion

3.1. The bibliometric analysis of number of publications

A total of 1000 publications on the theme of biodiesel with the raw materials of rapeseed, corn, cottonseed, sunflower, soybean, sesame, and coconut have been identified in the Google Scholar database. Those publications are published from 2012 to 2021 in article forms, including original research articles, review articles, and editorials. All publications are written in English. 679 out of 1000 were selected as the most related to the topic of rice husk-based briquette. The publications were taken in RIS format for further analysis using VOSviewer.

3.2. The bibliometric analysis of names of authors

The author's name written in the papers and appearing more than 5 times in the Google Scholar database was registered in the analysis. Of the 2290 article authors, 15 met the threshold. Based on association strength settings, the author's name that appears the most is "Masjuki" with 19 documents and a total link strength of 15 as shown in Table 1. The author has a strong relationship with the writers named "Kalam", "Mamat", and "Mofijur" as shown in Figure 3. In the same figure, we can see that the author named "Rasul" is connected with the authors named "Mamat" and "Mofijur". Meanwhile, the author named "Aswath" is connected with "Rasul". In Table 1, it can be seen that these authors are the six authors with the most articles. In this case, it can be said that these six authors with the most articles are related either directly or indirectly.

Table 1. Names of authors appearing more than 5 times

Selected	Author	Documents	Total link strength
☑	masjuki, hh	19	15
☑	kalam, ma	13	14
☑	mofijur, m	6	7
☑	rasul, mg	9	7
☑	mamat, r	7	3
☑	ashwath, n	5	2
☑	demirbas, a	5	0
☑	dunn, ro	6	0
☑	giakoumis, eg	6	0
☑	gunstone, fd	7	0
☑	ilkilic, c	5	0
☑	ingle, ap	5	0
☑	marchetti, jm	5	0
☑	romano, sd	5	0
☑	sharma, mp	5	0

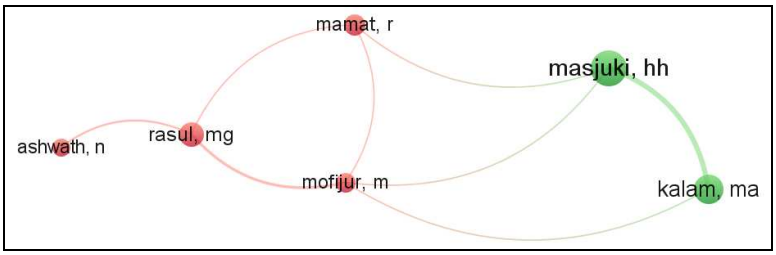

Fig. 3. A bibliometric analysis of names of authors by the number of documents with linked authors

Table 2. Keywords appearing more than 10 times

Selected	Term	Occurrences	Relevance
☑	sunflower oil	304	0.20
☑	soybean oil	296	0.20
☑	rapeseed oil	194	0.16
☑	corn oil	173	0.12
☑	fuel	124	0.11
☑	peanut	107	0.37
☑	blend	79	0.68
☑	crop	78	2.07
☑	transesterification	70	0.64
☑	safflower	65	0.36
☑	effect	61	0.26
☑	performance	60	0.89
☑	methyl ester	55	0.34
☑	diesel	54	0.78
☑	coconut oil	51	0.30
☑	cotton	42	1.18
☑	soy	42	0.86
☑	diesel engine	42	0.70
☑	emission	41	0.84
☑	catalyst	39	0.49
☑	lipase	37	1.12

3.3. The bibliometric analysis of keywords

Keywords provided by the authors of the papers and appearing more than 10 times in the Google Scholar database were registered in the analysis. of 3860 keywords, 141 met the threshold. The number of mentions of these 141 keywords was then counted and sorted. By limiting 60% of the most relevant terms, we got 85 keywords as shown in Table 2. Based on Table 2, the keywords that appear the most are “sunflower”, “soybean oil”, “rapeseed oil”, “corn oil”, and “fuel” with the number of occurrences of 304, 296, 194, 173, and 124, respectively.

