KONVERSI
Homepage:
https://ppjp.ulm.ac.id/journal/index.php/konversi

Characterization of essential oil from red citronella leaves (*Cymbopogon nardus L.*)

Akhmad Permadi Wicaksono, Fadila Ardiansyah Afandi, Guardiola Rosa Wira, Mayla Fayzza Adzani, Nove Kartika Erliyanti*

Department of Chemical Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia

ARTICLE INFO

Article history:
Received: 31 July 2024
Received in revised form: 19 October 2024
Accepted: 21 October 2024

Keywords:
Cymbopogon nardus L., essential oil, ultrasound microwave-assisted extraction, NaCl salt solution

ABSTRACT

Citronella leaves are generally processed using conventional methods to obtain its essential oil. UMAE (Ultrasound-Microwave Assisted Extraction) method can be a replacement of conventional methods. UMAE is an extraction process assisted by ultrasonic waves and microwaves. NaCl solution can be used as a solvent in the UMAE method due to its large dielectric constant value. This research aimed to examine the effect of microwave power and salt concentration on the characteristics of citronella leaf essential oil (density, refractive index, color, and solubility in alcohol). The extraction method used in this research was Ultrasound Microwave-Assisted Extraction (UMAE). The solvent and material used in this research were NaCl salt solution and Red Citronella Leaves (Cymbopogon nardus L.). The first stage carried out in this research was pre-treatment assisted by ultrasonic waves for five minutes at a temperature of 35 ^{o}C, solvent concentrations of 0, 2, 4, 6, and 8% (w/v). The second stage was microwave-assisted extraction with a microwave power of 150, 300, 450, 600, and 750 Watts. The best results were produced at a concentration of 4% NaCl salt solution and 450Watt microwave power with yellow color, density value 0.8898 g/mL, refractive index 1.456, and solubility in alcohol 1:2. Overall, the quality of citronella leaves essential oil was in range of SNI 06-3953 1995. Therefore, the Red Citronella Leaves (Cymbopogon nardus L.) in the future can be considered as the alternative resource of citronella essential oil due to its good characteristics, among many varieties of citronella plants.

1. Introduction

Essential oils (EOs), also called etheric oils, are aromatic compounds that are found in large quantities in oil sacs or oil glands in various depths or layers of fruit skin, especially in the cuticle and flavedo [1]. These oils are known for their unique and distinctive aromas, which are extracted from various parts of plants, such as flowers, bark, leaves, seeds, and fruit [1]. Indonesia has abundant biological natural resources such as various plant species that are prospective to be developed into essential oil commodities. One plant that has high prospects for producing essential oils is citronella (*Cymbopogon nardus* L). According to BPS data in 2019, world consumption of citronella oil reached 2000-2500 tons per year. Based on data from the Directorate General of Plantation for 2022 shows that the average growth rate of demand for citronella essential oil is 5-10% per year and will continue to increase. The use of citronella plants has yet to be maximized. In general, citronella plants are only used as kitchen spice and only undergo a little further processing. This plant basically contains essential oils, which can increase its selling price [2]. Citronella essential oil can be used as a primary ingredient for cosmetics, perfume, medicines, and aromatics [3].

Citronella contains essential oils with the most significant components, namely citronellol 32-45%, geraniol 12-18%, and citronellal 12-15%. These components are crucial for various industries, determining the intensity of the smell, fragrance, and price value of citronella oil [4]. The leaves, with their high levels of essential oils, are the most commonly extracted part of citronella, boasting a high commercial value on the global market [5]. The parts of the citronella plant, including leaves, false stems, and stems, each have their unique properties. The leaf part, for instance, yields a significant amount of essential oil, around 0.88%, compared to the false stem part's 0.59% [2].

