ANALYSIS OF ESSENTIAL OIL COMPOUND CONTENT OF FENNEL SEEDS (*Foeniculum vulgare* Mill.) AND LAVENDER (*Lavandula angustifolia*) USING THE GS-MS METHOD

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ABSTRACT

Fennel seeds (*Foeniculum vulgare* Mill.) and lavender (*Lavandula angustifolia*) is a part of of aromatic plants that produce essential oils with various biological activities and are widely used in the pharmaceutical, cosmetic, and aromatherapy industries. Identification of compounds in essential oils can be done using Gas Chromatography-Mass Spectrometry (GC-MS), which offers high sensitivity and excellent separation capabilities. This study aims to obtain essential oils from fennel seeds and lavender through steam distillation methods and analyze their chemical compound content using GC-MS. Essential oils were obtained through steam distillation for 7 hours and then the yield percentage was calculated, the results showed that the yield of fennel seed essential oil was 1.05% and lavender was 0.51%. The results of GC-MS analysis showed that fennel seed essential oil contained 10 identified compounds, with the compounds with the highest area percentage being benzene, 1-methoxy-4-(1-propenyl) (anethole) at 45.60%, methyl chavicol at 26.60%, 1,2,3-trimethyl bicyclo[2.2.1]heptan-2-ol at 20.63%, and limonene at 3.06%. Meanwhile, lavender essential oil contains 39 identified compounds, with eucalyptol having the highest area percentage at 34.41%, followed by bicyclo[2.2.1]heptan-2-one,1,7,7-trimethyl at 14.10%, α-bisabolol at 12.19%, linalool at 10.85%, and bicyclo3.1.1heptane, 6,6-dimethyl-2-methylene at 5.26%. The results showed that the GC-MS method was effective in identifying the compound profiles of fennel and lavender essential oils.

Keywords: 1; Essential oils 2; Fennel Seeds 3; GC-MS 4; Lavender 5; Steam Distillation

INTRODUCTION

Essential oils are volatile vegetable oils with a distinctive aroma, characterized by being insoluble in water or highly hydrophobicity. Essential oils are often used as raw materials for perfumes or natural therapeutic massage oils. Essential oils can be obtained from all parts of the plant, including flowers, leaves, seeds, bark, fruit, roots, or rhizomes (Chandra *et al*., 2024).

Fennel seeds (*Foeniculum vulgare* Mill.) is a plant from the apiaceae family that is widely used as a traditional medicine and aromatherapy. Fennel seed essential oil is known to contain phenylpropanoid compounds such as anethole and estragol, as well as other terpenoid compounds. GC-MS analysis results indicate that anethole is a major component of fennel essential oil. Furthermore, fennel essential oil has been reported to possess antibacterial activity, making it potentially useful as a natural ingredient in the pharmaceutical and health sectors (Nurrahman *et al*., 2021).

Lavender (*Lavandula angustifolia*) is an aromatic plant widely used in aromatherapy and cosmetic products. Lavender essential oil is known to have a calming effect, helping reduce stress, improve sleep quality, and promote relaxation. This activity is associated with the volatile compounds contained in lavender essential oil, such as linalool, linalyl acetate, eucalyptol, and other terpenoids (Putriyanti *et al*., 2024).

Essential oils are generally obtained through a distillation process, one of which is steam distillation. This method is widely used to extract essential oils from aromatic and medicinal plants because the process is relatively simple, the equipment is easy to operate, and it can produces high-quality essential oils. In steam distillation, water vapor generated from a boiler passes through the plant material, carrying the volatile components of the essential oil with the steam. This is then condensed into a mixture of oil and water, which is then separated to obtain the essential oil (Suyono & Pranowo, 2024)

Essential oils contain various volatile compounds that contribute to their biological activity and aroma characteristics. Therefore, an analytical method capable of accurately identifying the components of essential oils is needed. Gas Chromatography–Mass Spectrometry (GC-MS) is an instrumental analytical technique that combines gas chromatography and mass spectrometry to separate, detect, and identify chemical compounds in a sample. Gas chromatography separates components based on their volatility and interactions with the column's stationary phase, while mass spectrometry determines molecular structure through ion fragmentation patterns. This method is widely used in the analysis of volatile organic compounds, especially essential oils, due to its high sensitivity, selectivity, and identification accuracy (Indahyani *et al.*, 2024).

