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Bibliometric Analysis of Research on Essential Oils in Indonesia (1997-2022) using VOSviewer

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Abstract

Essential oil is one of the ingredients that has been widely used as medicine or fragrance by humans for a long time. Essential oil is obtained from the extraction process of certain parts of a plant. At this time the use of essential oil is increasingly widespread in various fields, such as the field of food production, pharmaceuticals, and cosmetics. This study will contain a bibliometric analysis of the development of essential oil research in Indonesia in the last 25 years (1997-2022). The data was retrieved from the Scopus database and was analyzed using VOSviewer to determine the relationship between keywords and the author of each published document. The data obtained 774 document publications with an average of 33 publications annually. So far, Mahfud, M. and Kusuma, H.S. are the most prolific authors with 27 and 19 publications. The results showed that the topic of essential oils began to receive considerable attention from Indonesian researchers from 2000 to 2022, although in the previous year (1997-1999) there were no publications of documents on essential oil research. Overall, this study could be used by researchers to quantitatively examine this research topic's trends and future direction.

Keywords: Bibliometric analysis, Essential oil, Scopus, VOSviewer.

1. Introduction

Essential oils have long played an important role in everyday life, being used for perfume, food flavoring, and even healing. Even today, essential oils and their constituents are used therapeutically in modern medicine [1,2]. Essential oils are mostly aromatic and volatile hydrocarbon molecules with a variety of various procedures. Terpenes, sesquiterpenes, aldehydes, and phenols are common constituents of essential oils [3]. The distinctive flavor and scent of essential oils result from the combination of these substances [4]. Essential oils are not found in large quantities in plants. As a result, only 10% of the 1,500,000 plant species are classified as "aromatic," meaning they can produce and emit aromatic essences [5,6].

Indonesia is blessed with abundant biodiversity and natural resources. One of them is the existence of biodiversity in essential oil-producing plants. In Indonesia, 40-50 varieties of essential oil-producing plants can produce 80 types of essential oils. This makes Indonesia one of the world's largest exporters of essential oils. Approximately 85% of Indonesia's essential oil exports are dominated by patchouli oil with a volume of 1.200-1.500 tons/year and are exported to several countries including Singapore, the United States, Spain, France, Switzerland, England, and other countries [7]. In addition, there are also other commodities, namely vetiver, jasmine, cloves, sandalwood, eucalyptus, and lemongrass [8].

With so many sources of essential oils that have not been explored, researchers have many opportunities to develop essential oil research. However, how much interest scientists have in essential oil research, especially in Indonesia, needs to be known. Therefore, bibliometric analysis is used, which is a quantitative review method that uses data mining, mathematics, and statistics [9]. This analysis seeks to identify research trends over a specific time period. This analysis can also be used to comprehend the essential oils research development process and future prospects. Bibliometrics assesses studies from around the world, institutions, and authors based on the number of citations, publications, impact factors, and a variety of other parameters. It is useful for illustrating the history of a particular area or subject,

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predicting its future, and improving communication between researchers [10]. The goal of this research is to help academics discover patterns and future directions for essential oils. However, it also plays a vital function in presenting the history of a specific area or subject and improving communication among researchers, all of which will affect the increase in more in-depth research on essential oils.

2. Methods

Bibliometric analysis is a quantitative evaluation method that evaluates data using a variety of mathematical and statistical methods [9]. This review technique aims to identify the interrelationships between citations in each journal and summarize the current trend of the specified research area. The data for the bibliometric analysis came from Scopus' citation index. This bibliometric analysis will focus more on the quantitative assessment of article attributes (publications, keywords, authors, affiliates, etc.) and their link to one another, which can reflect research trends, directions, and current research subjects [11].

The first step in implementing bibliometric analysis is determining the research. The substance and scope of the research must be established before the investigation begins [12]. If this is overlooked, the experiment clearly will suffer since it will diverge from the research's core purpose. As a result, it is vital to select the keywords that will be utilized in data collection. The next step is to determine where the database comes from. In this study, the database was collected from Scopus and extracted in Microsoft Excel format.

Performance analysis, scientific analysis (bibliometric mapping), and network analysis will be the next phases in the bibliometric analysis [11]. Performance analysis is a descriptive method for analyzing publications and citation indicators, such as the overall number of publications. Scientific analysis is a process that examines the influence and relationship of articles and authors through co-occurrences and co-authorships. Network analysis in the form of network analysis, network matrix evaluation, grouping, and visualization can improve the analysis results [11].

Science and network analysis was performed using Scopus and analyzed with VOSviewer (version.1.6.18.0) which is one of the most prominent applications in bibliometric research. Van Eck & Waltman (2010) [13] created this tool to make it easier to visualize readable bibliometric analysis. VOSviewer provides three forms of visualization: network visualization, overlay visualization, and density visualization. Network visualization is exclusively used by researchers since it will be used to group data (co-occurrences, co-authorship) to show a relationship with each other concerning the published topic. The VOSviewer is color-coded based on how popular and similar the study is. An interconnected line of items will alter in contrast if an item is utilized in multiple trials. If, on the other hand, the colors practically merge, this indicates that the things have a minor link [11]

3. Results and Discussion

The Scopus database on the Scopus website (https://www.scopus.com) is managed by the query ((TITLE(essential AND oil) OR KEY(essential AND oil) AND AFFILCOUNTRY(Indonesia)) AND PUBYEAR > 1996 AND PUBYEAR > 1996). The bibliometric analysis of this study only focuses on the results of research in Indonesia related to essential oils over the last four centuries. As a result, the Scopus database contains 774 publications organized into eight main paper types (Figure 1). Articles (403) account for 52% of all published material, with conference papers (337) accounting for 44%, and reviews (28) accounting for 3%. Apart from that, there are also book chapters, data papers, erratum, short surveys, and retracted papers which are also published regularly.

