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Optimization of Distillation Process for Scale-up Production of Lavender Essential Oil: A Literature Review

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Abstract

Lavender essential oil being one of the most used essential oils. Oxygenated monoterpenes are the largest constituent of lavender essential oil and the determinant of the characteristic aroma produced. Lavender flowers are composed of several ingredients, such as essential oils, alpha-pinene, beta-myrcene, limonene, cineol, linalool, terpinine-4-ol, and linalyl acetate. The aim of this study is to develop an efficient, effective, and profitable method of lavender oil extraction that can be used for commercial scale production, in order to determine which method is most suitable for scale-up production. The method used in this study is literature review with the results of literature reviews conducted, the method with the highest percentage of essential oil components is the use of innovative methods such as extraction with the help of microwaves (MW) with the percentage of linalool (32.90%) linaly acetate (27%), extraction with the help of ultrasonic (AS) with the percentage of linalool (37.6%), linalyl acetate (18.4%)., supercritical fluid extraction (SF) with linalool (24%), extraction, and negative pressure extraction (NPCE) with linalool percentage (27.18%) linaly acetate (25.23%). While the smallest percentage of essential oil components in the use of molecular distillation is the percentage of Linalool (4.56%), linaly acetate (12.78%). The originality of this research contribution can open the door for further research and wider practical applications.

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INTRODUCTION

Essential oils have evolved since 3000 years ago with various uses. Essential oils are used as the basic ingredients of antimicrobial and aroma therapy that is typical of some processed products (Nugraha et al., 2019). Indonesia is known as a world producer of essential oils since the XV century. Indonesian essential oils trade has reached the continent of Europe. Indonesia exports 66. 742.46 tons of essential oil in 2011 with a value of 438.16 million US$. Based on Trade Statistics data from the Ministry of trade of the Republic of Indonesia, exports of essential oils, cosmetics, and Indonesian fragrances in 2018 amounted to US$ 779.2 million and increased by 8.8% from 2017. The value of agricultural exports in 2021 increased by US$123.0 million, up 2.99 percent compared to 2020. This increase was mainly due to the increase in exports of medicinal plants and essential oils by 23.80 percent or an increase of US$147.2 million (Badan Pusat Statistik Indonesia, 2021). Aromatic compounds contained in essential oils make it potential to be developed widely (Agustien et al, 2021).

Currently, the demand for aromatherapy products is increasing among the public. The current demand for essential oils for the general industry is 60 %, the flavor industry is 20%, and the medical industry is 20%. But behind the high demand, most of the quality of essential oils from traditional refiners does not meet international standards (Emalia et al., 2023). Improving the quality of Indonesian essential oils is carried out in export destination countries. In addition, Indonesia's essential oil agro-industry still revolves around the problem of production continuity, farmers and essential refiners are not yet professional, conventional production techniques, low quality, and the development of downstream essential industries (Fitri & Mohammad, 2015). The competitiveness of Indonesian essential oils is still relatively low, this is reflected in the low productivity caused by efficiency factors that have not been successfully achieved and the certainty of supply has not been guaranteed. More than 80 kinds of essential oils circulating in the World Trade. While in Indonesia, there are 12 types of essential oils exported to the world market, one of which is lavender (Efendi et al., 2014).

Lavender essential oil is one of the most widely used essential oils so that it becomes the most beneficial special plant (I. A. M. Dewi & Masfuri, 2021). Lavender flowers are widely used for the manufacture of cosmetics, in addition to brighten the skin, prevent acne, relieve symptoms of skin diseases, lavender is also known as one of the aromatherapy agents that are very effective to provide a relaxing effect (Sari et al., 2022). Fresh lavender flowers contain about 0.7-14% essential oil. Lavender essential oil is a clear liquid, pale yellow in color. Essential oils obtained from the flowers have a softer fragrance than essential oils obtained from leaves or other plant parts (Nuriska et al., 2023).