Several studies have been carried out on extracting essential oils from citronella plants, generally using conventional methods such as maceration, soxhlet, and water distillation. Research on the extraction of essential oil from citronella leaves using the Soxhlet method was carried out by Gultom et al. [4] that obtained a yield of 1.8% (v/w) with an extraction time of 90 minutes and an n-hexane solvent. In the maceration method for extracting essential oil from citronella leaves carried out by Ishak et al. [6] with different material weight variables, the solvents were methanol and n-hexane. The highest yield obtained was 11.64% within three days. The maceration and soxhlet extraction methods have low extraction efficiency, where the energy used is quite large and requires too much time in the extraction process [7]. The most commonly used extraction method for citronella essential oil is the water distillation method [8]. Research conducted by Adiandasari et al. [9] regarding the extraction of essential oil from citronella leaves using the water distillation method with variations in time and temperature. The research results showed that the highest yield of citronella leaf essential oil was 1.22% in 4.5 hours at a temperature of 130 ^{o}C. The weakness of the water distillation method is that it does not suit the components that have small difference boiling points and big volatilities [10].

* Corresponding author. Tel.: +628563057767
Email: nove.kartika.nke.tk@upnjatim.ac.id
http://dx.doi.org/10.20527/k.v13i2.20129

Based on several research studies on extracting essential oils using conventional methods, the results could have been more optimal, accompanied by a very long process and the need for oversized materials. This underscores the need for a breakthrough in the latest extraction method using non-conventional methods. In research on extracting essential oil from citronella leaves using the solvent-free microwave Extraction (SFME) method with variable microwave power, the highest yield was 1.096% at a power variable of 450 Watts [11]. Research conducted by Gotama et al. [12] compared the use of conventional and non-conventional methods. This research shows that the results of extracting kaffir lime leaf essential oil using the hydrodistillation method produce a yield of 0.33%, the MAE extraction method produces a yield of 1.045%, and the US-MAE method produces a yield of 1.684% in 60 minutes. This promising research suggests that the non-conventional methods, particularly the US-MAE method, could significantly impact the field of essential oil extraction, offering a more efficient, shorter, and selective extraction process.

Based on the description above, research was carried out on the characterization of essential oils from red citronella leaves (*Cymbopogon nardus* L.), which were extracted using the ultrasound microwave-assisted extraction (UMAE) method. The solvent used in this research was NaCl salt solution. This research aimed to examine the effect of microwave power and salt solution concentration on the characteristics of citronella leaf essential oil, including density, refractive index, color, and solubility in alcohol. The results of citronella essential oil will be compared with SNI 06-3953 of 1995 to determine its quality.

2. Materials and Methods

2.1. Materials

The raw material used in this research is the finest citronella leaves (*Cymbopogon nardus L.*), which come from the reputable Kosagrha Lestari Rungkut Surabaya farmer group. Citronella leaves are harvested at 08.00 – 09.00 a.m, ensuring their peak quality. The solvent used in this research was a table salt solution, usually called sodium chloride (NaCl), which was obtained from a commercial minimarket in the Rungkut area of Surabaya. Table salt contains 99.25% NaCl. The supporting material used in this research was distilled water. The extraction equipment used in this research was a cleaning bath-type sonicator with a frequency of 45 KHz, a modified microwave set, and several glassware.

2.2. Methods

This research began with harvesting citronella leaves at 08.00-09.00 WIB from the land of the Kosagrha Lestari farmer group. Harvesting at this time is intended to obtain better quality essential oils [3]. Then, the citronella leaves are cut to a size of ± 1 cm. Size reduction is carried out so that the extraction process takes place optimally [13]. The cut citronella leaves are dried until they reach a constant weight. Drying is carried out until the mass shrinks by 65%. Drying is done to get more essential oil yields. After that, 40 grams of dried citronella leaves were weighed. Then, a salt solution was made with concentrations of 0, 2, 4, 6, and 8% (w/v) from a solution volume of 400 mL. The concentrated salt solution was made using table salt obtained from commercial minimarkets, which had a NaCl content of 99.25% diluted with distilled water. Table salt was used in this study because of its very high purity, like special analytical salts [15]. A ratio of 1:10 was chosen to obtain optimal essential oil yields [16]. Then, the citronella leaves were pretreated with ultrasonic waves for 5 minutes at a temperature of 35 ^{o}C. The sonicator used is a cleaning bath type with a frequency of 45 KHz. The pre-treatment results were continued with an extraction process using a microwave for 60 minutes with variations in microwave power of 150, 350, 450, 600, and 750 watts. This series of microwave-assisted extraction tools is in accordance with the research design of Erliyanti et al. [7]. The essential oil results obtained were then analyzed for density, refractive index, color, and solubility in alcohol in accordance with the quality of SNI 06-3953 of 1995.