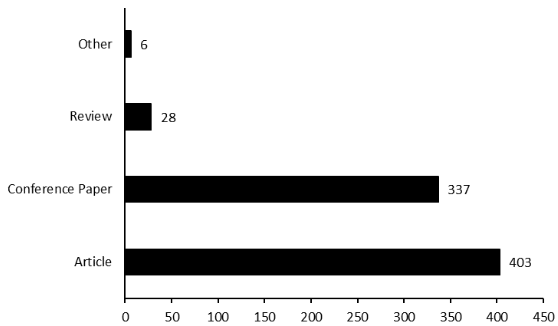


Figure 1: Document Type of essential oil publications (1997-2022).

3.1. Publication Performance Analysis

The purpose of this analysis is to assess publication, affiliation, and author performance using keyword queries entered into Scopus. The frequency of research publications every year is the basis of knowledge of publication performance in discussing a field. Figure 2 displays the annual publishing rate from 1997 through 2022, with 774 publications in total. The inactive years of 1997-1999 and 2001-2003 are included in the annual publication. This demonstrates that the issue of essential oil research was not yet popular that year and declined in the early 2000s. The year with the fewest publications (n = 1) was 2000, followed by 2004, 2005, and 2006. However, after that, the number of publications per year began to rise, and since 2019, the number of publications has never been less than 100. The publication data peaked in 2021, with 170 articles, with 33 documents produced on average per year.

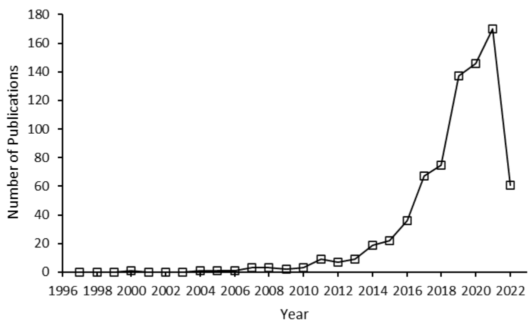


Figure 2: The number of essential oil publications (1997-2022).

Over the last 25 years, 160 member institutions have contributed to the advancement of essential oil research. Table 1 shows the top ten connected institutions with more than 25 publications. According to these data, Universitas Gadjah Mada ranks first among affiliated institutions with 76 publications (8%), followed by IPB University with 71 publications (7%). Furthermore, Universitas Indonesia, Universitas Padjadjaran, Universitas Sebelas Maret, and Brawijaya University each contributed 36 publications (4%). In addition, Institut Teknologi Sepuluh Nopember, Universitas Sumatera Utara, and Institut Teknologi Bandung each contributing 3%. The next one is Universitas Airlangga, which has 25 publications (2%).

Table 1: Affiliated institutions with more than 25 publications

Rank	Institution Name	Total Publications
1	Universitas Gadjah Mada	76
2	IPB University	71
3	Universitas Indonesia	36
4	Universitas Padjadjaran	36
5	Universitas Sebelas Maret	36
6	Brawijaya University	36
7	Institut Teknologi Sepuluh Nopember	30
8	Universitas Sumatera Utara	29
9	Institut Teknologi Bandung	27
10	Universitas Airlangga	25

Table 2: Top ten authors in publications

Rank	Author	Total Publications
1	Mahfud, M.	27
2	Kusuma, H.S.	19
3	Khasanah, L.U.	13
4	Utami, R.	13
5	Praseptiangga, D.	11
6	Yusiati, L.M.	11
7	Manuhara, G.J.	10
8	Batubara, I.	9
9	Kurniawati, A.	8
10	Muchtaridi	8

Many authors have made significant contributions to this essential oil research (1997-2022). According to the Scopus database, there are 160 authors involved. Table 2 shows the most prolific author, Mahfud, M., who has a total of 27 research articles. Then there's Kusuma, H.S., with 19 published studies, Khasanah, L.U., and Utami, R., each one with 13 publications. Praseptiangga, D. (11), Yusiati, L.M. (11), Manuhara, G.J. (10), Batubara, I. (9), Kurniawati, A. (8), and Muchtaridi, M. are also present (8).

3.2. Science and Network Analysis

This analysis will be separated into co-occurrence mapping and co-authorship mapping. Co-occurrence is referred to as a semantic network in this study and refers to the relationship between keywords. Co-authorship, on the other hand, refers to author interaction where two or more authors collaborate on a particular publication [14].

All keywords are employed as units of analysis in Co-occurrence mapping, which is assisted by the fractional computation approach. This analysis identifies many experimental constraints. There are limits in this bibliometric analysis, such as a minimum restriction of 10 times the recurrence of keywords as a limiting factor. So, just 189 of the 6,700 keywords in the 744 papers exceeded the criterion.