Based on this description, this study aims to obtain essential oils from fennel seeds (*Foeniculum vulgare* Mill.) and lavender (*Lavandula angustifolia*) through steam distillation and analyze the chemical compounds content of both oils using Gas Chromatography–Mass Spectrometry (GC-MS) method to obtain information about the main components of the essential oils.

METHODS

This research is a laboratory experiment, with the production of essential oils carried out at the Tawangmangu Traditional Service Functional Implementation Unit (UPF) and analysis of the content of essential oil compounds of fennel seeds and lavender using Gas Chromatography-Mass Spectrometry (GC-MS) instruments at the Organic Chemistry Laboratory of the Faculty of Mathematics and Natural Sciences, Gadjah Mada University. The tools used in this study include a set of water vapor distillation equipment consisting of a condenser, gas stove, thermometer, and separating funnel. In addition, micropipettes, sample vials, and a Shimadzu QP2010 SE Gas Chromatography-Mass Spectrometry (GC-MS) instrument are used to identify the compounds that make up essential oils. The main materials used in this study are dried fennel seeds and lavender obtained from the Telogo Dringo Gondosuli Aromatic Garden, Karanganyar Regency, Central Java Province.

Extraction

A total of 6,000 grams of dried fennel seeds and 6,000 grams of fresh lavender were placed in a kettle on a distillation apparatus. Next, add distilled water to the distillation apparatus. After ensuring that the sample and solvent are in the kettle on the distillation apparatus, close the distillation apparatus. Next, carry out the distillation process until the essential oil is visible after evaporation. The extraction results are then calculated as a percentage yield using the following formula:

$$\%\ \text{Yield} = \frac{\text{essential oil produced (ml)}}{\text{weight of raw materials used (gr)}} \times 100\%$$

Analysis of Essential Oils Using the GC-MS Method

Samples of Fennel and lavender essential oils were placed in a GC-MS vial, then 1 µL of the sample was injected into the Shimadzu GC-MS instrument through the inlet. The sample was carried by the carrier gas to the column and separated based on its interaction with the column's stationary phase. Components with higher migration rates were released first, while those with slower migration rates were released last. The separated compounds were then detected and a chromatogram was generated. Compound identification was performed based on the mass spectrum, molecular weight, and retention time (Rt) by comparing the results obtained with the mass spectrum library on the GC-MS system. The relative concentration of each component was expressed based on the percentage of peak area (% area) in the chromatogram (Mulyanti *et al*., 2023).