3. Results and Discussion

3.1. The effect of salt solution concentration on essential oil density at various microwave powers

This research on the extraction of citronella leaf essential oil, which aims to examine the effect of salt solution concentration and microwave power on the density of the citronella leaf essential oil produced, has the potential to significantly impact the field. The variables used in this research are salt solvent concentrations of 0%, 2%, 4%, 6%, and 8%, and microwave power of 150 watts, 300 watts, 450 watts, 600 watts, and 750 watts. Density or specific gravity, an important parameter that determines the quality of a material's essential oil, was measured using a pycnometer with a volume of 1 mL at room temperature. The relationship between the influence of salt solution concentration and microwave power on the density of citronella leaf essential oil is presented in Figure 1.

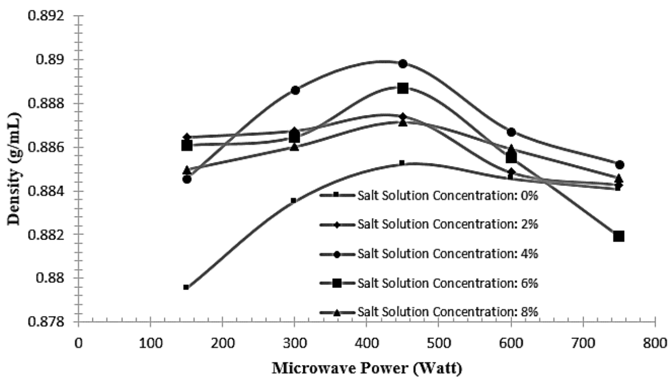

Fig. 1. Relationship between the effect of salt solution concentration on the density of essential oils at various microwave powers

The effect of the concentration of the salt solution on the density of the essential oil of citronella leaves is shown in Figure 1. The increasing mass transfer of citronella leaf essential oil results in more components of citronella leaf essential oil being extracted. The increase in extracted essential oil components shows that the molecular weight of the essential oil components is increasing. The molecular weight is proportional to the density value of the essential oil of citronella leaves. The higher the molecular weight of a compound, the higher its density [17]. The density of citronella leaf essential oil obtained increased along with the salt solution concentration. At salt solution concentrations after 4%, the density of the essential oil obtained decreased. The purpose of using salt in this research is to increase the boiling point of the solution and even out the heat distribution so that the solution does not boil quickly under normal conditions and the heat distribution is evener. The density of essential oils depends on their components and chemical bonds [18]. The decrease in density occurs due to the presence of thermolabile compounds that evaporate at high operating temperatures. High operating temperatures of materials can be caused by the knocking phenomenon (knocking sound in the microwave) in the distilling flask. The knocking phenomenon occurs when there is a defect in the distilling flask so that salt crystals come out of the flask and harden (recrystallization). This can significantly increase the temperature of the material and reduce the density of the essential oil obtained.

The effect of variations in microwave power on the essential oil of citronella leaves is shown in Figure 1. In Figure 1, information is obtained that the greater the microwave power, the greater the density of the essential oil of the citronella leaves. The greater the microwave power, the lower the density value of the essential oil of citronella leaves. The decrease in the density of citronella leaves is due to the presence of thermolabile compounds that experience degradation. Higher operating temperatures on materials cause the degradation of thermolabile compounds. The use of greater power will increase the energy supply to the material. A more excellent energy supply will increase the temperature of the material [19]. Increasing the operating temperature will increase the percentage of compounds that have high boiling points and reduce the percentage of compounds that have low boiling points. Compounds that have a high boiling point generally have a significant molecular weight, following the characteristics of a colligative solution [20]. The research results obtained are comparable to the research results of Hidayati and Syahnandiaratri [21] regarding the effect of microwave power on the density of essential oils. According to Hidayati and Syahnandiaratri [21], the greater the microwave power, the higher the density value of essential oils. However, when the microwave power is too large, the density of the essential oil will begin to decrease. If the essential oil obtained is mainly composed of compounds that have a low molecular weight, then the density obtained will also be low. The highest density was obtained at a variable of 450 watts and a salt concentration of 4%, amounting to 0.8898 gr/mL. When compared with SNI 06-3953 of 1995 of 0.88 – 0.922 gr/mL, then all the density data obtained is in accordance with SNI.

