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Bibliometric Analysis of the Use of Biodiesel Production from Essential Oils as Biofuels

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Abstract: Second-generation biodiesel, which is produced from essential oil plants, has important advantages, including a high yield of biofuels and the potential to reduce greenhouse gas emissions. The goal of this research was to examine the profile of original and review articles on biodiesel production from essential oils using bibliometric analysis. The search strategy identified 186 relevant and available peer-reviewed publications from 1981 to 2023, which were downloaded from the Web of Science (WoS) database. The retrieved documents were analyzed using VOSviewer. China was the predominant country publishing those documents, followed by the United States, India, Australia, and France. The keyword cluster analysis indicated the presence of 10 main research topics: diesel, fuel, and engine performance; extraction of lipids from microalgae; biofuel production from essential oils; green chemistry; the pyrolysis process; bioethanol production from renewable raw materials; obtaining biodiesel from essential oils; essential oil extraction; obtaining biofuels; and supercritical fluid extraction for fuels. The top three authors were Rahman, S. M. A., Cantrell, C. L., and Zheljazkov, V.D. The results showed that study topics such as different biodiesel raw material sources, biodiesel conversion technology, and the performance and emission characteristics of second-generation biodiesel are gaining popularity, with the goal to achieve a sustainable and clean environment.

Keywords: bibliometric analysis; biofuel and biodiesel; emission characteristics; engine performance; essential oil biodiesel; clean and renewable energy; sustainability; environmentally friendly; second-generation biodiesel

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1. Introduction

Essential oils are concentrated plant extracts containing the aromatic compounds of the plant from which they are derived [1–3]. Essential oils are typically extracted from the flowers, leaves, stems, and roots of plants [4–6]. The extraction process involves steaming or pressing the plant matter to release the essential oil [7–10]. Essential oils can be obtained from plants such as lavender, mint, thyme, sage, and eucalyptus, which are popular medicinal plants [11–13]. These oils are used both in aromatherapy applications [1,14] and in the fight against disease-causing agents in plants [5,15–17]. In addition, biodiesel can be obtained from essential oils [18,19]. Biodiesel can be obtained using biotechnological methods [20,21], the transesterification method, and from solid wastes left after obtaining essential oil from plants [22] via the pyrolysis method.

Biodiesel is a promising alternative to conventional diesel fuel that has the potential to reduce emissions and dependence on fossil fuels [23]. Biodiesel produced from materials such as household food waste, poultry farming waste, and waste tires are classified as first-generation biodiesel fuels [24]. A first-generation biodiesel can achieve good results, as can a second-generation biodiesel [25]. However, the biodiesel production process from first-generation sources is more laborious and complex than that from second-generation sources [26]. The large amount of biomass waste remaining after essential oil production represents an important biodiesel production source [27]. Hence, it has gained increasing attention. Essential oil is derived from plants and has properties that make it a promising feedstock for producing biodiesel [28,29]. It is used to operate diesel engines in vehicles by mixing biodiesel obtained from essential oils with diesel fuel [30,31]. A large portion of carbon monoxide emissions originate from vehicle emissions using fossil fuels [32,33], while a more environmentally friendly, renewable, and cleaner fuel is obtained with the fuel mixture created by adding biodiesel obtained from essential oils to diesel oil [34]. Thus, pollutant emissions released to the environment as a result of fuel combustion are reduced [35,36]. Reducing pollutant emissions also has a positive effect in negating global warming [37–39]. In recent years, there has been increasing interest in the performance and emission characteristics of diesel engines operated by biodiesel produced from essential oil [40,41]. Bibliometric analysis, which employs mathematical, statistical, and other measurement techniques, is useful for revealing the academic strength of a research finding and the possibility of citation/co-citation models [42]. Bibliometric analysis aims to provide a comprehensive overview of the research trends and developments in a field [43–46]. In this study, the goal of bibliometric analysis was to review the literature on the use of essential oils and volatile plant oils as biofuels for compression ignition engines and provide a comprehensive summary of the research in this area as it stands today.

The main objectives of this bibliometric analysis [42,47] were as follows:

1. To perform a thorough analysis of the literature regarding the use of biodiesel production from essential oils to power compression ignition engines.
2. To analyze the research trends and publishing patterns in the field, including the number of publications, authors, countries, and journals.
3. To identify the key topics and research gaps in the field and make suggestions for future investigations.