Figure 4 shows that the keywords that appear are grouped into five clusters. Cluster #1 has 26 keywords, represents characters for various types of biodiesels, and is colored red. Cluster #2 has 24 keywords, represents the relationship between physical properties and raw materials of biodiesel, and is colored green. Cluster #3 has 19 keywords, represents the evaluation of biodiesel production, and is colored blue. Cluster #4 has 8 keywords, covers various herbal oils, and is colored yellow. Finally, Cluster #5 has 8 items, discusses the manufacture of biodiesel by transesterification process with methanol and a catalyst, and is colored purple.

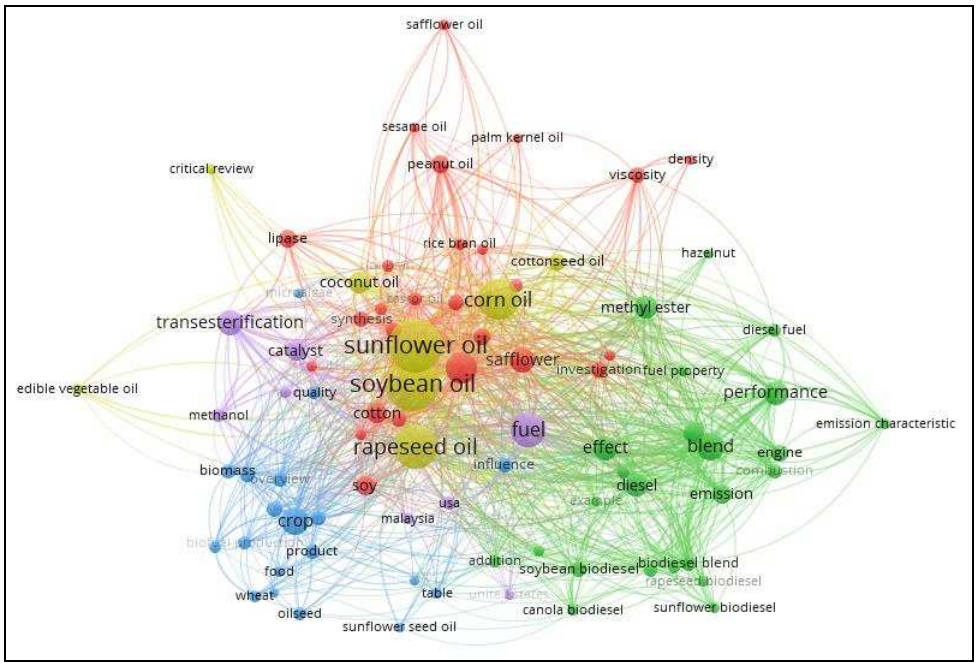

Fig. 4. A bibliometric analysis of themes by the number of occurrences and the relationship between themes

3.4. The bibliometric analysis of country

Table 3 shows the names of the countries listed in the titles and abstracts of the analyzed articles. The 10 names of countries with the most articles sequentially are the United States, Malaysia, Brazil, Turkey, Iran,

Canada, Indonesia, Italy, India, and Nigeria. This number does not necessarily indicate the number of publications from each of these countries. This is possible because not every article mentions the name of the country.

3.5. The bibliometric analysis of publication development

Figure 5 shows the number of publications on biodiesel from 2012 to 2022. As seen in the figure, the number of publications fluctuates. However, the number of publications tends to increase in that period. Figure 6 shows the theme of publication between 2013 and 2016. Based on the year of publication, it can be seen that the discussion on observing the properties of biofuels and vegetable oils has become a relatively recent topic.