3.2. The effect of salt solution concentration on the refractive index of essential oils at various microwave powers

This research on extracting essential oil from citronella leaves aims to determine the effect of salt solution concentration and microwave power on the refractive index of the essential oil produced. The variables used in this research were salt solvent concentrations of 0%, 2%, 4%, 6%, and 8% and microwave power of 150 watts, 300 watts, 450 watts, 600 watts, and 750 watts. The refractive index is the ratio between the speed of light propagation in air and the speed of light propagation in a substance whose refractive index will be measured at a specific temperature [22]. The refractive index of the essential oil of citronella leaves was measured using a unique oil refractometer, ensuring the highest level of accuracy. Before using a refractometer to observe the refractive index value of citronella leaf essential oil, the prism area was cleaned using an alcohol pad. Cleaning the refractometer prism with an alcohol pad is carried out every time the refractive index value of a different test sample is observed. The relationship between the influence of salt solution concentration and microwave power on the refractive index of citronella leaf essential oil is shown in Figure 2.

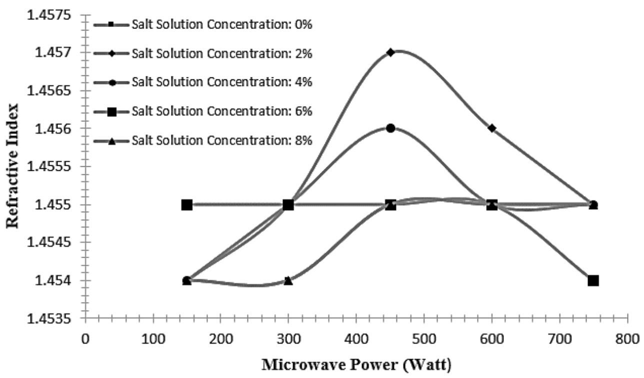

Fig. 2. Relationship between the effect of salt solution concentration on the refractive index of essential oils at various microwave powers

Figure 2 shows that microwave power and the concentration of the salt solution have a less significant effect on the refractive index of the essential oil produced by citronella leaves. The greater the concentration of the salt solution, the more the refractive index value of the essential oil of citronella leaves tends to increase. However, the increase in the refractive index is not very significant and ultimately decreases. The concentration of the salt solution can reduce the refractive index of citronella leaf essential oil. The function of using salt, apart from being related to heat transfer, also functions in stabilizing the emulsion. The use of salt can help stabilize the oil-in-water emulsion so that it separates clearly and does not mix easily [23]. The greater the concentration of the salt solution, the better its ability to stabilize the emulsion. The results of low refractive index values can be caused by the presence of water molecules which can reduce the refractive index value of essential oils [24]. These water molecules can form an emulsion, which is included in the oil that has been separated. The more water molecules there are, the lower the refractive index results will be.

Meanwhile, the decrease in the refractive index value as the salt concentration increases can be caused by the presence of salt crust on the glass prism used during the measurement. Using salt in the form of a solution at any concentration will leave scars in the form of salt crust if not cleaned properly. The salt crust on the prism glass can interfere with the entry of light, causing the measurement of the refractive index value to decrease.