Oxygenated monoterpenes make up the largest constituent of lavender essential oil and determine the characteristic aroma produced. Common monoterpenoids in lavender essential oil are alcohols, esters, ketones, and oxides (Eslahi et al., 2017). Lavender flowers are composed of several contents, such as essential oil, alpha-pinene, camphene, beta-myrcene, cymene, limonene, cineol, linalool, borneol, terpinine-4-ol, linalyl acetate, geranyl acetate, and caryophyllene. The main component in lavender essential oil is linalool, either esterified in the form of linaly acetate or free. The linaly content determines the superior or inferior quality of lavender essential oils and these constituents play a role in determining the floral sensory peculiarities of lavender oil (Nuriska et al., 2023).

The potential of lavender oil needs to be optimized to increase the productivity of essential oils continuously. However, the main problem in the development of essential oils in Indonesia is low quality and quality and quantity are not increasing. One of the factors that affect the quality of the essential oil content is the selection of the type of distillation method used (Caroline, 2022). Comparative investigations have also shown that the distillation method can also affect the parameters and extraction efficiency of lavender essential oil. The selection of distillation method used to be one of the quality benchmarks of the content of essential oils produced (L. K. Dewi et al., 2018). In addition to the extraction method, the treatment of raw materials before refining, the size of the material, the amount of material, the duration of the distillation process and fertilization are also factors that affect the quality of the oil produced. Optimization of extraction methods is necessary to obtain essential oils that have high quality and high percentage of yield (Nugraha et al., 2019).

The essential oil industry continues to evolve along with the evolving technology and find new methods of extracting essential oils to produce optimum oil (Sulaiman, 2014). It is becoming a challenge to produce high-quality aromatherapy based on essential oils (non-synthetic) without chemicals that negatively affect health and the environment (Putri et al., 2020). Various methods and ways to extract lavender oil have been widely practiced. The two conventional methods of essential oil extraction are hydrodistillation and steam distillation. Both methods use heat to evaporate the oil, allowing the oil to escape from the plant. The separation of water and oil is made possible by the difference in density of the two components. A comparative study showed that the steam distillation method produces oil of good quality, but with a higher concentration of camphor compared to other methods, while using hydrodistillation produces a higher content of linalool (Sulaiman, 2014). The use of distillation method is growing over time to find new methods to extract essential oils so as to produce optimum oil. Innovation form of hydrodistillation method is the method of hydrodistillation with the help of cellulase.

Hydrodistillation with the help of cellulase is one of the methods to produce optimum essential oils. This method provides the highest quality oil yield as well as being more efficient in terms of energy consumption, although the extraction time is longer due to the pre-treatment stage (Minyak et al., 2022). In addition, before these methods can be used for commercial processes, they must be assessed on a small laboratory scale to determine their feasibility for large-scale oil production. The results of small-scale experiments can be used to predict which method is most suitable for commercial-scale production (Haryono et al., 2018).

Traditional extraction procedures (such as heat reflux (HR) extraction, maceration, and soxhlet extraction) are widely used in the food industry. However, this procedure takes a long time and requires a lot of Labor, and requires a large amount of organic solvents that are expensive and ecologically hazardous, can cause thermosensitive degradation, and incur large disposal costs (Rohinjead et al., 2016). Microwave assisted extraction (MW), ultrasonic assisted extraction (AS), supercritical fluid extraction(SF), pulsed electrical energy assisted extraction (PEE), and accelerated solvent assisted extraction have recently been introduced to reduce organic solvent utilization and extraction time (Vorbeiv and Lebovka 2013; Rohinjead et al., 2016). Therefore, this study aims to develop an efficient, effective and profitable method of lavender oil extraction that can be used for commercial scale production.

Indonesia is the third largest producer of essential oils in the world after France and China. The essential oil business, particularly in the production of lavender, is wide open, when tight will lead to a well-off economy. The very wide use of essential oils in the cosmetic, aromatherapy and medicinal industries allows us to conclude that this industry has bright opportunities. Therefore, optimize distillation, not only a way to improve performance, but also a way to reduce production costs, reduce waste, more competitive in the global market. Originality of contribution this research makes an original contribution to the field of study by presenting new and innovative findings that have never been seen before. These findings may open the door to further research and wider practical applications.

METHOD

The research method used is literature study which is a method of problem identification, literature search, and data analysis by digging and collecting systematic data. Data collection was done by searching various references both national and international articles with online databases published in the last 10 years (2014-2024). This literature study uses 10 relevant articles that contain data on the methods used to extract lavender flowers into essential oils and contains the percentage of lavender essential oil content produced from various methods used. In addition, journals relevant to the topic were obtained by searching the database using the keywords "essential oils", "Essential oils", "lavender essential oil" and "lavender essential oil extraction methods".