The keyword is analyzed using software where links, total link strength, and occurrence are calculated. According to Guo et al (2019) [15] links are related to the co-occurrence of one item (keywords) to another, and the total link strength corresponds to the total cited references between one item and another. In addition, occurrence represents the number of articles in which the keyword was found. As shown in Table 3, the keywords with the highest occurrence or with the highest co-occurrence are Essential oils (356), Essential oils (314), Distillation (87), Mass fragmentography (57), Plant extract (51), Indonesia (47), Gas chromatography (46), Plants (Botany) (45), Plant leaf (44), and Extraction (42).

Figure 3 illustrates the formation of keyword associations through network analysis. There are 6,700 keywords in six clusters, with four primary clusters: cluster 1 (red), cluster 2 (green), cluster 3 (blue), and cluster 4 (yellow). The shape of the protrusion of circles and text in each cluster represents the frequency of occurrence in conjunction with other keys, while the distance between each item is a line, demonstrating the association of each term [11]. Based on the relationship between keywords and a theme in each cluster, the keywords in each cluster will be evaluated to determine thematic differences in each cluster.

Group 1. The first cluster (red) contains the keyword essential oil with an occurrence weight of 314. In other words, the keyword essential oil appears in 314 out of 744 articles, or around 42% of the publications examined. Furthermore, the essential oil has 176 links and a total link strength of 286. It is mainly related to the number of chemicals in essential oils and their bioactivity test in this cluster. This may be observed in the first cluster of keywords relating to essential oils. It is evident due to the keywords flavonoid, alkaloid, and alcohol.

Essential oils are classified as terpenes and hydrocarbons based on their chemical composition [16]. Terpenes are composed of a variety of isoprene units. Based on the number of isoprene units, terpenes are classified as hemiterpenes (C_5H_8), monoterpenes ($C_{10}H_{16}$), sesquiterpenes ($C_{15}H_{24}$), diterpenes (C20H32), and many more [17]. Monoterpenes compose over 90% of all essential oils. *Lavandula luisieri*, *Cymbopogon citrus*, white tea, and green tea are some essential oils containing monoterpene structures [18]. The chemical structures of the most common terpenes are shown in Figure 4.

Other constituent components of essential oils are hydrocarbons made of carbon and hydrogen atoms. Hydrocarbons are classified as aliphatic, alkane, or aromatic based on their structure. Citrus oil is recognized to have a distinct sour odor created by aliphatic hydrocarbons composed of 8-10 linearly connected carbon atoms. In addition, floral oils have a leafy green aroma due to an aliphatic molecule with six carbon atoms, but citrus oils have an odor due to octane aldehydes. Essential oils include only a limited number of aliphatic molecules with an oxygenated functional group linked to them, which are responsible for odor. Alkanes, on the other hand, are made up of carbon atoms bonded together by single bonds, whereas alkynes are made up of carbon-carbon triple covalent bonds [19].

Furthermore, the inclusion of antioxidant and antibacterial activity keywords indicates the presence of a bioactivity test. Food deterioration is usually caused by a process known as oxidation in the food industry. This can have an impact on food goods during processing and storage, resulting in lasting alterations to their organoleptic and nutritional qualities [20]. As a result, it is critical to use natural antioxidants rather than chemicals to prevent oxidation in food products. Essential oils are frequently utilized in food packaging because they are high in antioxidants. The capacity of essential oils to act as oxygen collectors and facilitate the diffusion of active chemicals into food product packaging demonstrates their antioxidant activity [21].

Table 3: Keywords with the highest occurrence

Rank	Keyword	Cluster	Link	Total Publications	Occurrence
1	Essential oils	3	168	330	356
2	Essential oil	1	176	286	314
3	Distillation	4	144	84	87
4	Mass fragmentography	1	137	57	57
5	Plant extract	1	134	51	51
6	Indonesia	3	116	47	47
7	Gas chromatography	4	122	46	46
8	Plants (Botany)	3	98	45	45
9	Plant leaf	1	132	44	44
10	Extraction	4	109	42	42

There are several methods for determining essential oil antioxidant activity. The FRAP (ferric-reducing antioxidant power) test is the most often used method, which uses antioxidants to decrease Fe^{3+} to Fe^{2+} in a colorimetric reaction at low pH. The ferrous-probe complex turns blue and the absorbance at 593 nm is evaluated about the overall reducing capacity of antioxidants [22]. Also, the DPPH or 2,2-diphenyl-1-picrylhydrazyl free radical method is used to investigate the antioxidant capabilities of natural goods by demonstrating the antioxidant scavenging ability of antioxidants contained in plants and food extract [23].

Essential oils from aromatic plants contain various bioactive components that can function as antibacterial agents. The mechanism of essential oil activity against microbes is depicted in Figure 5. A disc diffusion assay, in which a film disc is placed on top of a previously contaminated agar plate, is one of the most used screening procedures. This method was utilized by Schaefer and Cheung (2018) [24] to investigate the antibacterial activity of pectic-based edible films using Mexican lime essential oil. The results showed that bagasse pectic films exhibited better in vitro antibacterial activity against *E. Coli, S. Typhimurium, S. Aureus, B. Cereus,* and *L. Monocytogenes* while films with Mexican lime bagasse and pomace were more effective against Gram-negative bacteria.