Based on Figure 2, information is also obtained that the greater the microwave power used, the more the refractive index of citronella leaf essential oil increases. This is because the more significant the microwave power, the more essential oils are extracted. The greater the amount of essential oil obtained, the greater the amount of heavy fraction extracted so that the refractive index of the essential oil will also be more significant [25]. The greater the microwave power, the higher the temperature of the material, so that there are more components with long chains, double bonds, and carbon groups, and the darker the color of the essential oil produced. The dominant compound in the essential oil of citronella leaves is the terpenoid group [26]. Terpenoids are natural bioactive compounds that make up most essential oils and have many other derivative components. [27]. Meanwhile, too much microwave power can also reduce the refractive index value obtained. This is because the more significant the microwave power, the higher the temperature of the ingredients. When the temperature is high, several components that make up the long and multiple chains of citronella leaf essential oil experience degradation [28]. The lowest and highest results for the refractive index of citronella leaf essential oil were respectively obtained from extraction with 150 watts of microwave power with 0% salt solution and 450 watts of microwave power with 4% salt solution with refractive index values obtained of 1.454 and 1.456. It can be seen that the refractive index value does not change significantly when given variations in microwave power and salt solution concentration. The refractive index results, which were not significantly different, are similar to the refractive index results of research by Yulistiani et al. [24]. Research by Yulistiani et al. [24] shows that variations in microwave power and extraction time do not provide significant changes and tend to remain constant in the refractive index value of essential oils. Research by Hidayati and Syahnandiaratri [21] shows that the higher the microwave power, the more the refractive index value will decrease. The decrease in the refractive index value that occurred was also not significant and was similar to the results of this research on citronella leaf essential oil. The refractometer can influence the refractive index value obtained [29]. Apart from measuring instruments, measurement conditions will also affect the refractive index value obtained. The presence of water content can be identified by the presence of a blurry area between clear light and dark prisms so that a line or boundary area appears that looks sharper [30]. The higher the refractive index value, the better the value of the essential oil produced. The refractive index parameters of essential oils can be compared with the applicable SNI to determine their quality [31]. When compared with SNI 06-3953 data from 1995, the overall refractive index values obtained do not meet the applicable SNI. The refractive index value closest to SNI is 450 watts of microwave power with a 4% salt solution of 1.456 with a range from SNI 06-3953 in 1995 of 1.466-1.475. Results that do not meet SNI could be due to differences in citronella varieties, sources of raw materials obtained, and differences in measurement tools used.

3.3. The effect of salt solution concentration on the color quality of essential oils at various microwave powers

The color of the essential oil from citronella leaves obtained through an extraction process using the ultrasound microwave-assisted extraction method using a salt solvent has varying colors. The results of qualitative color analysis of citronella leaf essential oil are presented in Table 1. Color is an important parameter in determining the quality of a material's essential oil. The amount of certain color pigments in the oil determines the color intensity. The color of freshly extracted essential oil is usually colorless or yellowish. In color analysis, visual observations were carried out, namely by observing the color of the essential oil of citronella leaves at a distance of around 30 cm using a white background to make identification easier [7]. If essential oils are left in contact with air and exposed to sunlight for a long time, the oil can darken, the smell changes, and over time, it thickens, and eventually, a resin forms [9]. Based on this, observing the color of the essential oil of citronella leaves obtained can be used as a parameter that the essential oil obtained is in good condition and can be used as intended, thereby ensuring the quality and efficacy of the oil in practical applications such as aromatherapy and insect repellent.

Table 1. Quality of the essential oil color

Salt Solution Concentration (%w/v)	Power of Microwave (Watt)	Color Quality (Yellow)
0	150	Light
	300	Light
	450	Normal
	600	Normal
	750	Thick
2	150	Light
	300	Light
	450	Normal
	600	Normal
	750	Normal
4	150	Light
	300	Light
	450	Normal
	600	Normal
	750	Normal
6	150	Light
	300	Normal
	450	Normal
	600	Normal
	750	Thick
8	150	Normal
	300	Normal
	450	Thick
	600	Thick
	750	Thick

In Table 1, information is obtained that variations in the concentration of the salt solution and microwave power influence the color of the essential oil produced by the citronella leaves. If analyzed as a whole, the microwave power and salt solution concentration will give quite significant color differences when there are large variations in microwave power and salt solution concentration. The effect of varying the concentration of the salt solution is quite significant on the visible color of the essential oil obtained. This is comparable to research by Artanti et al. [32], which stated that variations in the concentration of the salt solution had an influence on the color produced but did not affect the odor produced. The greater the concentration of the salt solution, the thicker the essential oil of citronella leaves will make the difference in color clearly visible. The use of NaCl salt will not affect the smell of the citronella leaf essential oil produced. It has been proven that by varying the concentration of the salt solution, you will get essential oil from citronella leaves, which have a distinctive smell like citronella leaves before the extraction process is carried out.