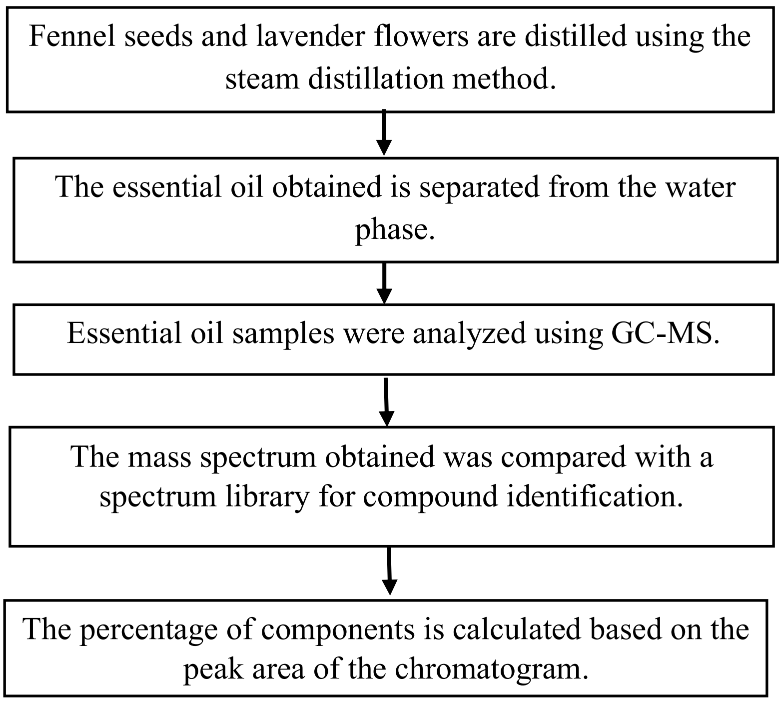
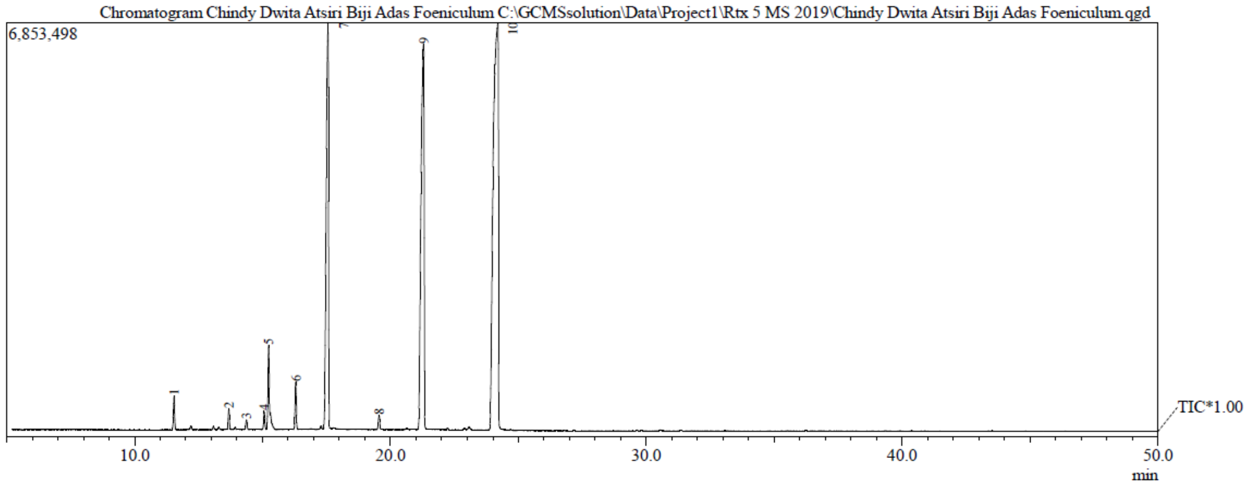


Figure 1. Research Flow

RESULTS

Table 1. Steam Distillation Extraction Results of Fennel and Lavender Seed Essential Oils

Sample	Sample Weight (grams)	Oil Volume (ml)	Yield (%)
Fennel Seeds	6.000 grams	63 ml	1,05 %
Lavender	6.000 grams	30,8 ml	0,51 %



Peak Report TIC

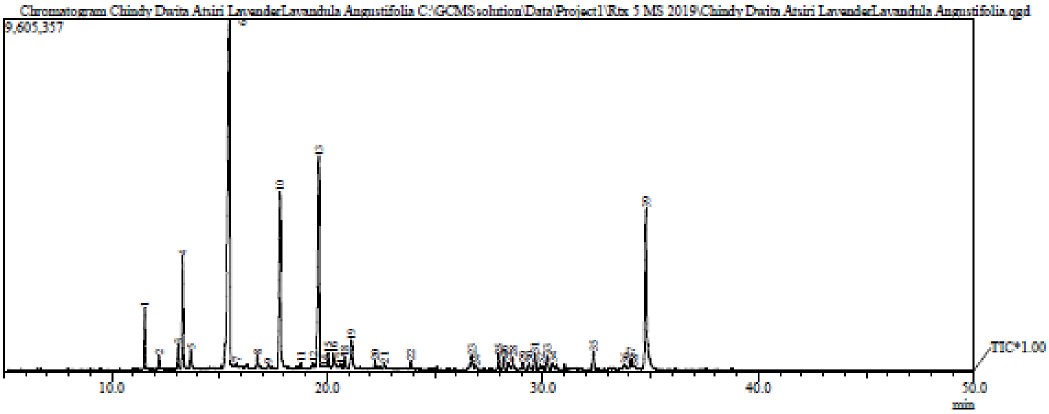
Peak#	R.Time	I.Time	F.Time	Area	Area%	Height	Name
1	11.541	11.433	11.625	1878267	0.92	558160	.alpha.-PINENE
2	13.682	13.600	13.792	1171566	0.57	354737	MYRCENE
3	14.372	14.292	14.475	564047	0.28	164049	.alpha.-Phellandrene
4	15.067	14.967	15.142	1048527	0.51	304593	l-Phellandrene
5	15.239	15.142	15.492	6254282	3.06	1396222	l-LIMONENE
6	16.298	16.192	16.392	2813173	1.38	792438	1,4-Cyclohexadiene, 1-methyl-4-(1-methylethy
7	17.557	17.367	17.683	42132014	20.63	6732267	l-1,2,3-Trimethylbicyclo 2.2.1 -2-heptanol
8	19.555	19.458	19.650	936172	0.46	241709	Bicyclo 2.2.1 heptan-2-one, 1,7,7-trimethyl-, (
9	21.296	21.042	21.433	54333878	26.60	6385224	METHYL CHAVICOL
10	24.173	23.850	24.375	93139008	45.60	6653558	Benzene, 1-methoxy-4-(1-propenyl)-
				204270934	100.00	23582957	