2. Materials and Methods

2.1. Data Collection

Clarivate Analytics Web of Science (WoS) is a comprehensive academic database that provides access to high-quality research from various scientific fields, including the natural sciences, social sciences, engineering, and humanities [48,49]. The database is widely used by researchers, scholars, and students to find and cite relevant research articles, conference proceedings, and other scholarly materials [50]. One of the notable features of Web of Science is its citation index, which tracks the number of times an article has been cited by other publications. This allows researchers to identify the most influential and impactful research in a particular field and track the progression of ideas over time. In addition, Web of Science includes a variety of search tools and filters to help users find the most relevant and up-to-date research [48,51]. Users can search by keyword, author, publication, or citation and narrow their results by date range, subject area, and other criteria [52,53]. The WoS Core Collection database (1981–present) (last data download 4 February 2023) was utilized to find research publications on the topic of essential oils. Accordingly, 48,537 documents were found that contain the words "essential oil" OR "volatile oil". To narrow down the findings, the search was restricted to publications with the following keyword query:

Topic: ("biodiesel fuel" OR "engine emission" OR "diesel fuel" OR "pyrolysis" OR "biodiesel" OR "biofuel" OR "diesel")

Then, 186 articles from the WoS Core Collection were examined, and the findings were further filtered by document type (article or review). There were no language restrictions. Total records and cited references from the analyzed papers were downloaded and imported into VOSviewer (version 1.6.18, 2022, Leiden University, Leiden, The Netherlands) for further citation analysis [54].

2.2. Bibliometric Analysis and Clustering

WoS data were visualized (network and overlay) using the software VOSviewer to determine co-occurrence and clusters of related articles, country, organization, and author collaboration (co-authorship), as well as clusters of interrelated research topics (text data). VOSviewer was utilized to illustrate the international collaboration among the authors, organizations, and nations, as well as trends in research across all keywords [55]. Items are displayed in the figures of this paper by a label and a circle. The weight (relative importance) of an item is indicated by the size of the circle. According to the program's calculations, the colors in the chain representation reflected arrays of related components. The strength of the relationships was represented by the distance between the items [56].

3. Results and Discussion

3.1. Time Trend Analysis, Publication Type, and Language

Increasing population growth, industrialization, and welfare have resulted in an increase in the use of fossil fuels, which has led to an increase in greenhouse gas emissions and climate change. Its adverse effects have been linked to increased floods, droughts, forest fires, and glacier melting, among other natural disasters. At the Paris Climate Conference (2015), which was held during the Conference of the Parties (COP21), an agreement was signed to limit global warming to below 2 °C. Achieving this objective will necessitate severe emission reductions to stabilize the concentration of greenhouse gases in the atmosphere. The substitution of fossil fuels with biofuels derived from plant biomass has the potential to drastically decrease emissions of greenhouse gases [57–60]. For that purpose, biofuels are receiving increasing research attention. In this study, five document types were discovered, under which there were 186 publications researching crops containing essential oils in the production of biodiesel, which is an important biofuel type. The types of documents and languages of the publications are shown in Table 1.

Table 1. Document types and languages of the publications on Web of Science concerning biodiesel production from essential oil.

Rank	Document Type	Records	% of 186	Language	Records	% of 186
1	Article	164	88.172	English	184	98.925
2	Review Article	22	11.828	Chinese	1	0.538
3	Book Chapters	7	3.763	Turkish	1	0.538
4	Early Access	5	2.688			
5	Proceeding Paper	3	1.613			

Among these document types, the most common were 164 articles (88.17%) and 22 reviews (11.83%), followed by 7 book chapters (3.76%), 5 early-access articles (2.69%), and 3 proceedings articles (0.89%). The majority of the documentation is written in English (98.93%), with small amounts in Chinese and Turkish (1.08%). Figure 1 illustrates the increase in the quantity of publications and citations related to the topic. Since the data were retrieved on 4 February, it is not surprising that there are few publications and citations in 2023.

3.2. Categories and Research Areas of Web of Science

In the science edition of WoS, there are sixteen subject categories and sixteen research areas pertaining to the influence of biodiesel production from essential oil (Table 2). The first eight WoS categories are Energy Fuels (33; 17.742%), Chemical Engineering (27; 14.516%), Food Science Technology (21; 11.290%), Analytical Chemistry (20; 10.753%), Environmental Sciences (20; 10.753%), Multidisciplinary Chemistry (19; 10.215%), Applied Chemistry (14; 7.527%), and Agronomy (11; 5.914%). The first eight research areas are Chemistry (60; 32.258%), Engineering (42; 22.581%), Energy Fuels (33; 17.742%), Environmental Sciences/Ecology (24; 12.903%), Food Science Technology (21; 11.290%), Agriculture (18; 9.677%), Biochemistry/Molecular Biology (18; 9.677%), and Science Technology Other Topics (16; 8.602%). The WoS allows for the classification of journals and publications into two or more categories, demonstrating the multidisciplinary character of this subject area [61,62]. The WoS also maps publications to WoS classes, which are more specialized than fields [63,64].