For this paper we have collected various perspectives, approaches, and research results from various authors and institutions. With this number, it is enough to describe the difference in methods, findings, and recommendations on the topic discussed. In a variety of ways, these things make the literature review more representative and play more into it. So that we can give a comprehensive view of the direction of research development. Exclusion criteria in this review is the type of plant extraction methods other than lavender flowers, the content and percentage of compounds are not described, taken from the thesis and the year less than 2014.

RESULTS AND DISCUSSION

Lavender essential oil is known for its calming aroma and antimicrobial and antioxidant properties that makes it in demand in cosmetic, health and pharmaceutical industries. This makes lavender essential oil one of the high value oil in the global market. However to produce high quality product, distillation process must be well controlled. So research on distillation optimization has practical impact to the industry. Distillation process basically utilizes the difference in boiling point of components to separate essential oil from plant material. For lavender essential oil, the common distillation method is steam distillation. Using factorial design to identify the effect of combination of several parameters (such as temperature, pressure, water ratio and time) on the distillation result. This gives detailed data on how each parameter affect each other and the range for each factor. With experimental data, mathematical model such as surface response or optimization using genetic algorithm can be applied. This model helps in predicting the result and minimize the number of experiment. Mathematical model based simulation also can give visualization to understand the optimum point that produce the best essential oil.

Based on the results of the review, several extraction methods that can be used to obtain lavender essential oil were obtained.

Table 1. Table of review

Code	Title of article	Bibliography	Type of Methods
1	Extraction of Essential Oils from *Lavandula × intermedia* 'Margaret Roberts' Using Steam Distillation, Hydrodistillation, and Cellulase-Assisted Hydrodistillation: Experimentation and Cost Analysis	Minyak, E., Roberts, M., Distilasi, M., Berbantuan, H., Eksperimen, S., Wainer, J., Thomas, A., & Chimhau, T., 2022 (Wainer et al., 2022)	Stem distillation, Hydrodistillation, and Cellulase-Assisted Hydrodistillation
2	Essential Oil Extraction From Lavender Using Negative Pressure Cavitation Extraction And Coating To Extend Grape Shelf Life	Owais Gul, Aamir Hussain Dar, Kshirod Kumar Dash, GVS BhagyaRaj, Shafat Ahmad Khan, Umar Sultan, Wani Suhana Ayoub, Insha Zahoor, Shahid Rasool, Madhuresh Dwivedi (Gul et al., 2023)	Conventional steam distillation and negative pressure extraction
3	A solar steam distillation system for extracting lavender volatile oil	Radwan, M. N., Morad, M. M., Ali, M. M., & Wasfy, K. I., 2020 (Radwan et al., 2020)	Solar steam distillation
4	Molecular Distillation of Lavender Supercritical Extracts: Physicochemical and Antimicrobial Characterization of Feedstocks and Assessment of Distillates Enriched with Oxygenated Fragrance Components	(Dębczak et al., 2022)	Molecular Distillation and supercritical fluid extraction

5	Supercritical Fluid Extraction of Lavender (Lavandula angustifolia): Optimization of the Extraction Process and Phenolic Content Analysis	Ty, K., Konkol, M., Superkritis, D. E., Nowych, I., Chemicznych, S., Akademik, E., & Shellie, R., 2019 (Tyśkiewicz et al., 2019)	Extraction with supercritical fluid
6	Efek Ekstrak Lavender (Lavandula Angustifolia) terlihat Nyata (Culex SP.) sebagai Diffuser Organik	Jeni Susi Sihite (Sihite, 2022)	Steam Distillation
7	Analysis and characterization of Lavender and Peppermint essential oil by Gas chromatography-mass spectroscopy (GC-MS)	Ni Made Sukma Sanjiwania, Dewa Ayu Ika Paramithab, Agung Ari Chandra Wibawac , I Made Dedy Ariawand , Ni Wayan Trisna Dewie , Ni Made Dewi wahyunf , I Wayan Sudiarsag (Ariawan et al., 2020)	Gas Chromatography
8	Aroma Characteristics of Lavender Extract and Essential Oil from Lavandula angustifolia Mill	Xianyang Guo, Pu Wang (Guo & Wang, 2020)	Steam Distillation
9	Optimization of Microwave-assisted Extraction of Essential Oil from Lavender Using Response Surface Methodology	Bing Liu, Jihong Fu,Yan Zhu, and Ping Chen (Liu et al., 2018)	Hydrodistillation (HD) and Microwave-Assisted Hydrodistillation (MAHD)
10	Ohmic Accelerated Steam Distillation Of Essential Oil From Lavender In Comparison With Conventional Steam Distillation	Mohsen Gavahian and Yan-Hwa Chu (Gavahian & Chu, 2018)	ohmic accelerated steam distillation (OASD