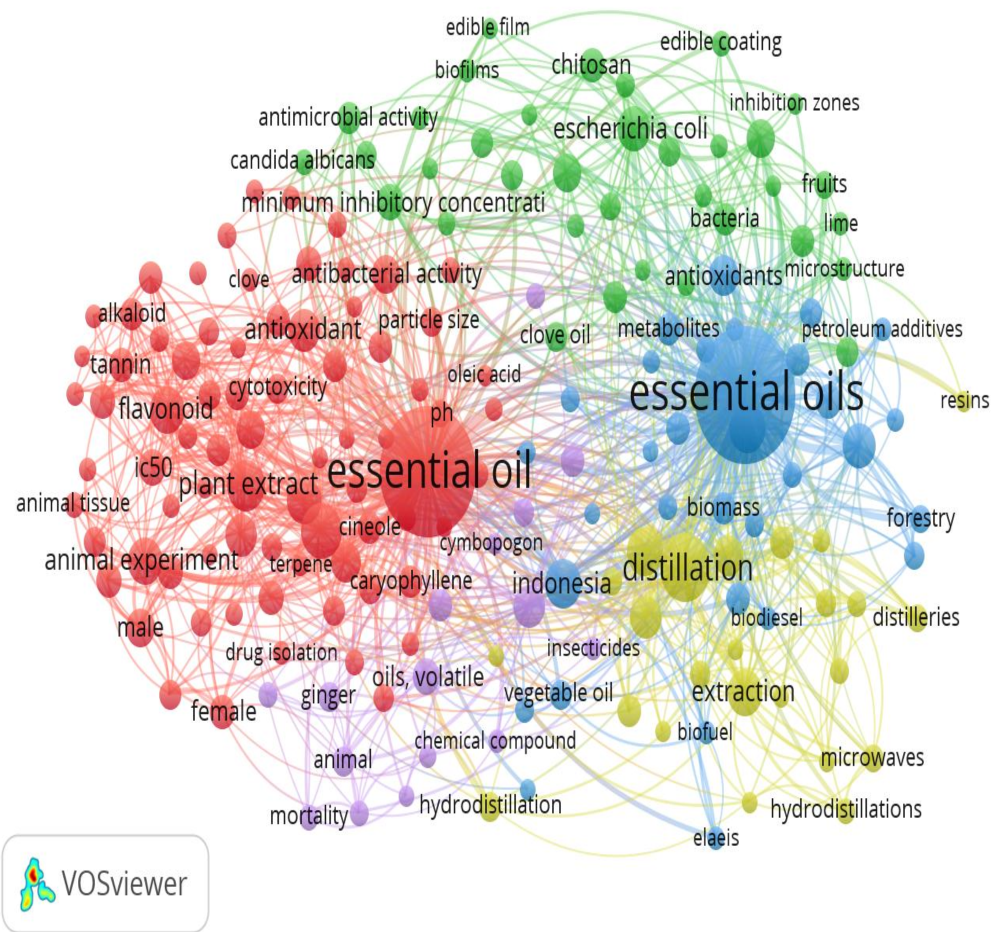
Group 2. *Escherichia coli* has the strongest co-occurrence, with a weight occurrence of 38 or 5% of all publications, 107 linkages, and 38 total link strengths. This cluster still discusses the bioactivity of essential oils in the second cluster, as evidenced by the inclusion of the phrases *Escherichia coli* (bacteria), antioxidants, and antibacterial activity. According to Dai et al (2021) [25], *Litsea cubeba* essential oil (LC-EO) was used as a natural anti-bacterial agent to investigate the anti-bacterial mechanism against *Enterohemorrhagic Escherichia coli* (EHEC). In the research of the anti-bacterial mechanism, the LC-EO was demonstrated to have strong membrane penetration ability, which could destroy bacterial cell structure and disrupt membrane permeability, resulting in intracellular organic matter leaking. Furthermore, the inhibitory effects of LC-EO on EHEC's physiological metabolism include respiratory metabolism, enzyme activity, nucleic acid replication, and transcription levels of major virulence genes. This demonstrates that particular essential oils can inhibit bacterial development.

In addition to discussing the bioactivity of essential oils, this cluster also relates to the use of essential oils in the food packaging sector as indicated by the keywords edible film and edible coating. Edible Film is a thin layer consisting of edible components used as the main food packaging. It restricts oxygen entrance, maintains moisture, and protects food without changing the contents inside [26]. However, the edible coating is a natural polymer packaging that is applied to the product by immersion method and is safe to ingest directly with the product. Several studies have shown that edible coatings can be used to transport food additives such as anti-browning agents, antimicrobials, colors, flavorings, and nutrients [27].

The difference between the two is that the edible coating layer is placed and made directly on the surface of the food, while, whereas the film is a thin layer that is applied after being printed in sheet form previously [28].

