

## Analysis Of Essential Oil Compound Content Of Fennel Seeds (*Foeniculum Vulgare* Mill.) And Lavender (*Lavandula Angustifolia*) Using The Gs-MS Method

Chindy Dwita Ningrum, Bangkit Riska Permata, Anna Fitriawati

Bachelor of Pharmacy, Faculty of Health Sciences, Duta Bangsa University Surakarta, Indonesia

Email: [chindydwita1234@gmail.com](mailto:chindydwita1234@gmail.com)\*

### ABSTRACT

Fennel seeds (*Foeniculum vulgare* Mill.) and lavender (*Lavandula angustifolia*) is a part 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%,  $\alpha$ -bisabolol at 12.19%, linalool at 10.85%, and bicyclo[3.1.1]heptane, 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: Essential oils; Fennel Seeds; GC-MS; Lavender; Steam Distillation

This is an Open Access article licensed under the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are properly cited

## 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 produce 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  $\mu\text{L}$  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 ( $R_t$ ) 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).

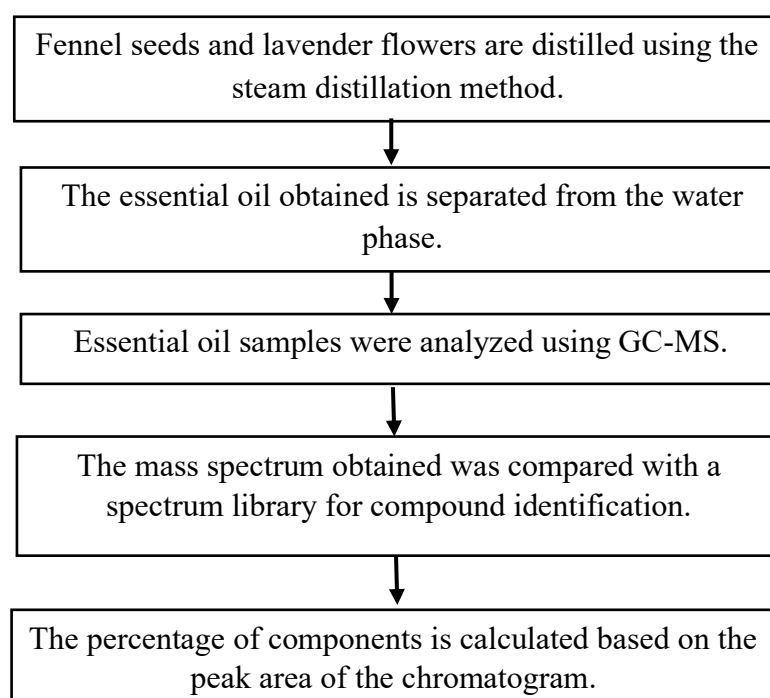
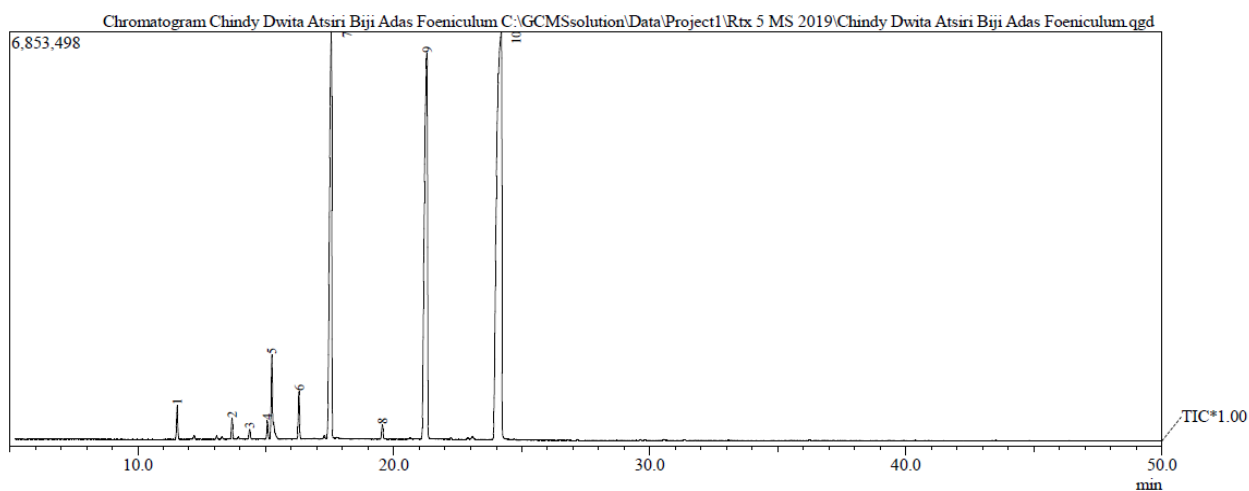


Figure 1. Research Flow

## 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# | 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   | 1-Phellandrene                                  |
| 5     | 15.239 | 15.142 | 15.492 | 6254282   | 3.06   | 1396222  | 1-LIMONENE                                      |
| 6     | 16.298 | 16.192 | 16.392 | 2813173   | 1.38   | 792438   | 1,4-Cyclohexadiene, 1-methyl-4-(1-methylethyl)- |
| 7     | 17.557 | 17.367 | 17.683 | 42132014  | 20.63  | 6732267  | 1,1,2,3-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%.