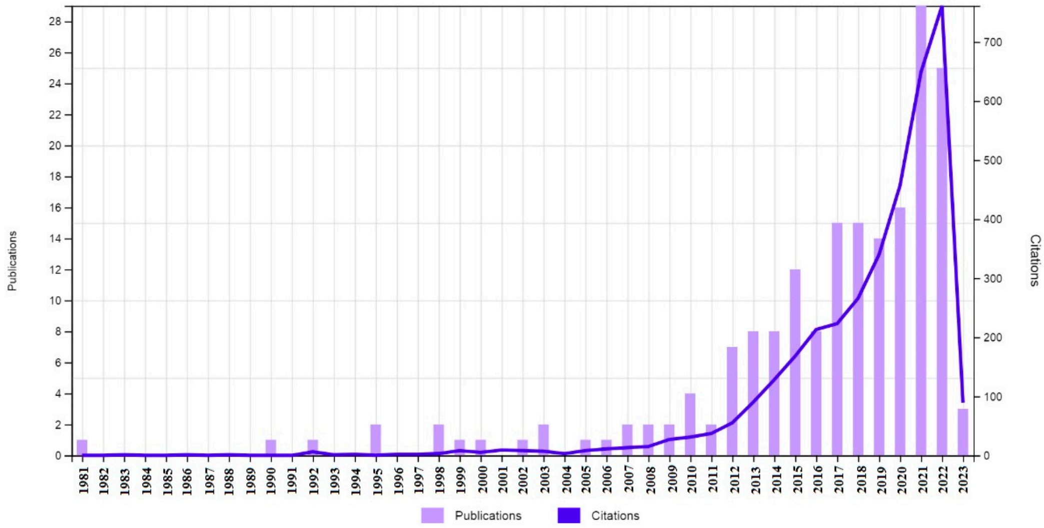

Figure 1. Annual growth of publications and their total citations per year on biodiesel production from essential oil (1981–2023).

Table 2. Web of Science (WoS) categories and research areas concerning biodiesel production from essential oil.

Rank	WoS Categories	TP	Ratio (%)	Research Areas	TP	Ratio (%)
1	Energy Fuels	33	17.742	Chemistry	60	32.258
2	Chemical Engineering	27	14.516	Engineering	42	22.581
3	Food Science Technology	21	11.290	Energy Fuels	33	17.742
4	Analytical Chemistry	20	10.753	Environmental Sciences/Ecology	24	12.903
5	Environmental Sciences	20	10.753	Food Science Technology	21	11.290
6	Multidisciplinary Chemistry	19	10.215	Agriculture	18	9.677
7	Applied Chemistry	14	7.527	Biochemistry Molecular/Biology	18	9.677
8	Agronomy	11	5.914	Science Technology/Other T opics	16	8.602
9	Biochemistry/Molecular Biology	11	5.914	Plant Sciences	11	5.914
10	Environmental Engineering	11	5.914	Materials Science	10	5.376
11	Plant Sciences	11	5.914	Biotechnology/Applied Microbiology	9	4.839
12	Green Sustainable Science Technology	10	5.376	Thermodynamics	8	4.301
13	Agricultural Engineering	9	4.839	Polymer Science	6	3.226
14	Biotechnology/Applied Microbiology	9	4.839	Geology	5	2.688
15	Physical Chemistry	9	4.839	Integrative Complementary Medicine	3	1.613
16	Thermodynamics	8	4.301	Spectroscopy	3	1.613

Ratio refers to the percentage out of 186. TP = total publications.

3.3. Core Journals

According to JCR 2021 data (released in 2022), research on the influence of biodiesel production from essential oil is featured in 25 journals across all categories of WoS. The leading 20 base journals are listed in Table 3. The leading 5, leading 10, leading 15, leading

20, and leading 25 journals published 13.97%, 21.50%, 26.88%, 32.25%, and 37.09% of the articles, respectively. The most effective journal was *Industrial Crops and Products* with eight articles (4.301%), followed by *Fuel* (7%; 3.763%), *Journal of Analytical and Applied Pyrolysis* (4%; 2.151%), *Journal of Chromatography A* (4%; 2.151), and *Energy Fuels* (3%; 1.613%). Each of these journals published more than three articles. There were 11 journals from Q1 (quartile), 10 journals from Q2, 3 journals from Q3, and 1 journal from Q4 among the top 25 journals (Table 3). It is crucial that the publications appear in a journal with a high impact factor (IF). Citation analysis is not a measure of scientific excellence, but a reflection of its importance [65–67].

Table 3. The top 25 journals on Web of Science for research on biodiesel production from essential oil.