Essential oils are commonly used as additional components in the production of protein-based edible films. Protein cannot be used alone to form an edible film because proteins are not biopolymers, It cannot be utilized alone to form edible films [30]. Essential oil used as a source of lipids not only improves the hydrophobic quality but also increases the air barrier ability. Vegetable oils such as olive oil, sunflower oil, rapeseed oil, and others are used as essential oils [29].

Figure 3: Keyword Co-occurrence mapping

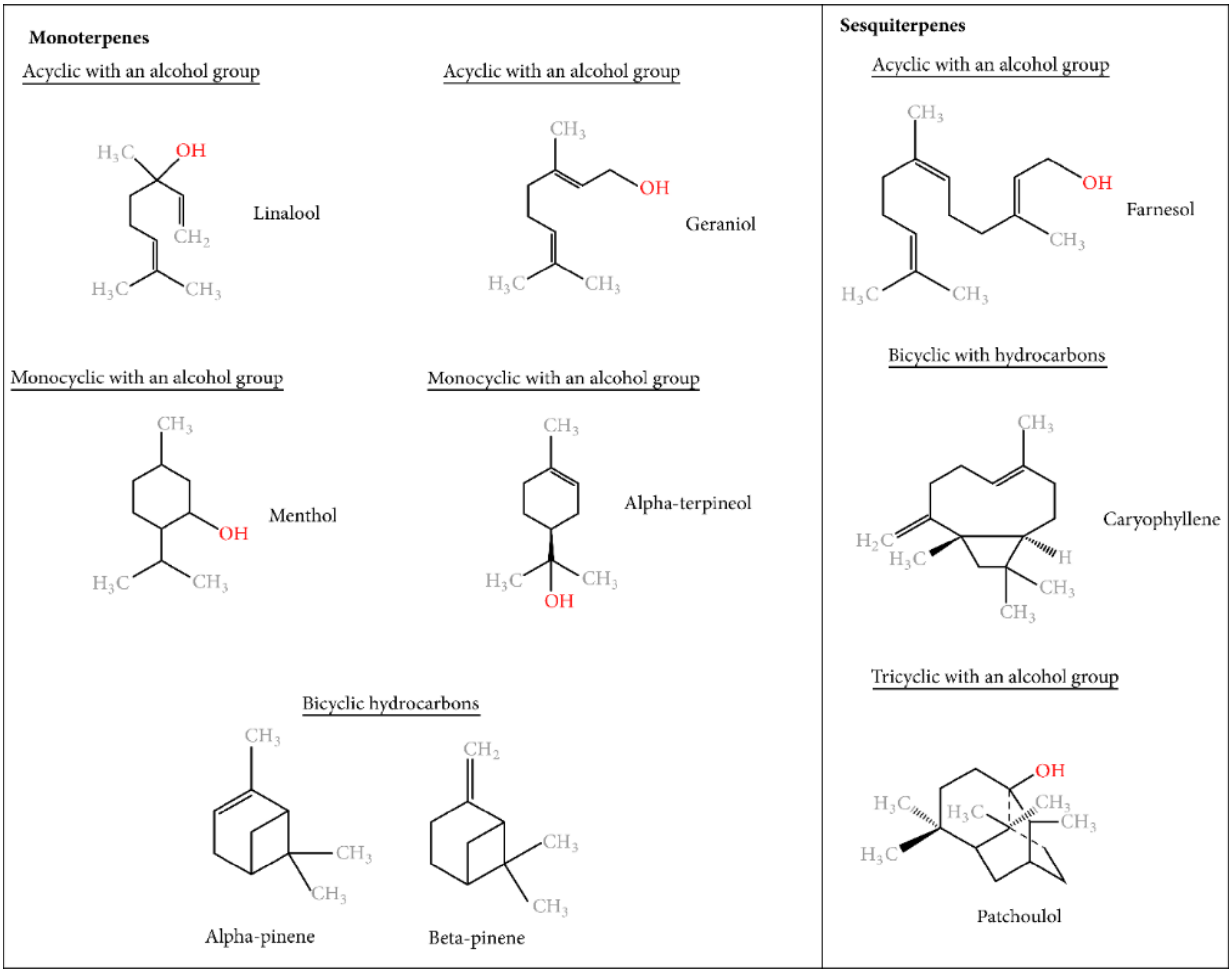


Group 3. The top keywords in the third cluster (blue) are Essential oils with 168 links and 330 total link strength. Essential oils also became the owner of the highest occurrence among all the keywords analyzed, which were 356 (48%) articles from 744 articles. Among all the keywords related to essential oils in this cluster are biomass, biodiesel, and biofuel, which are environmentally friendly fuels. So that this cluster also discusses the use of essential oils as an energy source. Raw Materials for Making Biofuel are usually made from corn oil, sunflower oil, neem oil, karanja oil, palm oil, soybean oil, jatropha oil, and olive oil [31].

Recognizing the urgency of reducing emissions while fulfilling the needs of businesses, researchers and scientists agreed that renewable energy is the best contender to meet society's needs in the future, with hydrogen being one of the candidates. In research by

Kelly-Yong et al. (2007) [32] discuss the availability of palm oil biomass that may be turned into hydrogen as a sustainable energy source via a gasification reaction in supercritical water with an annual global production of approximately 184.6 million tons of oil palm biomass. The maximum theoretical yield of hydrogen that can potentially be produced by oil palm biomass is 2.16×10^{10} kg H_2 year^{-1} with an energy content of 2.59 exajoule (EJ) year^{-1}. These results show that palm oil fulfills nearly 50% of the current global hydrogen demand.