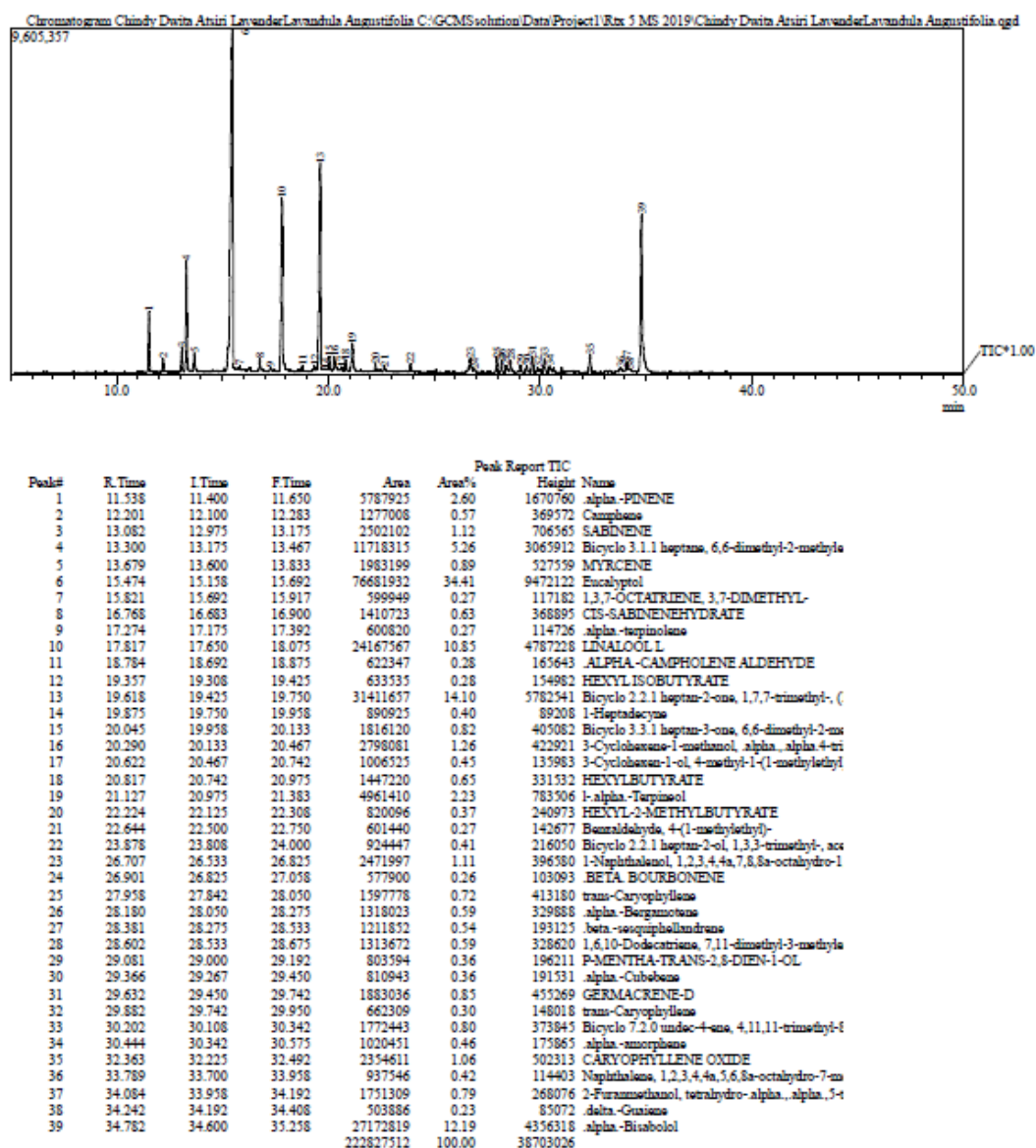


Figure 3. Results of Lavender Essential Oil Analysis Using the GC-MS Method

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 eucaplyptol, 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 of 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, in 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 in the material and the effectiveness of the release of volatile compounds during the distillation 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%,  $\alpha$ -bisabolol at 12.19%, linalool at 10.85%, and bicyclo 3.1.1 heptane, 6,6-dimethyl-2-



methylene at 5.26%.  $\alpha$ -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%,  $\alpha$ -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 Kranglean (*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. *Inpharmmed Journal (Indonesian Pharmacy and Natural Medicine Journal)*, 5(2), 8–16. <https://doi.org/10.21927/inpharmmed.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., Nurawati, 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>