Figure 2. Results of Analysis of Fennel Seed Essential Oil Using the GC-MS Method

Table 2. Highest Peak in GC-MS Results of Fennel Seed Essential Oil

Peak	R.Time	Area %	Height	Compound Name
10	24.173	45,60	6653558	Benzene, 1-methoxy-4-(1propenyl) (Anethole)
9	21.296	26,60	6385224	Methyl Chavicol
7	17.557	20,63	6732267	1,2,3-Trimethylbicyclo [2.2.1]heptan-2-ol
5	15.239	3,06	1396222	Limonene

Based on the results of GC-MS analysis, it was shown that fennel seed essential oil contains 10 compounds detected based on the chromatogram. The highest identified peak was Benzene, 1-methoxy-4-(1-propenyl) (anetol) with an area percentage of 45.60%.



Peak Report TIC

Peak#	R.Time	I.Time	F.Time	Area	Area%	Height	Name
1	11.538	11.400	11.650	5787925	2.60	1670760	.alpha.-PINENE
2	12.201	12.100	12.283	1277008	0.57	369572	Camphene
3	13.082	12.975	13.175	2502102	1.12	706565	SABINENE
4	13.300	13.175	13.467	11718315	5.26	3065912	Bicyclo 3.1.1 heptane, 6,6-dimethyl-2-methyle
5	13.679	13.600	13.833	1983199	0.89	527559	MYRCENE
6	15.474	15.158	15.692	76681932	34.41	9472122	Eucalyptol
7	15.821	15.692	15.917	599949	0.27	117182	1,3,7-OCTATRIENE, 3,7-DIMETHYL-
8	16.768	16.683	16.900	1410723	0.63	368895	CIS-SABINENEHYDRATE
9	17.274	17.175	17.392	600820	0.27	114726	.alpha.-terpinolene
10	17.817	17.650	18.075	24167567	10.85	4787228	LINALOOL L
11	18.784	18.692	18.875	622347	0.28	165643	.ALPHA.-CAMPHOLENE ALDEHYDE
12	19.357	19.308	19.425	633535	0.28	154982	HEXYL ISOBUTYRATE
13	19.618	19.425	19.750	31411657	14.10	5782541	Bicyclo 2.2.1 heptan-2-one, 1,7,7-trimethyl-, (
14	19.875	19.750	19.958	890925	0.40	89208	1-Heptadecyne
15	20.045	19.958	20.133	1816120	0.82	405082	Bicyclo 3.3.1 heptan-3-one, 6,6-dimethyl-2-me
16	20.290	20.133	20.467	2798081	1.26	422921	3-Cyclohexene-1-methanol, .alpha.,.alpha.4-tri
17	20.622	20.467	20.742	1006525	0.45	135983	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl
18	20.817	20.742	20.975	1447220	0.65	331532	HEXYLBUTYRATE
19	21.127	20.975	21.383	4961410	2.23	783506	l-.alpha.-Terpineol
20	22.224	22.125	22.308	820096	0.37	240973	HEXYL-2-METHYLBUTYRATE
21	22.644	22.500	22.750	601440	0.27	142677	Benzaldehyde, 4-(1-methylethyl)-
22	23.878	23.808	24.000	924447	0.41	216050	Bicyclo 2.2.1 heptan-2-ol, 1,3,3-trimethyl-, ace
23	26.707	26.533	26.825	2471997	1.11	396580	1-Naphthalenol, 1,2,3,4,4a,7,8,8a-octahydro-1
24	26.901	26.825	27.058	577900	0.26	103093	.BETA. BOURBONENE
25	27.958	27.842	28.050	1597778	0.72	413180	trans-Caryophyllene
26	28.180	28.050	28.275	1318023	0.59	329888	.alpha.-Bergamotene
27	28.381	28.275	28.533	1211852	0.54	193125	.beta.-sesquiphellandrene
28	28.602	28.533	28.675	1313672	0.59	328620	1,6,10-Dodecatriene, 7,11-dimethyl-3-methyle
29	29.081	29.000	29.192	803594	0.36	196211	P-MENTHA-TRANS-2,8-DIEN-1-OL
30	29.366	29.267	29.450	810943	0.36	191531	.alpha.-Cubebene
31	29.632	29.450	29.742	1883036	0.85	455269	GERMACRENE-D
32	29.882	29.742	29.950	662309	0.30	148018	trans-Caryophyllene
33	30.202	30.108	30.342	1772443	0.80	373845	Bicyclo 7.2.0 undec-4-ene, 4,11,11-trimethyl-8
34	30.444	30.342	30.575	1020451	0.46	175865	.alpha.-amorphene
35	32.363	32.225	32.492	2354611	1.06	502313	CARYOPHYLLENE OXIDE
36	33.789	33.700	33.958	937546	0.42	114403	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-me
37	34.084	33.958	34.192	1751309	0.79	268076	2-Furanmethanol, tetrahydro-.alpha.,.alpha.,5-t
38	34.242	34.192	34.408	503886	0.23	85072	.delta.-Guaiene
39	34.782	34.600	35.258	27172819	12.19	4356318	.alpha.-Bisabolol
				222827512	100.00	38703026	

Figure 3. Results of Lavender Essential Oil Analysis Using the GC-MS Method

Tabel 3. Highest Peak in GC-MS Results of Lavender Essential Oil

Peak	R.Time	Area%	Height	Compound Name
6	15.474	34.41	9472122	Eucaplyptol
13	19.618	14,10	5782541	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl
39	34.782	12,19	4356318	α-Bisabolol
10	17.817	10,85	4787228	Linalool
4	13.300	5,26	3065912	Bicyclo 3.1.1 heptane, 6,6-dimethyl-2-methylene

The GC-MS analysis showed that lavender essential oil contained 39 compounds detected in the chromatogram. The highest peak identified was eucaplytol, with an area percentage of 34.41%.

DISCUSSION

Fennel and lavender seed essential oils are obtained through steam distillation, an extraction method that utilizes hot steam to evaporate volatile compounds contained in plant material, then condenses them into a mixture of essential oil and water. This method is widely used in essential oil extraction because it does not require organic solvents and is capable of producing essential oils f good quality. The application of steam distillation to fennel and lavender seeds is considered appropriate because both materials contain volatile compounds that are easily carried away by the steam flow. In this study, the distillation process was carried out for approximately 7 hours to optimize essential oil recovery. Distillation time is one of the factors that affect essential oil yield, n addition to material size, water content, temperature, pressure, and the effectiveness of the condensation process. Thus, the distillation process not only affects the amount of essential oil produced but can also affect the composition of chemical compounds identified in GC-MS analysis.