Rank	Journal	TP	Ratio	IF 2021	IF 5-yr	QC
1	*Industrial Crops and Products*	8	4.301	6.449	6.508	Q1
2	*Fuel*	7	3.763	8.035	7.621	Q1
3	*Journal of Analytical and Applied Pyrolysis*	4	2.151	6.437	5.914	Q1
4	*Journal of Chromatography A*	4	2.151	4.601	4.313	Q1
5	*Energy Fuels*	3	1.613	4.654	4.582	Q2
6	*Journal of Cleaner Production*	3	1.613	11.072	11.016	Q1
7	*Journal of The American Oil Chemists Society*	3	1.613	1.952	2.346	Q3
8	*Journal of Thermal Analysis and Calorimetry*	3	1.613	4.755	3.641	Q1
9	*Molecules*	3	1.613	4.927	5.110	Q2
10	*ACS Omega*	2	1.075	4.132	4.197	Q2
11	*Algal Research Biomass Biofuels and Bioproducts*	2	1.075	5.276	5.813	Q2
12	*Energies*	2	1.075	3.252	3.333	Q3
13	*Food Chemistry*	2	1.075	9.231	8.795	Q1
14	*Journal of Agricultural and Food Chemistry*	2	1.075	5.895	6.048	Q1
15	*Journal of Applied Polymer Science*	2	1.075	3.057	2.813	Q2
16	*Journal of Essential Oil Research*	2	1.075	2.532	2.450	Q2
17	*Journal of Hazardous Materials*	2	1.075	14.224	12.984	Q1
18	*Marine and Petroleum Geology*	2	1.075	5.361	5.476	Q1
19	*Organic Geochemistry*	2	1.075	3.623	4.402	Q2
20	*PLoS ONE*	2	1.075	3.752	4.069	Q2
21	*Polymer Degradation and Stability*	2	1.075	5.204	5.147	Q1
22	*Rapid Communications in Mass Spectrometry*	2	1.075	2.586	2.538	Q3
23	*Russian Journal of Bioorganic Chemistry*	2	1.075	1.254	1.063	Q4
24	*Sustainable Chemistry and Pharmacy*	2	1.075	5.464	5.599	Q2
25	*AAPG Bulletin*	1	0.538	3.863	4.470	Q2

Ratio refers to the percentage out of 186. IF = impact factor; QC = quartile in the category; TP = total publications. Data are from the 2021 edition of *Journal Citation Reports*.

3.4. Author Co-Authorship Analysis

Internationally collaborative articles were accompanied by interinstitutional collaborative publications, single-country articles, and single-author articles, which had the maximum visibility and scholarly impact on average [68,69]. According to the publication data, 932 authors produced the 186 works. There were 932 authors who had at least one publication. Nevertheless, just 35 authors were interconnected. Figure 2 displays the WoS authorship network for the study of the effects of essential oils on biodiesel production. The circle sizes show the number of records. Authors who belong to the same cluster have studied the same subject and collaborated closely.

Table 4 includes information on citations, average citations, organizations, and nations for the authors of studies between 1981 and 2023 addressing the impact of adding essential oils to biodiesel production. The leading 20 writers who have produced more than nine articles are included in Table 4, along with their total citations, average citations, organizations, and countries. After correcting for different spellings of author names, the leading five authors were Rahman, S. M. A., Cantrell, C. L., Zheljazkov, V.D., Astatkie, T., and Brown, R. J.; each published more than 2 articles. The top nine authors with the most citations per article were Rahman, S. M. A., Dowell, A., Davin, Laurence B., Cantrell, C. L., Zheljazkov, V. D., Kaloustian, J., Brown, R. J., Nabi, Md. N., Ristovski, Z. D., Islam, M. A. Their average citation per article was over 53.22. Among the top 20 authors, there were six from Australia, four from the United States, four from Hungary, three from Spain, and one each from Canada, Denmark, and France.