After searching the article, then analyze the extraction method and the percentage of lavender essential oil compounds in each study that has been conducted, as follows.

Table 2. Extraction method and the percentage of lavender essential oil extracted

Code	Type of Methods	Content
1	Steam distillation, hydrodistillation, and cellulase-assisted hydrodistillation	Stem distillation: 1,8-cineole (14,18%), linalool (13,67%) Hydrodistillation: 1,8-cineole (15,6%), linalool (21,89%) cellulase-assisted hydrodistillation: 1,8-cineole (26,82%), linalool (20,18%)
2	Conventional steam distillation and negative pressure extraction (NPCE)	NPCE: Linalool (27,18%) Linaly asetat (25,23%) Conventional: Linalool (24,62%), linaly asetat (17,23%)

Code	Type of Methods	Content
3	Solar Steam Distillation	Linalol (37,6%) linaly asetat (12,78%), Terpineol-4-ol (3,3%) and Cymene (5,4%)
4	Molecular distillation and supercritical fluid extraction	Linalool (4,56%), linaly asetat (12,78%)
5	Extraction with supercritical fluid .	Linalool (24%)
6	Steam Distillation	Linalool (28,96%), lavandulol (3,56%), linaly asetat (37,03%), lavanduly asetat (4,12%) and E-β caryophyllene (3,73%)
7	Gas Chromatography	Linalool (24,60%)
8	Steam Distillation	Linalool (16,82%), linaly asetat (46,76%)
9	Hidrodistilation (HD) and Microwave-Assisted Hydrodistillation (MAHD)	Linalool (32,90%) linaly asetat (27%)
10	Ohmic Accelerated Steam Distillation (OASD)	linalool (37,6%), linalyl asetat (18,4%). Terpineol-4-ol (3,3%) and Cymene (5,4%) t

Based on the data obtained, all lavender essential oils contain 1,8-cineole, linalool, and linaly acetate which are quite dominant compared to other ingredients. The percentage of the main component of lavender essential oil is found in the most innovative new methods such as extraction with the help of microwaves (MW) with the percentage of linalool (32.90%) linaly acetate (27%), ultrasonic extraction with the percentage of linalool (AS) (37.6%), linalyl acetate (18.4%), supercritical fluid extraction (SF) with linalool (24%), extraction, and negative pressure extraction (NPCE) with acetate (25.23%). While the smallest percentage of essential oil components in the use of molecular distillation is the percentage of Linalool (4.56%), linaly acetate (12.78%).

The compound content in Study 1 showed mixed results. the results were influenced by several methods used, namely steam distillation, hydrodistillation, and cellulase-assisted hydrodistillation. the diversity of the results of these three methods is influenced by the extraction time. Extraction time refers to the total distillation time, starting from room temperature, temperature rise until when the separator reaches 200 mL, that is, excluding the pre-treatment time. The mean extraction times for steam distillation, Hydro distillation, and cellulase-assisted hydrodistillation were 57 -, 51 -, and 49 minutes (L. K. The goddess et al., 2018). Cellulase-assisted hydrodistillation has the shortest extraction time. In this method, the plant mixture is already at a temperature of 40 °C after pretreatment, which explains why the plant mixture heats up and boils faster. Shorter extraction times are more desirable to reduce costs (Fachrudin et al., 2016); however, it should be noted that the total process time for cellulase-assisted hydrodistillation is significantly longer than for other methods due to the 45-minute pre-treatment stage.