The steam distillation process of 6,000 grams of material produced 63 mL of fennel seed essential oil with a yield of 1.05%, while the yield of lavender essential oil was 30.8 mL with a yield of 0.51%. The higher yield of fennel seed essential oil compared to lavender indicates that each material has a different ability to produce essential oils. This difference in yield is thought to be related to the natural essential oil content contained inthe material and the effectiveness of the release of volatile compounds during thedistillation process. In addition, the yield of essential oils can also be influenced by several factors, such as material characteristics, particle size, water content, and the conditions of the distillation process used (Hamidi et al., 2024).

The results of the extraction using the steam distillation method produce oil that will be analyzed for essential oil content using the GC-MS method. The reason for using the GC-MS method is able to separate, detect, and identify volatile compounds in a sample based on the retention time and resulting mass fragmentation patterns. Analysis with GC-MS also requires a relatively fast time, does not damage the sample, has high sensitivity so it can separate various compounds even in low levels or concentrations.

The results GC-MS analysis of fennel seed essential oil revealed 10 identified compound peaks. Each peak in the chromatogram represents a component of the essential oil that elutes at a specific retention time. Based on the identification results, the compound with the highest area percentage was found in peak 10 with a retention time of 24.173, namely benzene, 1-methoxy-4-(1-propenyl) (anethole) at 45.60%. The high area percentage indicates that anethole is the compound with the highest area percentage in the steam-distilled fennel seed essential oil. Anethole belongs to the phenylpropanoid group which is known to play a role in providing the distinctive sweet aroma of fennel. In addition to anethole, other identified compounds were methyl chavicol at 26.60%, 1,2,3-trimethylbicyclo[2.2.1]heptan-2-ol at 20.63%, and limonene at 3.06%. The presence of these compounds indicates that fennel seed essential oil is dominated by phenylpropanoid and terpenoid compounds which contribute to the characteristic aroma of fennel.

The results of GC-MS analysis of lavender essential oil showed 9 identified compound peaks. Chromatogram data showed that the compound with the highest area percentage was found in peak 6 with a retention time of 15.474 minutes, namely eucalyptol at 34.41%. Eucalyptol or 1,8-cineole is a monoterpene compound known to have a fresh aroma and is found in many types of essential oils. In addition to eucalyptol, other compounds were identified in quite large quantities. are bicyclo[2.2.1]heptan-2-one,1,7,7-trimethyl at 14.10%, α-bisabolol at 12.19%, linalool at 10.85%, and bicyclo 3.1.1 heptane, 6,6-dimethyl-2-

methylene at 5.26%. α-bisabolol is known to belong to the sesquiterpene alcohol group, widely used in cosmetics and pharmaceuticals. Meanwhile, linalool is a volatile compound that plays a key role in lavender's distinctive aroma, contributing to its relaxing effect, calming the nervous system, and improving sleep quality.

The GC-MS method has proven effective in identifying volatile compounds found in essential oils. The resulting chromatograms are able to show the number of components and the relative proportions of each compound based on the peak areas formed. The results of the GC-MS analysis indicate that the essential oils of fennel and lavender have different chemical profiles. Differences in the composition of essential oil compounds can be influenced by geographical factors, climatic conditions, plant varieties, harvest time, and extraction methods.

CONCLUSION

Based on research conducted, essential oils from fennel seeds (*Foeniculum vulgare* Mill.) and lavender (Lavandula angustifolia) were successfully obtained through steam distillation for approximately 7 hours. From 6,000 grams of material, 63 mL of fennel seed essential oil was obtained with a yield of 1.05%, while 30.8 mL of lavender essential oil was obtained with a yield of 0.51%. These results indicate that fennel seeds produce a higher yield of essential oil than lavender.

Analysis using the Gas Chromatography–Mass Spectrometry (GC-MS) method showed that fennel seed essential oil contained 10 identified compounds, with the compound with the highest area percentage being anethole at 45.60%, followed by methyl chavicol at 26.60%, 1,2,3-trimethylbicyclo[2.2.1]heptan-2-ol at 20.63%, and limonene at 3.06%. Meanwhile, lavender essential oil contains 39 identified compounds, with the compound with the highest area percentage being eucalyptol at 34.41%, followed by bicyclo[2.2.1]heptan-2-one,1,7,7-trimethyl at 14.10%, α-bisabolol at 12.19%, linalool at 10.85%, and bicyclo 3.1.1 heptane, 6,6-dimethyl-2-methylene at 5.26%. The results of this study indicate that the GC-MS method is effective for identifying the components of fennel and lavender essential oils and providing information on the profile of the compounds contained therein.