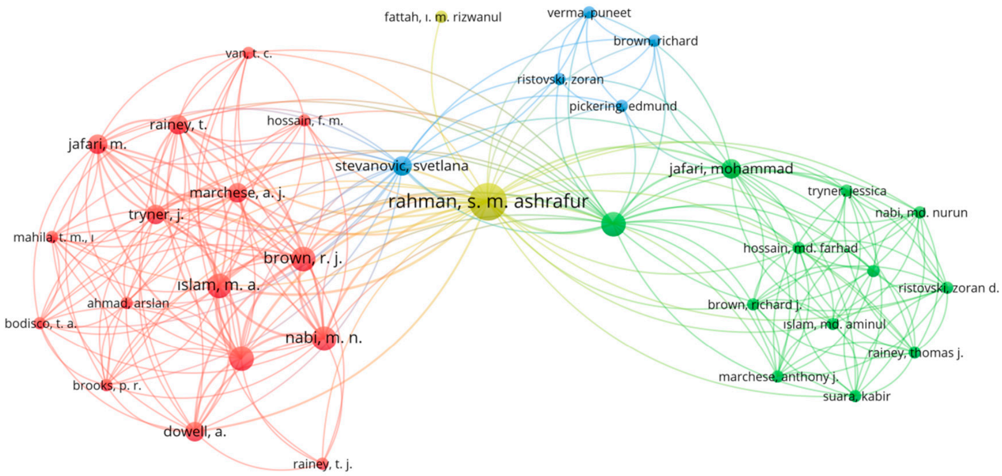

Figure 2. Web of Science network visualization map of authors of studies on biodiesel production from essential oil.

Table 4. Top 20 most prolific authors who published articles in the field of biodiesel production from essential oil on Web of Science.

Rank	Author	Articles	Citations	Organization	Country
1	Rahman, S. M. Ashrafur	6	91	Queensland University of Technology	Australia
2	Cantrell, Charles L.	5	47	Mississippi State University	United States
3	Zheljazkov, Valtcho D.	5	47	Oregon State University	United States
4	Astatkie, Tessema	3	19	Dalhousie University	Canada
5	Brown, Richard J.	3	37	Queensland University of Technology	Australia
6	Dowell, Ashley	3	82	Southern Cross University	Australia
7	Kaloustian, Jacques	3	47	UDICE-French Research Universities	France
8	Nabi, Md. Nurun	3	37	Central Queensland University	Australia
9	Ristovski, Zoran (Ristovski, Z. D.)	3	37	Queensland University of Technology	Australia
10	Islam, Aminul (Islam, M. A.)	3	37	Technical University of Denmark	Denmark
11	Aucejo, Susana (Aucejo, S.)	2	13	ITENE Research Center	Spain
12	Babinszki, Bence (Babinszki, B.)	2	21	Hungarian Academy of Sciences	Hungary
13	Barta-Rajnai, Eszter (Barta-Rajnai, E.)	2	21	Hungarian Research Centre for Natural Sciences	Hungary
14	Saldaña, Jose Maria Bermudez (Bermudez, J. M.)	2	13	ITENE Research Center	Spain
15	Blazso, Marianne (Blazso, M.)	2	21	Hungarian Research Centre for Natural Sciences	Hungary
16	Burkhardt, Andy (Burkhardt, Andy)	2	28	Montana State University	United States
17	Camean, Ana Maria (Camean, A. M.)	2	13	University of Sevilla	Spain
18	Czegeny, Zs.	2	21	Hungarian Academy of Sciences	Hungary
19	Davin, Laurence B.	2	54	Washington State University	United States
20	Dowell, Averie (Dowell, A.)	2	9	Southern Cross University	Australia

3.5. Country/Region Co-Authorship Analysis

There were 54 countries or areas that contributed to this study's 186 papers. The top 14 nations or locations where more than two articles originated are listed in Table 5. The top five article-producing nations were China, the United States, India, Australia, and France. China, France, Malaysia, Canada, and the United States produced the most citations per paper. An international country co-authorship network map was developed using VOSviewer software. The threshold has been set to 1. A total of 53 nations/regions fulfilled the criteria, and 38 nations /regions were interlinked (Figure 3).

Table 5. Top 14 countries/regions publishing articles on Web of Science in the field of biodiesel production from essential oil.

Rank	Country/Region	Records	Cluster	Total Link Strength	Citations
1	China	27	4	5	485
2	United States	23	10	23	332
3	India	23	5	6	258
4	Australia	15	8	17	243
5	France	10	3	4	419
6	Canada	8	5	7	358
7	Egypt	7	5	7	107
8	Malaysia	7	2	2	408
9	Saudi Arabia	5	5	9	38
10	Taiwan	4	1	1	69
11	Greece	3	1	1	75
12	Pakistan	3	3	3	5
13	Republic of Korea	3	5	6	24
14	Austria	2	8	0	34