Differences in the process of the three extractions will affect the quality of the oil produced. Oil quality is determined by detecting the main compounds in the oil and their concentration (Sipahelut, 2019). To determine the concentration of various components in the oil sample then proceed through the analysis of GC-MS. GC-MS analysis identifies up to 35 components in each oil sample, but most have a peak area lower than 5% of the total Peak area. The concentration of the main components contained in the oil samples in this study are linalool, 1,8-cineole and camphor. The oil samples on the chromatogram showed unusually high terpinolene content in three oil samples. Meanwhile, in Study 6, steam distillation method was also used which resulted in the extraction of lavender flower essential oil by steam distillation method with the main components in lavender essential oil consisting of linalool (28.96%), lavandulol (3.56%), linaly acetate (37.03%), lavanduly acetate (4.12%) and E-β caryophyllene (3.73%) using KG-MS analysis.

Research 1 more terpinolenya content. The most obvious reason is that these oil samples actually contain more terpinolene. Terpinolene is characterized by high antimicrobial and antifungal activity (Lupia et al., 2024). Therefore, the high content of terpinolene indicates that this oil is suitable for use as an ingredient in soaps and detergents. Terpinolene is also effective as a sedative, which makes this oil effective in aromatherapy. Another explanation for the high terpinolene content is that initially there was linalool in the sample, but it was converted to terpinolene when stored. Linalool can be chemically rearranged into a carbocation, which can then be converted into terpinolene, which is more stable. Some samples were stored for up to three weeks before being analyzed, so linalool was likely converted to terpinolene (Nguyen et al., 2020).

Therefore, it is justified to interpret the concentration of terpinolene as the concentration of linalool. This interpretation means that all samples contain 1,8-cineole, linalool and camphor as the main elements. The higher camphor content and lower linalool concentration across the oil samples in the study suggest that Margaret Roberts ' lavender oil is preferred for soaps, detergents, aromatherapy, and Phytotherapy, and will not be widely used for perfumes and cosmetics.

Extraction becomes the most basic technique to extract bioactive compounds from plant sources. Steam distillation method became one of the traditional extraction procedures used in Study 2 and then compared with negative pressure extraction. The essence of this negative pressure extraction method is in the cavitation process. The rupture of cavitation bubbles causes a strong local shock and pressure wave, which in turn damages the plant cell wall, allowing internal chemicals to escape into the solvent (Mounika et al., 2022). The extracted solution, now including the target chemical, must be isolated from the rest of the solid plant material and solvent after the extraction procedure so that the pure form of the desired is obtained. To determine the components present in lavender essential oil, it was analyzed using GC-MS. Based on the results of GC-MS analysis, the detected components come from several categories with varying amounts. The extracted essential oil contains monoterpenes, monoterpene isoprenoids, and sesquiterpenes.

In the case of negative pressure cavitation extraction, the main content of essential oil is linalool (oxygenated monoterpene) and linalyl acetate with values of 27.12% and 25.23%, respectively. The amount of linalool and linalyl acetate in conventional hydrodistillation was 24.61% and 17.23%, respectively. Lower values of linalool and linalyl acetate during conventional hydrodistillation may be due to partial degradation of linalyl acetate. Compared to traditional hydro distillation, negative pressure cavitation removal was found to be a faster and energy efficient way to extract essential oils from lavender (Hedayati et al., 2024). Negative pressure cavitation (NPCE) extraction produces lavender essential oil with higher bioactive components than conventional hydrodistillation.

The yield of obtaining essential oils is higher with NPCE than with conventional hydrodistillation. The total phenolic content and antioxiandt properties of lavender essential extract collected by NPCE are much higher compared with traditional hydrodistillation. The yield of lavender essential oil was 2.13°0.03 achieved by using the following extraction temperature of 40◦C and extraction period of 45 minutes at 70% ethanol solvent concentration with negative pressure of -30 kPa and nitrogen pressure of 15 kg/cm2. The total phenolic content of the extracted NPCE sample was observed to be 73.17°0.97 mg GAE / 100ml. The IC50 value of lavender essential oil extracted using NPCE was obtained at 328.86°0.13 micrograms/mL.