REFERENCES

1. Chandra, P. P. B., Efrilia, M., & Handayani, I. A. (2024). Formulasi Sediaan Roll On Aromaterapi Kombinasi Minyak Atsiri Krangean (Litsea cubeba (Lour) Pers.) Dan Minyak Atsiri Lavender (Lavandula angustifolia Miller). *Jurnal Insan Farmasi Indonesia*, *7*(1), 95–104. https://doi.org/10.36387/jifi.v4i1.1947
2. Dika, D. R. (2020). Perancangan Alat Penyulingan Minyak Nilam Kondensor Dan Separator. *Jurnal Teknik Mesin*, *9*(1), 15–23. https://doi.org/10.22441/jtm.v9i1.6815
3. Fatmawati, A., Zuliyati, I. C., & Mulyaningsih, S. (2021). Formulasi dan Evaluasi Sediaan Roll On Aromaterapi Blended Peppermint, Lavender dan Lemon sebagai Antiemetika. *Inpharnmed Journal (Indonesian Pharmacy and Natural Medicine Journal)*, *5*(2), 8–16. https://doi.org/10.21927/inpharnmed.v5i2.1904
4. Hamidi, Z., Sribudiani, E., & Pramana, A. (2024). *Rendemen dan kualitas minyak atsiri pucuk merah dengan metode penyulingan uap*. *42*(2), 19–28.
5. Indahyani, N., Natasha, L., Nurmawati, A., & ... (2024). Optimasi Waktu Distilasi Air dan Rasio Bahan Baku pada Ekstraksi Minyak Atsiri Daun Serai Dapur (Cymbopogon citratus). *Jurnal Integrasi* …. https://jurnal.untirta.ac.id/index.php/jip/article/view/29086
6. Khasanah, U., Shalas, A. F., Rifai, B., Ihsan, P., Farmasi, D., Kedokteran, F., & Brawijaya, U. (2022). *Peningkatan Nilai Ekonomi Tanaman Adas (Foeniculum vulgare) Melalui Penyulingan Minyak Atsiri*. *2*(2), 63–69.

https://doi.org/10.21776/ub.jtridharma.2022.002.02.63
7. Latifah, F., Taufiq, H., & Fitriyana, M. (2023). Uji Antioksidan dan Karakterisasi Minyak Atsiri dari Kulit Jeruk Purut (Citrus hystrix D. C). *JPSCR: Journal of Pharmaceutical Science and Clinical Research,* *8*(1), 46–62. https://doi.org/10.20961/jpscr.v8i1.67396
8. Mulyanti, N., Hidayaturahmah, R., & Marcellia, S. (2023). Analisis Minyak Atsiri Pada Kulit Kayu Manis (Cinnamomum Burmanii) Dengan Metode Gass. *Jurnal Farmasi Malahayati*, *6*(2), 203–210.
9. Nurrahman, A., Pamudji, W. G., & Ikasari, E. D. (2021). *Optimasi Emulgel Minyak Atsiri Adas (Foeniculum vulgare Mill.) Sebagai Anti Jerawat. Media Farmasi Indonesia*. *16*(1), 1632–1642. https://doi.org/10.53359/mfi.v16i1.170
10. Putriyanti, A., Mulyani, Y., Yunita, S. R. I. D., Ernawati, H. W., Rinaldi, M. D., Ulfah, R. R. M., Jungjunan, R. A., Septiani, Y., & Budiana, W. (2024). Review Jurnal: Pemanfaatan Lavender (Lavandula angustifolia Mill.) Sebagai Aromaterapi. *Farmaka*, *22*(3), 396–406. https://jurnal.unpad.ac.id/farmaka/article/view/55655
11. Suyono, A., & Pranowo, D. (2024). Proses Ekstraksi Minyak Atsiri pada Kunyit (Curcuma Domestica Val .). *Talenta Conference Series: Energy and Engineering (EE)*, *7*(1). https://doi.org/10.32734/ee.v7i1.2183