In Table 1, information is also obtained about the effect of microwave power on the color of the essential oil of citronella leaves. Variations in the use of microwave power show an influence on the color of the essential oil obtained. The greater the microwave power used, the more intense the color of the essential oil produced. Using low microwave power will produce brightly colored citronella leaf essential oil. The greater the microwave power, the more intense the yellow color of the citronella leaf essential oil you get. Higher microwave power has the same effect as a longer extraction time. The longer the extraction time, the more essential oil is extracted [9]. This will make it easier to observe the essential oil visually. The observation results obtained were then compared with SNI number 06-3953 of 1995 concerning specifications for the quality of citronella essential oil. From observations, it is known that the color of the essential oil of citronella leaves is pale yellow to dark yellow. This shows that the oil obtained is in accordance with SNI 06-3953 of 1995, which has been determined to be between pale yellow and brownish yellow.

3.4. The effect of salt solution concentration on the color quantity of essential oils at various microwave powers

The color of essential oil from citronella leaves is obtained through an extraction process using the ultrasound microwave-assisted extraction method, which uses varying concentrations of salt solution and varying microwave power so that it has varying colors. The results of the quantitative analysis of the color of the essential oil of citronella leaves are presented in Table 2.

Table 2. Quantity of the essential oil color

Color (RGB)	L (%)	A	B	Hue (°)	Chroma(%)
246 240 233	95.12	0.95	3.32	1.2909	0.0345
242 232 212	92.40	0.85	8.83	1.4752	0.0887
249 230 199	92.25	2.51	14.11	1.3946	0.1433
245 228 196	91.36	1.84	14.31	1.4428	0.1443
243 225 181	90.19	1.17	19.17	1.5096	0.1921
250 243 231	96.15	0.74	5.35	1.4336	0.0540
252 240 218	95.32	1.23	9.76	1.4456	0.0984
255 236 212	94.47	3.09	11.31	1.3039	0.1172
255 232 208	93.42	4.28	11.78	1.2222	0.1253
247 235 202	93.38	0.26	14.10	1.5522	0.1410
254 243 229	96.43	1.68	6.53	1.3188	0.0674
245 233 212	92.89	1.33	9.42	1.4303	0.0952
242 233 210	92.61	0.28	9.90	1.5426	0.0990
248 230 207	92.31	2.91	10.87	1.3091	0.1125
230 218 192	87.52	0.91	11.53	1.4920	0.1156
236 230 218	91.52	0.47	5.30	1.4833	0.0532
226 220 204	87.92	0.08	6.93	1.5592	0.0693
236 217 198	87.89	3.61	9.51	1.2077	0.1017
229 219 192	87.68	0.23	11.70	1.5515	0.1170
232 218 185	87.56	0.90	14.51	1.5092	0.1454
240 230 210	91.69	0.85	8.85	1.4750	0.0889
245 228 209	91.59	2.98	9.21	1.2574	0.0968
238 222 194	89.23	1.91	12.70	1.4215	0.1284
241 221 185	89.09	2.44	16.30	1.4225	0.1648
238 222 184	89.06	1.07	16.65	1.5069	0.1668

Table 2 shows that the results of measuring the color of the essential oil of citronella leaves are presented in the form of numbers. This presentation in the form of numbers is intended to determine the value of each color produced. Assessments based on the five senses, especially the sense of sight, will be relative and subjective for each individual. In this regard, quantitative measurements using instrumentation need to be carried out. The color of the essential oil is scanned using the Color Meter Software on the device. The essential oil object was scanned at a distance of 30 cm on a white background. The scan results come out in the form of an RGB scale. The RGB scale (Red, Green, Blue) is then converted and calculated until data is obtained in the form of a CIELAB scale. The CIELAB scale was chosen because it is widely used internationally and is widely used in maintaining color standards [33]. The LAB scale consists of components L, A, and B. Component L indicates brightness, component A indicates red, and component B indicates yellow. The greater the L value, the brighter an object. The greater the value of A, the lower the object. If the A value is negative, it means the object is close to green. The greater the B value, the yellower the object. If the B value is negative, it means the object is close to blue [34]. Meanwhile, Hue is the type of color detected, and Chroma is the color density of an object [35].