Extraction methods have evolved more and more over time. Now, there is a new extraction process that is ohmic accelerated steam distillation (OASD) in 10 studies designed with the help of ultrasonics. OASD can be considered as a potential energy and time saving alternative compared to conventional steam distillation methods. Accelerated ohmic steam distillation overcomes the disadvantages of the previously proposed ohmic-assisted hydrodistillation method, including the possibility of electrochemical reactions between the electrode and the extraction medium, the limited applied frequency range, the need to use expensive corrosion-resistant electrodes (Gavahian & Chu, 2018). Therefore, this method is potentially applicable to SD which is the preferred industrial extraction technique for many essential oils.

Based on the results of the analysis, there are 49 volatile compounds detected in both essential oils extracted and covering 99.5% of the total Peak area. Linalool with a percentage of 16.3 ° 1.6 a, 1.8-cineole 14.4 ° 0.8 A and camphor 13.0 ° 0.6 A are the main components of lavender essential oil. Good results in terms of process time and energy used for OASD as the new technique reduces respectively 55% and 58% of time and process energy used. In contrast to OAHD, the separation of plant materials and ohmic electrodes eliminates the potential negative effects of electrochemical reactions and corrosion electrodes on phytochemicals and allows exploration of a wide range of electrical field frequencies, higher electrolyte concentrations, and low-cost electrode materials.

Research 3 used a solar steam distillation method built for use in extracting essential oils with a simple design and high efficiency. The results of this study show that the solar steam distillation system has proven to be an effective way to extract high quality lavender essential oil by producing system productivity of 7.3 ml, system efficiency of 60.25%, extraction efficiency of 98.13%, and essential oil yield of 0.785% (w/w). The final quality of lavender essential oil resulting from this study shows that the chemical properties of lavender essential oil extracted by solar system construction approximately meet the quality standards. The results showed that the content of linalool is 37.6% higher than the content of linalyl acetate is 18.4%. The content of Linalool (37.6%), Terpineol-4-ol (3.3%) and Cymene (5.4%) is in accorandce with the standard of lavender oil ISO 3515: 2002.

While the content of Linalyl acetate in lavender plants is lower than the standard lavender oil ISO 3515: 2002. Camphor content of 7.3% does not meet the standard of lavender oil ISO 3515: 2002. The composition of the essential oil of the lavender plant varies depending on many factors, among them the technology of oil extraction. A solar steam distillation system takes two hours to extract oil from a batch size of 400 g, while it takes about three and four hours to extract oil from a batch size of 600 and 800 g, respectively (Radwan et al., 2020). Based on the results obtained, it is recommended to use a solar steam distillation system to extract lavender essential oil due to its high extraction efficiency accompanied by high product quality.

The results of research 4 extraction of lavender essential oil using molecular distillation method combined with supercritical fluid extraction. Molecular distillation is a type of vacuum distillation that separates mixtures of components based on their different volatilities. Whereas supercritical fluid extraction allows processing of plant materials at low temperatures, thus limiting thermal degradation and avoiding the use of toxic solvents (Drabińska et al., 2023). In this study, supercritical fluid extraction was combined with molecular distillation mainly to enrich the scco2 extract with lavender oxygenated monoterpenes, avoid thermal degradation or hydrolysis and solvent contamination, and maintain the natural characteristics of the oil obtained.

The results of this study certify the quality of the lavender extraction results with an increase in pressure of up to 30 Mpa at a temperature of 40 °C, causing the CO_2 density to also increase, which favors a higher extraction result and a marked solubility of the most characteristic lavender—smelling molecular group-oxygenated monoterpenes, that is, ester or alcohol components. the composition of the extract was determined through qualitative analysis of GC-MS. Analysis of GC-MS revealed the presence of more than sixty different compounds in the extract, some of the components of which are β-caryophyllene, β-caryophyllene oxide, α-santalene, α-santalol, β-santalol, β-farnesene, α-bergamotene, nerolidol, α-bisabolol, tau-cadinol, ledene oxide-(II), etc.