Figure 4: Chemical structure of essential oils [16].



Group 4. The fourth cluster focuses on essential oil production methods. This can be seen from the top keyword in this cluster distillation with 144 links and 84 total link strength. Distillation also has an occurrence of 87 (12%) articles from 744 articles. By examining the keywords associated with this cluster, it can be seen that the concentration of the topic is on a variety of essential oil production methods.

The Soxhlet extraction method also has several drawbacks, including the need for organic solvents to extract essential oil content which results in an increase in oil production costs. In addition, extracting the complete essential oil content takes a long time, making it less efficient.

Microwave Assisted Extraction is a new extraction process invented by Daniswara et al. (2017) [33] that uses a distillation apparatus and microwave heating. Microwave hydrodistillation, microwave steam distillation, microwave steam diffusion, and solvent-free microwave extraction were all derived from this approach. The microwave hydrodistillation method was used in this investigation. The purpose of this research is to investigate and compare the processes of extracting essential oils utilizing microwave hydrodistillation and Soxhlet extraction methods.

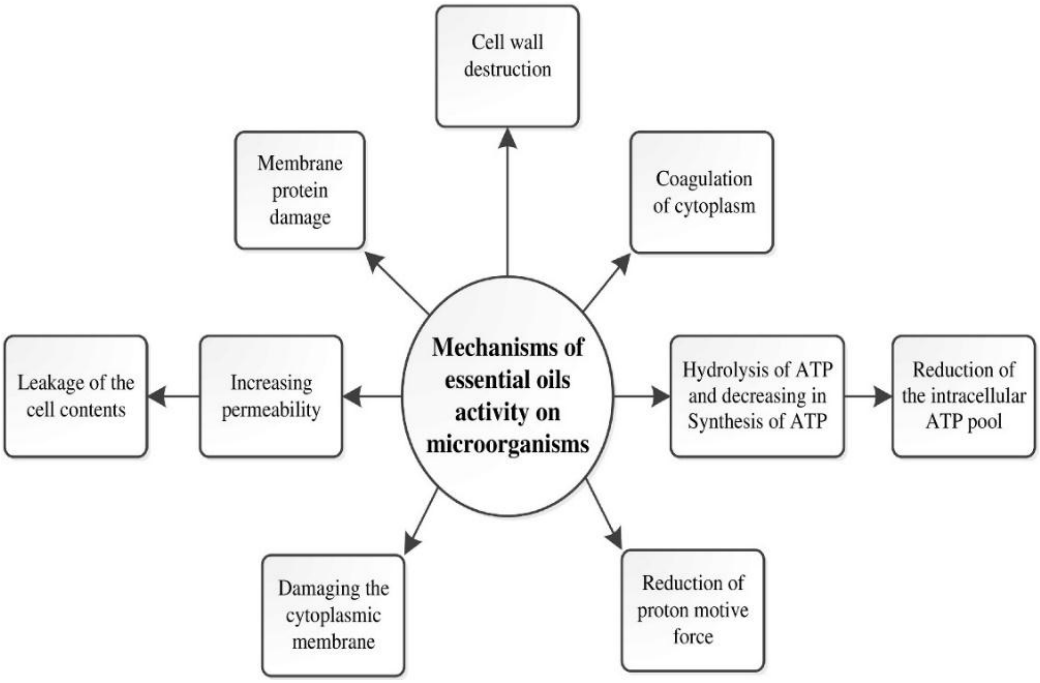


Figure 5: Mechanism of antimicrobial activity of essential oils [34]

Co-authorship refers to author collaboration, which is a key feature in encouraging teamwork among diverse scientific researchers to boost productivity and obtain new scientific knowledge. Collaboration among co-authors might be intramural (between departments, institutions, or research groups) or extramural (international collaboration) [35]. This analysis is a powerful method for identifying leading authors in a specific research area. VOSviewer software can be used to examine scientific articles from co-authors to exhibit research collaboration through picture visualization [36].

In this analysis, the total number of authors was 2503 in 744 publications. In this analysis, there is also a limitation, namely setting the minimum number of articles published by the author (individually) to three. Thus 153 authors met the threshold. In the image visualization, each node represents an author and the node size indicates the number of published articles. The link that connects the two nodes indicates the cooperative relationship between the two authors, and the thickness of the link indicates the intensity of the cooperation. As can be seen in Figure 6 there are 56 clusters representing 153 authors. However, in this analysis, the three most prominent clusters among all clusters were taken, namely cluster 1 (green) with 7 items, cluster 2 (yellow) with 7 items, and cluster 3 (red) with 8 items.