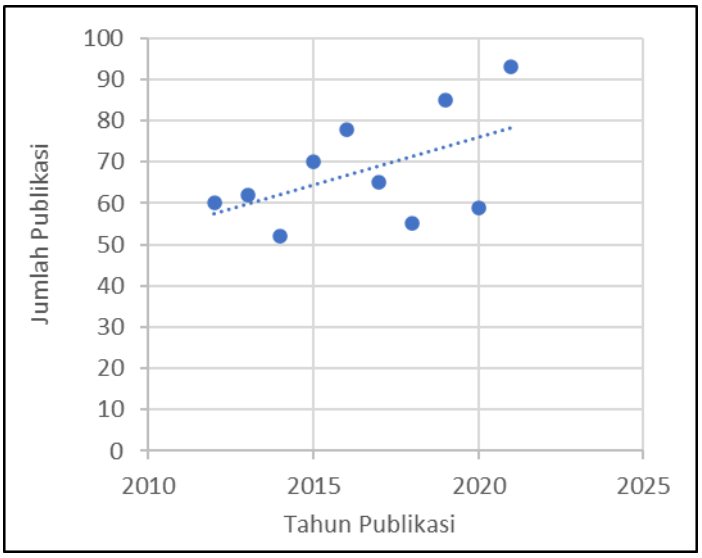

Fig. 5. Years of publication of articles related to biodiesel

3.6. The bibliometric analysis of country

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3.7. The bibliometric analysis of publication development

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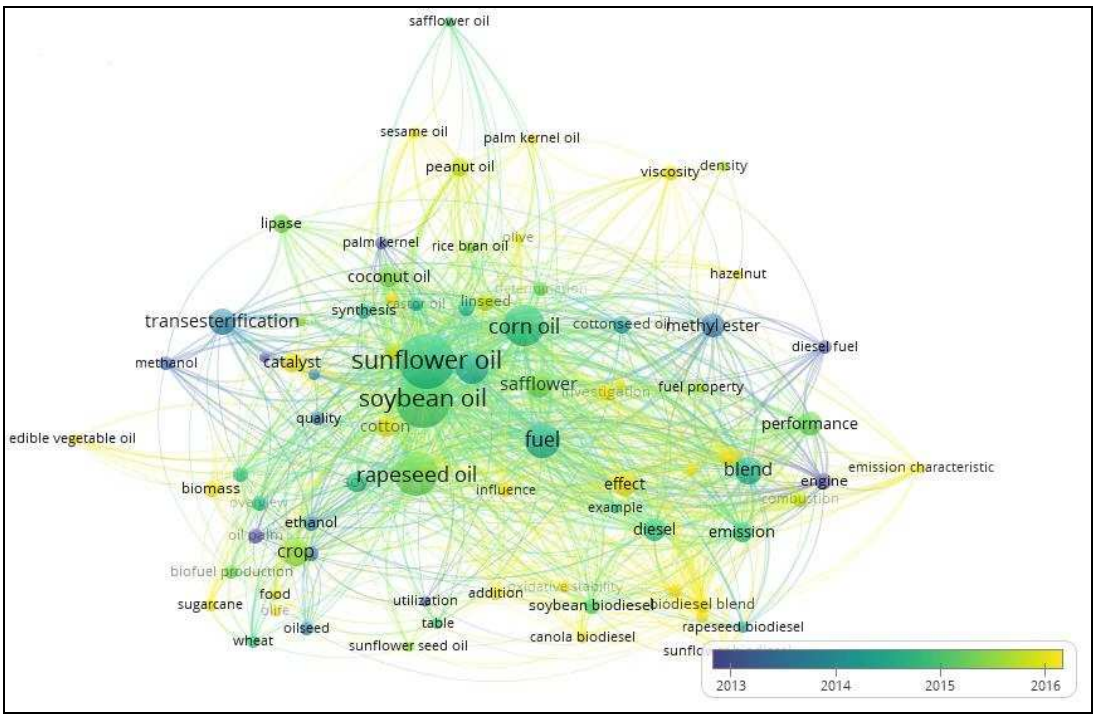