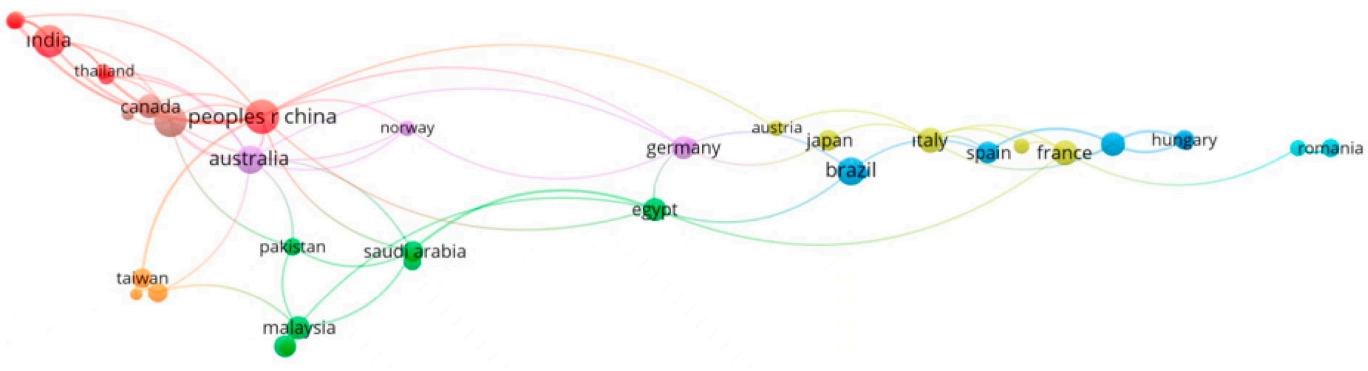

Figure 3. The country co-authorship network of research on biodiesel production from essential oil with 38 nodes and 8 clusters.

The VOSviewer software classified these 38 countries into eight distinct color groupings. The size of a circle symbolizes each record, while the range between nations reflects the power of their relationships. The different color ranges and groups were established in accordance with the countries. India, the United States, China, Germany, Australia, and Brazil had the six largest circles (Figure 3). The initial cluster included seven countries and regions (red color): Bangladesh, India, Mexico, China, Republic of Korea, Thailand, and Vietnam. The second cluster included seven countries/regions (green): Egypt, Greece, Iran, Malaysia, Nigeria, Pakistan, and Saudi Arabia. The third cluster included six countries (blue): Brazil, England, Hungary, Scotland, Spain, and Venezuela. The fourth cluster consisted of five countries and regions (yellow): Austria, Czech Republic, France, Italy, and Japan. The fifth cluster consisted of four countries (violet): Australia, Germany, Israel, and Norway. The sixth cluster consisted of three countries (light blue): Belgium, Estonia, and Romania. The seventh cluster consisted of three countries (orange): Indonesia, Netherlands, and Taiwan. The eighth cluster consisted of three countries (brown): Canada, Sweden, and the United States. China demonstrated increased studies and collaboration in the field of biodiesel production from essential oil. It appears that increasing cooperation results in more sophisticated scientific research output. Hence, geographic location is a significant aspect that influences international cooperation. The increasing number of international exchanges has facilitated scholarly contacts [70–72].

3.6. Organization Co-Authorship Analysis

According to the publication data, 365 organizations produced a total of 186 works. The examination of organization co-authorship indicated the level of communication across institutions as well as the prominent institutions in this field [73–75]. The 365 organizations satisfied the lowest threshold of one; however, 22 organizations were linked to one another (Figure 4). The VOSviewer program color-coded those 22 institutions into four distinct clusters. Localization plays a big role in how partnerships and joint ventures are formed [76,77].

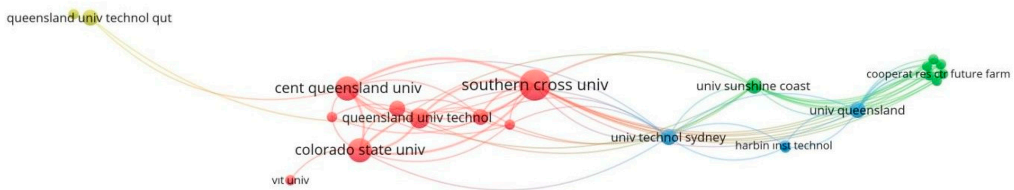

Figure 4. The organization co-authorship network of Web of Science research on biodiesel production from essential oil.

3.7. Co-Occurrence Analysis for All Keywords

There were only 75 keywords out of the 846 in total that met the threshold more than twice. The largest collection of linked items, which included 69 items in total, was divided into 10 major clusters (Figure 5).

The first cluster (red) highlighted diesel, fuel, and engine performance. It consisted of 11 keywords: fuel, fuel properties, diesel, emissions, combustion, combustion characteristics, compression ignition engine, engine performance, terpenoids, and particulate matter.

The second cluster (green) focused on solvents such as limonene, which are used to extract lipids from microalgae. The keywords were ranked as follows: microalgae, limonene, menthol, terpenes, carvacrol, viscosity, activation energy, kinetics, thermal analysis, and response surface methodology.

The third cluster (blue) focused on biofuel production from essential oils. It included keywords such as biofuels, bioproducts, biorefinery, bioactive compounds, crude glycerol, analytical pyrolysis, mass spectrometry, and sustainability.