In the first cluster in Figure 7, Mahfud, m. as the main author, is connected with six other authors in the cluster, namely Kusuma, h.s.; Putri, d.k.y.; Dewi, i.e.p.; Variyana, y.; Bhuana, d.s.; and Altway, a. The highest link strength was recorded for Mahfud, m. (n = 6) which means he has collaborated during research with all members of this cluster. The next highest link strength is Kusuma, h.s (n = 4) who has collaborated with Mahfud, m.; Putri, d.k.y.; Dewi, i.e.p.; and Altway, a. In addition, Mahfud, m. and Kusuma, H. are the most prolific authors with several publications 27 and 19. Due to the low number of co-authored publications in this cluster, we found weak link strength as noted by Variyana, y.; Bhuana, d.s.; and Altway, a. (n = 2).

The second cluster is yellow where there are 7 related items in total. If Khasanah, l.u. used as a focal point, it can be seen that he is connected with six other authors named Praseptiangga, d.; Utami, r.; Manuhara, g.j.; Kawiji; Setiawan, a.; and Muhammad d.r.a.

The highest link strength was recorded for Utami, r. (n = 5) who has collaborated with all members in this cluster except Praseptiangga, d. The weakest link strength is Setiawan, an (n = 2). This is shown in Figure 8.

The third cluster in red in Figure 9 is Yusiati, l.m. considered as the main author, and other authors, namely Hanim, c.; Agus, a.; Daning, d.r.a.; Suhartanto, b.; Hadianto, i.; Kurniawati, a.; and Widyobroto, b.p. The highest link strength was recorded for Yusiati, l.m (n = 8) which means that she has conducted research collaborations with all members of this cluster as well as in other non-dominant clusters namely Widodo, w. (grey cluster). The next highest link strength is Hanim, c. (n = 6) who had collaborated with all members of the third cluster except Widyobroto, b.p. Because, the low number of publications also affects the strength of weak links, namely in Daning, d.r. (n = 3).

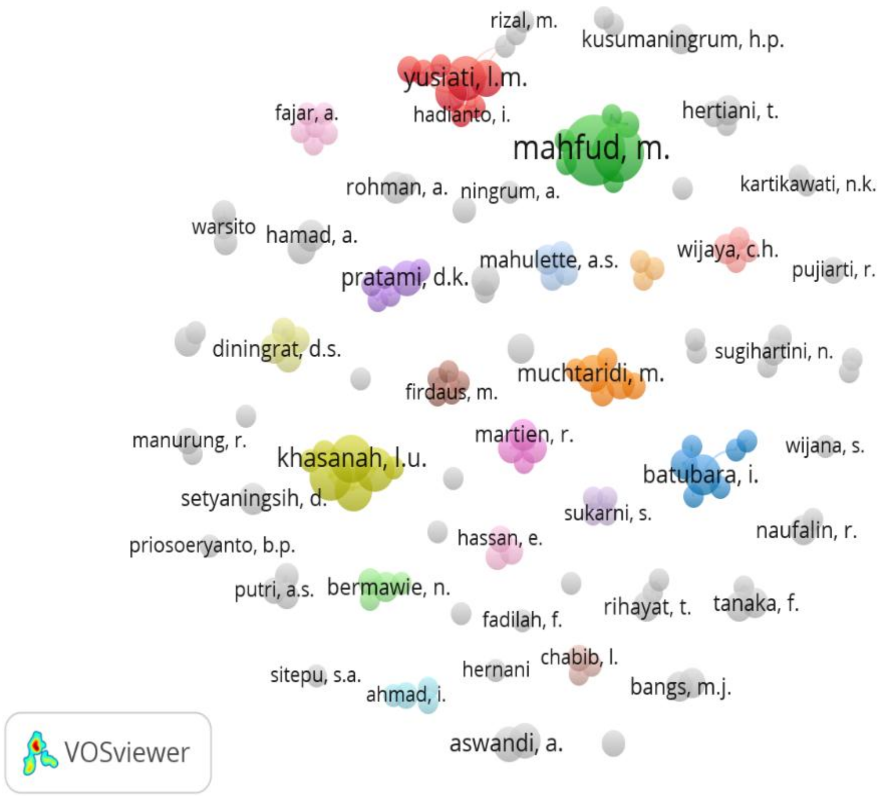


Figure 6: Mapping of author - co-authorship.

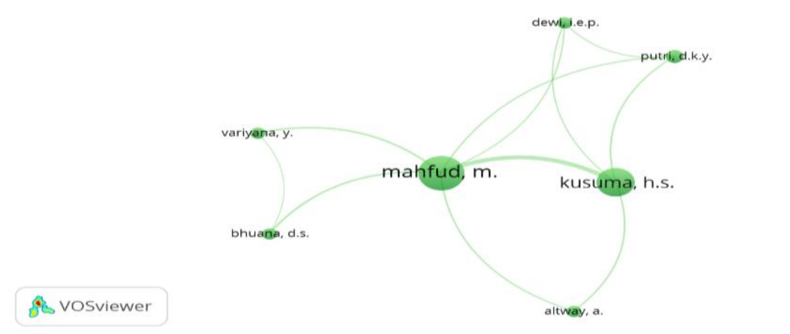


Figure 7: Mapping of the first cluster co-authorship.