Fig. 6. A bibliometric analysis of themes by year of publication

4. Conclusion

Studies on biodiesel have been widely carried out and published in the last decade. In this study, the researchers conducted a bibliometric analysis to review the research development of biodiesel from vegetable oil. The papers observed in this study were published between 2012 and 2021 and taken from the Google Scholar database. In this study, the researchers attempted to illustrate the relationship among those works of literature. Based on the bibliometric analysis on 679 relevant articles, the words with the highest frequency of occurrence were “Masjuki”, “Sunflower Oil”, and “USA” as the author, topic, and country, respectively. In addition, based on the year of publication, we may see that the number of research publications addressing

this topic over the past decade has increased. Furthermore, the theme of observing the properties of biofuels and vegetable oils has become a relatively new issue.

References

Tayari, S., Abedi, R., & Rahi, A. 2020. Comparative assessment of engine performance and emissions fuelled with three different biodiesel generations. Renewable Energy 147, part 1, pp. 1058-1069. https://doi.org/10.1016/j.renene.2019.09.068

Maheshwari, P., Haider, M.B., Yusuf, M., Klemeš, J.J., Bokhari, A., Beg, M., Al-Othman, A., Kumara, R., & Jaiswal, A.K. 2022. A review on latest trends in cleaner biodiesel production: Role of feedstock, production methods, and catalysts. Journal of Cleaner Production, Volume 355, 131588, https://doi.org/10.1016/j.jclepro.2022.131588

Habibullah, M., Masjuki, H.H., Kalam, M.A., Rahman, S.M.A., Mofijur, M., Mobarak, H.M., & Ashraful, A.M. 2015. Potential of biodiesel as a renewable energy source in Bangladesh. Renewable and Sustainable Energy Reviews, 50, pp. 819–834

Putri, P.C.E. dan Supriyo, E. 2020. Transesterifikasi Minyak Kelapa Sawit menggunakan Katalis Kalsium Oksida (CaO) menjadi Biodiesel. Metana: Media Komunikasi Rekayasa Proses dan Teknologi Tepat Guna, Desember 2020 Vol. 16(2), pp. 75-80.

Pratigto, S., Istadi, & Wardhani, D.H. 2019. Karakterisasi Katalis CaO dan Uji Aktivitas pada Kinetika Reaksi Transesterifikasi Minyak Kedelai. Metana: Media Komunikasi Rekayasa Proses dan Teknologi Tepat Guna. Desember 2019 Vol. 15(2):57-64.

Colombo, K., Ender, L., Santos, M.M., Baros, A.A.C. 2019. Production of biodiesel from Soybean Oil and Methanol, catalyzed by calcium oxide in a recycle reactor. South African Journal of Chemical Engineering. Volume 28, April 2019, pp. 19-25.

Koc, A.B., Abdullah, M. and Fereidouni, M. 2011. Soybeans Processing for Biodiesel Production. In book: Soybean - Applications and Technology. ed. Tzi-Bun Ng. IntechOpen ltd., London.

Alam, M.M. and Rahman, K.A. 2013. Biodiesel from Mustard oil: a Sustainable Engine Fuel Substitute for Bangladesh. Int. Journal of Renewable Energy Development 2 (3) 2013: 141-149.

Rana, Q.U.A., Irfan, M., Ahmed, S., Hasan, F., Shah, A.A., Khan, S., Ur Rehman, F., Khan, H., Ju, M., Li, W. & Badshah, M. 2019. Bio-catalytic transesterification of mustard oil for biodiesel production. Biofuels, Vol. 13, No. 1, pp. 1-8. https://doi.org/10.1080/ 17597269.2019. 1655907

Mofijur, M., Masjuki, H.H., Kalam, M.A., Hazrat, M.A., Liaquat, A.M., Shahabuddin, M., & Varman, M. 2012. Prospects of biodiesel from Jatropha in Malaysia. Renewable and Sustainable Energy Reviews,16 (2012), pp. 5007–5020. https://doi.org/10.1016/j.rser. 2012.05.010

Folaranmi, J. 2013. Production of Biodiesel (B100) from Jatropha Oil Using Sodium Hydroxide as Catalyst. Journal of Petroleum Engineering, Vol. 2013, No. 956479, pp. 1-6. http://dx.doi.org/10.1155/2013/956479

Solis, J.L., Berkemar, A.L., Alejo, L. & Kiros, Y. 2017. Biodiesel from rapeseed oil (Brassica napus) by supported Li2O and MgO. International Journal of Energy Environmental Engineering, Vol 8, pp. 9–23.