The fourth cluster (yellow) focused on green chemistry. The keywords included green chemistry, cellulose, holocellulose, lignin, wood, drying, chemical analysis, and ionic liquids.

The fifth cluster (violet) focused on the pyrolysis process and the anti-inflammatory, antioxidant, and antimicrobial activities of pyroligneous acid from *Rosmarinus officinalis*. It included keywords such as pyrolysis, anti-inflammatory, antioxidant activity, antimicrobial activity, GC-MS, pyroligneous acid, and *Rosmarinus officinalis*.

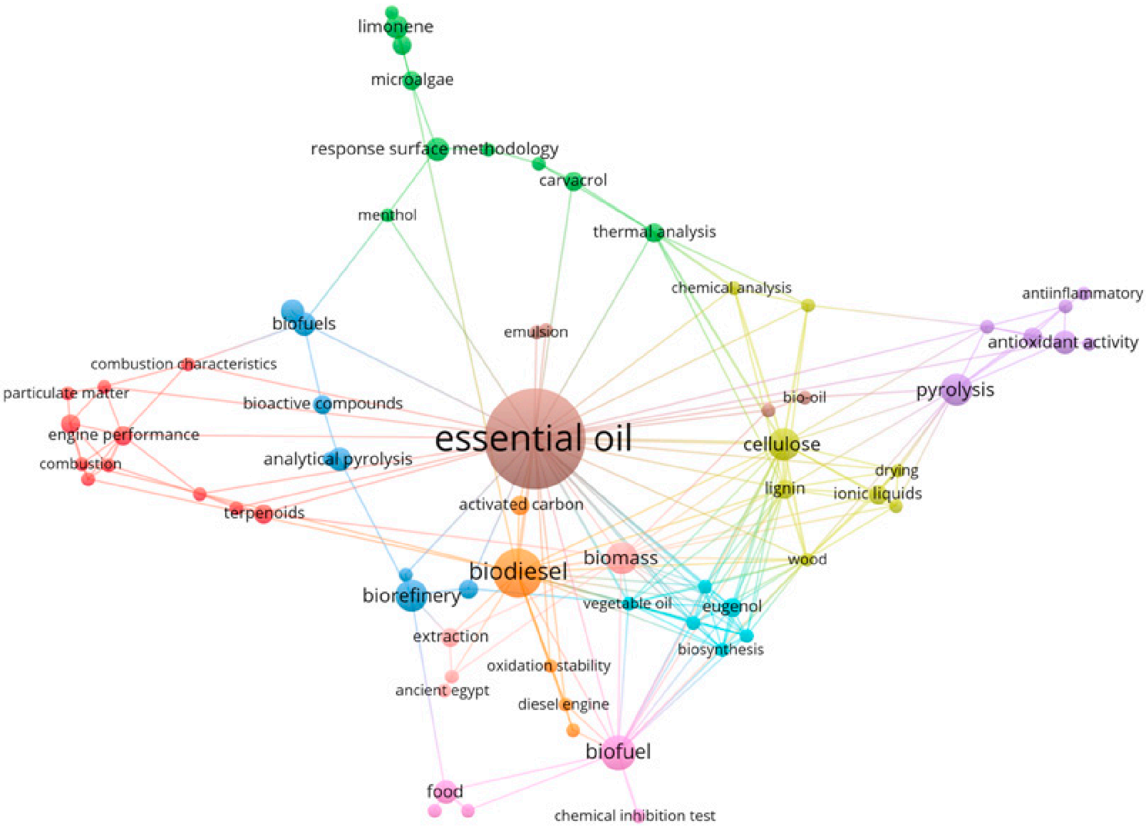

Figure 5. VOSviewer co-occurrence network visualization mapping the most frequent keywords (minimum of two occurrences) in Web of Science research on biodiesel production from essential oil.

The sixth cluster (light blue) focused on bioethanol production from renewable raw materials. The keywords included bioethanol, biosynthesis, eugenol, metabolic engineering, switchgrass, and vegetable oil.

The seventh group (orange) concerned obtaining biodiesel from essential oils. It included keywords such as activated carbon, biodiesel diesel, engine, lemon, essential oil, and oxidation stability.

The eighth group (brown) focused on essential oil extraction. The keywords included bio-oil, emulsion, essential oil, oxidative stability, and pretreatment.

The ninth group focused on obtaining biofuels. It included keywords such as biofuels, chemical inhibition testing, cosmetics, food, and supercritical fluid extraction.

The tenth group focuses on supercritical fluid extraction for fuels. The keywords included ancient Egypt, biomass, extraction, and oxidation.

Figure 6, illustrated by VOSviewer, shows co-occurrence overlay mapping of the most common keywords (a least two occurrences) for Web of Science research on biodiesel production from essential oil. In recent years, it can be seen that some keywords (green-yellow) have been used frequently. These words are: essential oil, biofuel, biodiesel, combustion performance, and microalgae.