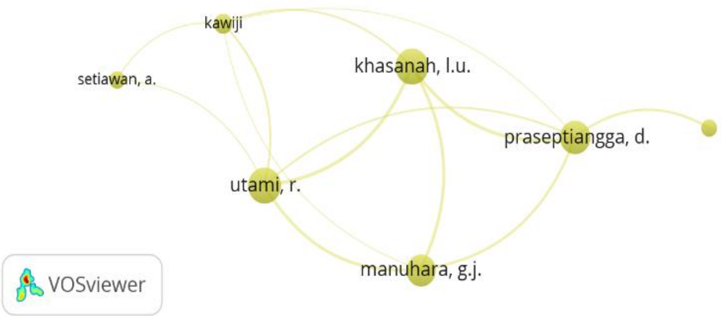


Figure 8: Mapping of the second cluster co-authorship.

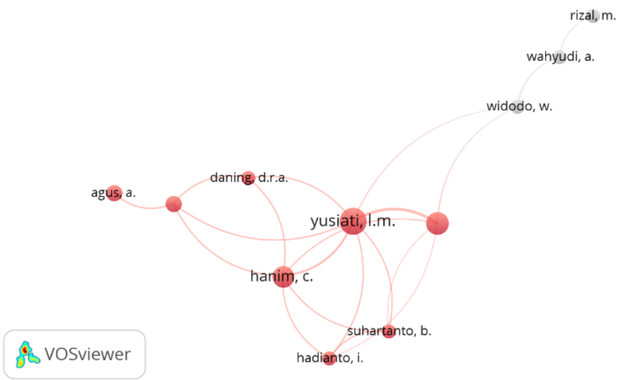


Figure 9: Mapping of the third cluster co-authorship.

4. Future Trends

The development of essential oil research can be seen from the increasing number of studies and the variety of studies conducted by researchers. However, additional study is still required in the research process to probe certain unexplored areas. Among them is Ezeorba et al. (2022) [37] on *the potential for health and therapeutic benefits of garlic essential oils*, where more research is needed to develop research on several bioactivities, such as the fibrinolytic and cardioprotective activities of garlic, as well as toxicity studies on garlic, which are still uncommon. In addition to the use of essential oils, research in other areas has advanced, such as Reis et al. (2022) [38] on *Encapsulated essential oils: A perspective in food preservation*, which intends to encapsulate essential oils to keep their quality during delivery. In this study, more research on the efficiency of essential oils packaged in various matrices, as well as the adverse effects of employing encapsulated essential oils, is required.

Then there is also research on food packaging by Sharma et al. (2021) [39] on *Essential oils as additives in active food packaging which uses essential oils as bioactive to replace synthetic preservatives*. Several researchers are also increasingly raising this topic because of the positive results of combining essential oils and packaging fields. As Doğan et al. (2022) [40] discussed the use of lavender essential oil in developing nanofibers for food packaging (*Novel active food packaging based on centrifugally spun nanofibers containing lavender essential oil: Rapid fabrication, characterization, and application to preserve minced lamb meat*), then there is also research on the use of essential oils from star anise for food packaging (*Cross-linked* *gluten/zein nanofibers via Maillard reaction with the loading of star anise essential oil/β-cyclodextrin inclusions for food-active packaging*) by Zhang et al. (2022) [41]. Then there is Boro et al. (2022) [42] who has published an article entitled "*Synthesis and characterization of poly(lactic acid)/clove essential oil/alkali-treated halloysite nanotubes composite films for food packaging applications namely the use of clove essential oil*" and many more.

With these developments, it is clear that essential oil research will continue to expand in the future because there are still various elements that need to be researched. Furthermore, the incorporation of essential oils into food packaging has a good impact on the environment. The use of essential oils as bioactive food packaging transforms the role of synthetic preservatives and converts packaging into biodegradable packaging, which will aid in the problem of difficult-to-decompose inorganic waste pollution. So that it can build a clean and healthy environment on Earth.

5. Conclusions

Bibliometric analysis was used to examine the relationship and research trends of essential oils. Based on the performance analysis of 744 articles taken from Scopus, this research can claim that this research topic has only begun to develop rapidly since 2019. This is proven by the number of publications which has always been more than 100 documents per year since that year and publication data reached its peak in 2021 with 170 publications. With this number, the average number of documents issued per year in the span of 25 years is 33 publications. In addition, the performance analysis concluded that Universitas Gadjah Mada is an affiliated institution with the most publications, namely 76 publications (8%), and Mahfud, M. is the most prolific author with a total of 27 publications.

Meanwhile, in scientific and network analysis, it is known that in Co-occurrence mapping 6.700 keywords make up the four main clusters, namely cluster 1 (red) discussing compounds in essential oils and their bioactivity test, cluster 2 (green) describing the bioactivity of oils and the application of essential oils in the food packaging industry, cluster 3 (blue) on the use of essential oils as an energy source, and cluster 4 (yellow) focusing on the method of producing essential oils. Meanwhile, in the Co-authorship mapping, the total number of authors is 2503 which is divided into three dominant clusters. Namely, cluster 1 (green) has 7 items, cluster 2 (yellow) also has 7 items, and cluster 3 (red) has 8 items with the most dominant authors in each cluster being Mahfud, m., Khasanah, l.u., and Yusiati, l.m.

Future trends indicate that essential oil research, along with the development of publications and the author's interest in this field, will continue to be a trend in the future. Although many parts of this topic have yet to be thoroughly researched, this is what draws researchers to conduct research and gather data for future studies.

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