Dworakowska, S., Bednarz, S. & Bogdal, D. 2013. Production of biodiesel from rapeseed oil. 1st World Sustainability Forum, 1-30 November 2011, Basel, Switzerland.

Ferdous, K. Uddin, M.R., Khan, M.R., & Islam, M. A. 2012. Biodiesel from Sesame Oil: Base Catalyzed Transesterification. International Journal of Engineering and Technology, 1 (4) (2012) 420-431. DOI: 10.14419/ijet.v1i4.335

Dawodu, F.A., Ayodele, O.O., & Bolanle-Ojo, T. 2014. Biodiesel production from Sesamum indicum L. seed oil: An optimization study, Egyptian Journal of Petroleum, Vol. 23, No. 2, pp. 191-199. https://doi.org/10.1016/ j.ejpe.2014.05.006

Keera, S.T., El Sabagh, S.M., & Taman, A.R. 2018. Castor oil biodiesel production and optimization. Egyptian Journal of Petroleum, Vol. 27, No. 4, pp 979-984. https://doi.org/10.1016/j.ejpe.2018.02.007

González, C.S.O, Falcon, N.G., Salas, F.S., Saini, R., Brar, S.K., and Ramírez, A.A. 2020. Production of Biodiesel from Castor Oil: A Review. Energies, Vol. 13, No. 2467, pp. 1-22. doi:10.3390/en13102467

Nabi, M.N., Rahman, M.M., Akhter, M.S. 2009. Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions. Applied Thermal Engineering, Vol. 29, No. 11–12, pp. 2265-2270. https://doi.org/ 10.1016/j.applthermaleng.2008.11.009

Sinha, D. & Murugavelh, S. 2016. Biodiesel production from waste cotton seed oil using low cost catalyst: Engine performance and emission characteristics. Perspectives in Science, Vol. 8, pp. 237-240. https://doi.org/10.1016/ j.pisc.2016.04.038

Ali, M.H., Mashud, M., Rubel, M.R., Ahmad, R.H. 2013. Biodiesel from Neem Oil as an Alternative Fuel for Diesel Engine. Procedia Engineering, Vol. 56, pp. 625–630. https://doi.org/10.1016/j.proeng.2013.03.169

Madai, I.J., Jande, Y.A.C., and Kivevele, T. 2020. Fast Rate Production of Biodiesel from Neem Seed Oil Using a Catalyst Made from Banana Peel Ash Loaded with Metal Oxide (Li-CaO/Fe2 (SO4)3). Advances in Materials Science and Engineering, Vol. 2020, No. 7825024, pp. 1-11. https://doi.org/10.1155/ 2020/7825024

Scott, S.A., Davey. M.P., Dennis, J.S., Horst, I., Howe, C.J., Smith, D.J.L., & Smith, A.G. 2010. Biodiesel from algae: challenges and prospects. Current Opinion in Biotechnology, Vol. 21, No. 3, pp. 277-286.

Medipally, S.R., Yusoff, F.M., Banerjee, S., & Shariff, M. 2015. Microalgae as Sustainable Renewable Energy Feedstock for Biofuel Production. BioMed Research International, Vol. 2015, No. 519513, pp. 1-13. http://dx.doi.org/10.1155/2015/519513.

Hossain, M.A., Chowdhury, S.M., Rekhu, Y., Faraz, K.S., & Ul Islam, M. 2012. Biodiesel from Coconut Oil: A Renewable Alternative Fuel for Diesel Engine. World Academy of Science, Engineering and Technology, 68, pp. 1289-1293.