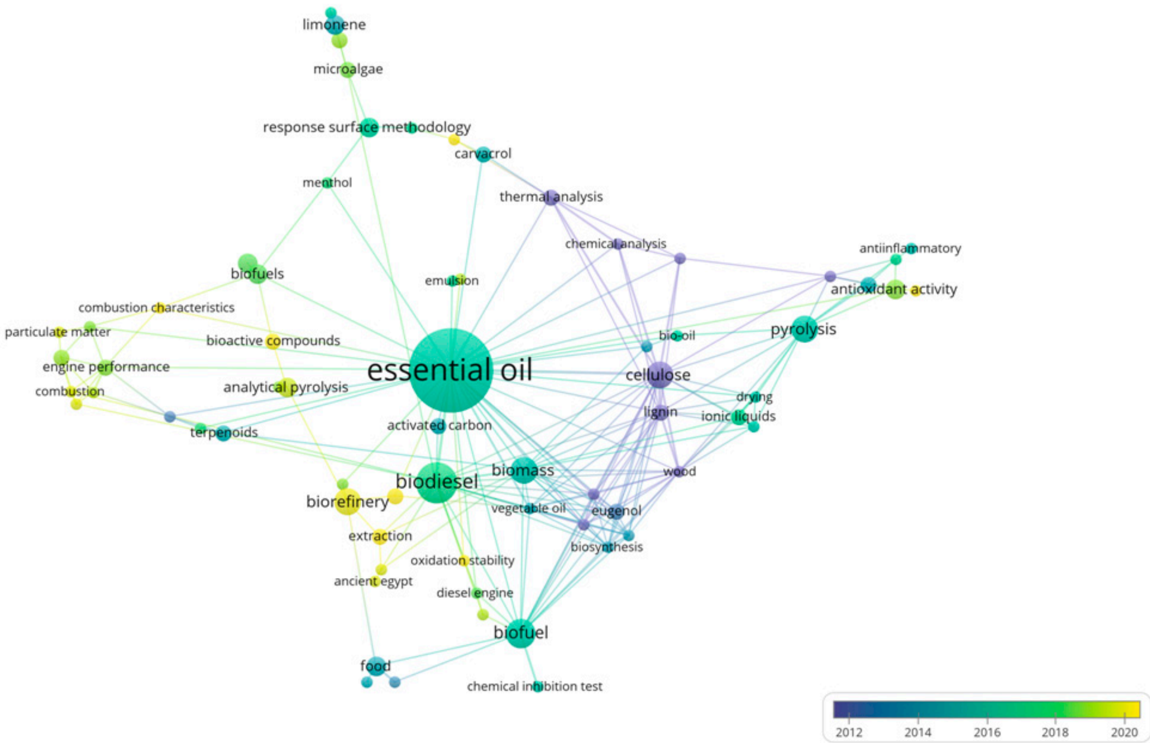

Figure 6. VOSviewer co-occurrence overlay visualization mapping of most frequent keywords (minimum of two occurrences) for Web of Science research on biodiesel production from essential oil.

4. Conclusions

In this study, 186 WoS papers (articles and reviews) on biodiesel production from essential oils were analyzed. The majority of these papers were written in English (98.93%) and were published by 932 authors from 54 countries/territories and 365 organizations. These papers were published in diverse categories of the WoS Core Collection. The five leading base journals were as follows: *Industrial Crops and Products*; *Fuel*; *Journal of Analytical and Applied Pyrolysis*; *Journal of Chromatography A*; and *Energy Fuels*. The top five article-producing nations were China, the United States, India, Australia, and France. The top five organizations were Queensland University of Technology, Southern Cross University, Central Queensland University, Colorado State University, and UDICE-French Research Universities. The top five authors were Rahman, S. M. A., Cantrell, C. L., Zheljazkov, V. D., Astatkie, T., and Brown, R. J. The keywords from research on biodiesel production from essential oil were divided into ten clusters with distinct research subjects. Cluster interpretation can only be offered exploratorily and is always subjective. Other experts may identify more patterns. In addition to relying on vocabulary chosen by the authors, which may be idiosyncratic, such research is also limited by its reliance on nomenclature. On the other hand, this could be considered a strength since the authors are adept at choosing their terms. They may alter throughout time, which is detectable through visualizations. So, such a study can serve as a resource for researchers. It provides useful information on the current condition of a scientific topic or discipline and predicts potential future advances. The analysis and visualizations shown here provide explorative data about the state of a particular scholarly area/discipline at the present time and suggest potential directions for future research.

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Conflicts of Interest: The author declares no conflict of interest.

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