Linalool and linalool acetate being the main components of lavender oxygenated monoterpenes and are the most abunandt components. However, the percentage differs from one extract to another. The targeted compounds represented the lowest percentage composition in the case of L-Bg-E samples with 4.56% and 12.78% for linalool and linalool acetate, respectively. The highest percentages of linalool; linalool acetate and lavandulol; lavandulol acetate and terpinen-4-ol were confirmed in the case of L-Pl-E (17.02; 25.68; 1.40, 3.96 and 6.02%, respectively). The best results for high-quality distillates were obtained at 85 °C (EVT) and confirmed that the linalyl acetate content increased from 51.54 mg/g (early Bulgarian lavender extract, L-Bg-E) and 89.53 mg/g (early Polish lavender extract, L-Pl-E) to 118.41 and 185.42 mg/g, respectively, which corresponds to an increase of 2.3 and 2.1-fold, respectively, in both distillate streams. Lavandulol and its acetate are in great demand in the cosmetics and perfumery industry, as they give the oil a sharp, rosaceous floral aroma. Therefore, higher levels of natural oils can significantly increase their price.

Extraction of lavender essential oil using supercritical fluid extraction method was conducted in Study 5. Extraction with supercritical fluid is an efficient separation technique that depends on several aspects such as the type of mobile phase (pure or modified), process parameters (temperature, pressure, time), and the type of raw material and pretreatment. This technique is most commonly used to extract lavender essential oil. Optimization of extraction parameters was carried out to increase the content of phenolic compounds in lavender flowers. While in Study 7, the results of the study stated that there was 24.60% linalool content in lavender essential oil which was analyzed using GC-MS.

Research 8 for extraction of lavender essential oil using steam distillation method. Steam distillation is a distillation process with water as a source of hot steam contained in a "boiler" which is located separately from the distillation boiler. The steam produced has a higher pressure than the outside air pressure. The aroma compounds identified in the Sensory Evaluation and aroma analysis of the final lavender extract, including linalyl acetate (46.76%), lavandulyl acetate (14.21%), lavandulol (1.54%), linalool (16.82%), linalool oxide I (0.90%), and linalool oxide II (1.20%), accounted for 97.84% of the total amount of volatiles, and the relative content of camphor%.

Hydrodistillation (HD) and Microwave-Assisted hydrodistillation (MAHD) methods. Microwave-Assisted hydrodistillation (MAHD) method to extract lavender essential oil was conducted in study 9. This method is a continuation level of hydrodistillation with a technique that uses microwave energy and water to extract the desired compounds from the plant material. In addition, the chemical composition of the essential oil was analyzed using Gas chromatography-mass spectrometry (GC-MS). The parameters used in the MAHD extraction were microwave power (400-700 W), extraction time (10-40 min) and liquid to solid ratio (6-22 mL/ g), where the effect of each parameter was investigated in a single factor experiment.

CONCLUSION

Lavender flowers contain about 0.7-14% essential oil with components as diverse as, essential oil, alpha-pinene, camphene, beta-myrcene, cymene, limonene, cineol, linalool, borneol, terpinine-4-ol, linalyl acetate, geranyl acetate, and caryophyllene. The main component in lavender essential oil is linalool, either esterified in the form of linaly acetate or free. The linaly content determines the superior or inferior quality of lavender essential oil and these constituents play a role in determining the floral sensory peculiarities of lavender oil. Based on the literature review conducted, the method with the highest percentage of essential oil components is the use of innovative methods such as extraction with the help of microwaves (MW) with the percentage of linalool (32.90%) linaly acetate (27%), extraction with the help of ultrasonic (AS) with the percentage of linalool (37.6%), linalyl acetate (18.4%)., supercritical fluid extraction (SF) with linalool (24%), extraction, and negative pressure extraction (NPCE) with linalool percentage (27.18%) linaly acetate (25.23%). While the smallest percentage of essential oil components in the use of molecular distillation is the percentage of Linalool (4.56%), linaly acetate (12.78%).

This study provide guidance to run the distillation parameters in the perfume factory in an optimal way., In this way it may be able to help in improving the performance and reducing the energy consumption of the appliance., While at the same time the mag-thirteen oil trading system measured the distance for pygame Nisarga Adobe or as a flag merunting udata O Mo which in its place was located as a small dog. A discovery of this diamater can bring tremendous local product competitiveness in the heady market, and this will have a positive economic impact on the Jasmine grass farming community as well as the domestic industry.

RECOMMENDATIONS

This research can still be continued by examining in more detail about what affects each method so that the essential oil produced is more optimal.

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