Rasyid, R., Sabara, Z., Pratiwi A.H., Juradin, R., & Malik, R. 2018. The Production Of Biodiesel From A Traditional Coconut Oil Using NaOH/γ-Al2O3 Heterogeneous Catalyst. IOP Conf. Series: Earth and Environmental Science 175 (2018) 012025, pp. 1-6. doi:10.1088/1755-1315/175/1/012025.

Oniya, O.O. & Bamgboye, A.I. 2014. Production of biodiesel from groundnut (Arachis hypogea, L.) oil. Agric Eng Int: CIGR Journal, Vol. 16, No.1, pp. 143-150.

Britannica. How is biodiesel produced from rapeseed oil? Available online: https://www.britannica.com/video/179995/biodiesel (accessed on 15 July 2022).

Li, M.; Zheng, Y.; Chen, Y.; Zhu, X. Biodiesel production from waste cooking oil using a heterogeneous catalyst from pyrolyzed rice husk. Bioresour. Technol. 2014, 154, 345–348.

Schmutzler, L.O.F. 1993. (54) Process for Refining Glyceride Oil. 4. Available online: https://patents.google.com/patent/US5248799A/en (accessed on 15 July 2022).

Suleman, N., Abas, Paputungan, M. 2019. Esterifikasi dan Transesterifikasi Stearin Sawit untuk Pembuatan Biodiesel. Jurnal Teknik, Vol. 17, No. 1, pp. 66-77. https://doi.org/10.37031/jt.v17i1.54

Chitra, P., Venkatachalam, P., Sampathrajan, A. 2005. Optimisation of experimental. conditions for biodiesel production from alkali-catalysed transesterification of Jatropha curcus oil. Energy Sustainable Dev, Vol. 9, pp.13–8.

Ramadhas, A., Muraleedharan, C., Jayaraj, S. 2005. Performance and emission evaluation of a diesel engine fuelled with methyl esters of Rubber seed oil. Renewable Energy, Vol. 30, pp.1789–800.

El-Mashad, H.M., Zhang, R., Avena-Bustillos, R.J. 2008. A two-step process for biodiesel production from salmon oil. Biosyst Eng, Vol. 99, pp. 220–227.

Nugraha, A., Fatimah, S., & Nandiyanto, A.S. 2022. The Research Trends of Rice Husk-Based Briquettes Using Bibliometric Analysis. Journal of Earth Energy Science, Engineering, and Technology, Vol. 5, No. 2, pp. 55-65.

Veljkovića, V.B., Biberdžićb, M.O., Ilića, I.B.B., & Djalovićc, I.G., Tasića, M.B., Nježićd, Z.B., Stamenkovića, O.S. 2018. Biodiesel production from corn oil: A review. Renewable and Sustainable Energy Reviews, Vol. 91, pp. 531-548.

El Boulifi, N., Bouaid, A., Martinez, M., & Aracil, J. 2010. Process Optimization for Biodiesel Production from Corn Oil and Its Oxidative Stability. International Journal of Chemical Engineering, Vol. 2010, No. 518070, pp. 1-9. doi:10.1155/2010/518070

Shimada, Y., Watanabe, Y., Samukawa, T., Sugihara, A., Noda, H., & Fukuda, H. 1999. Conversion of vegetable oil to biodiesel using immobilized Candida Antarctica lipase. J Am Oil Chem Soc, Vol. 76, pp. 789–793.

Tweddell, R.J., Kermasha, S., Combes, D., Marty, A. 1998. Esterification and interester-ification activities of Lipases from Rhizopus niveus and Mucor miehei in three different types of organic media: a comparative study. Enzyme Microb Technol, Vol. 22, pp. 439–445.

Watanabe, Y., Shimada, Y., Sugihara, A., Tominaga, Y. 2002. Conversion of degummed soybean oil to biodiesel fuel with immobilized Candida antarctica lipase. J Mol Catal B: Enzym, Vol. 17, pp. 151–155.