In Table 1 above, information is obtained that the greater the microwave power and concentration of the salt solution, the more intense the color of the essential oil of citronella leaves will be. If Table 1. for color quality is matched with Table 2. for color quantity, a linear correlation is obtained. The brighter the color of the essential oil, the greater the L value and the smaller the B value. If the essential oil is darker in color, the L value becomes smaller and is followed by a more excellent B value. Component A is not taken into account in this discussion because component A shows a red quality.

Meanwhile, the Hue and Chroma components are used to determine the type and intensity of the color. The practical implication of this is that it allows us to accurately measure and reproduce the color of citronella leaf essential oil. The Chroma component, which indicates color density, is given more weight than the Hue component. The Hue component, on the other hand, shows the relative color based on the type of color detected. The greater the microwave power and salt concentration, the more intense yellow the color of citronella leaf essential oil will be. This can be clearly seen where the L value is getting smaller, B is getting bigger, and Chroma is getting bigger. According to Kaemba et al. [36], a small value of A together with a large value of B will produce a bright yellow color. In Table 2 above, the A value is always smaller than the B value, so you will get a color hue that is yellow or close to yellow. The color of essential oils is not always the same as the color of the source material. In the essential oil, citronella leaves will have a yellow color, while the false stems will be reddish green and the leaves will be green. The yellow color of citronella leaf essential oil is produced by a carotene compound [37]. If the color of the essential oil produced is close to the color of the material, it is possible that there is a color pigment from the original material that was also extracted.

3.5. The effect of salt solution concentration on the solubility of essential oils in alcohol at various microwave powers

The essential oil of citronella leaves obtained will be analyzed for its solubility in alcohol. Solubility in alcohol is one way to test the quality of essential oils based on their chemical properties [38]. Solubility in alcohol can also be used to determine fake essential oils. This is because some impurities separate from the essential oil. Many essential oils are soluble in alcohol and insoluble in water [23]. In the solubility test, the alcohol used was 80% ethanol. The effect of salt solution concentration on the solubility of citronella essential oil in alcohol at various microwave powers is presented in Table 3.

Table 3 shows that the results of the 80% alcohol solubility test for all samples obtained a ratio of 1:2 until clear. This 1:2 ratio indicates that 1 mL of citronella leaf essential oil can be dissolved in 2 mL of 80% alcohol. Varying the salt solution concentration and microwave power resulted in equal solubility in all test samples. This shows that the microwave power and concentration of the salt solution do not have a significant effect on the quality (solubility in alcohol) of the essential oil of citronella leaves. The addition of alcohol is done gradually and is stopped when opalescence occurs [3]. Opalescence is demonstrated when the essential oil of citronella leaves and alcohol can mix perfectly without any dividing lines. Testing the solubility of essential oils in alcohol aims to determine the ability of essential oils to dissolve in alcohol. Tests carried out showed that in a ratio of 1:2, essential oils were dissolved in 80% alcohol to form a clear solution. The essential oil of citronella leaves are dissolved because it has the OH group. If essential oil contain a lot of OH groups, it will dissolve more easily in alcohol [9]. The more excellent the solubility of the essential oil in alcohol, the better the quality of the essential oil [31]. The ratio of 1:2 solubility test results are in accordance with SNI 06-3953 of 1995.

Table 3. The Effect of Salt Solution Concentration on the Solubility of Citronella Essential Oil in Alcohol at Various Microwave Powers

Salt Solution Concentration (%w/v)	Power of Microwave (Watt)	Solubility in Alcohol
0	150	1:2
	300	1:2
	450	1:2
	600	1:2
	750	1:2
2	150	1:2
	300	1:2
	450	1:2
	600	1:2
	750	1:2
4	150	1:2
	300	1:2
	450	1:2
	600	1:2
	750	1:2
6	150	1:2
	300	1:2
	450	1:2
	600	1:2
	750	1:2
8	150	1:2
	300	1:2
	450	1:2
	600	1:2
	750	1:2

4. Conclusion

The variables of salt solution concentration and microwave power have a significant influence on the density and color of citronella leaf essential oil. The best conditions for extracting essential oil from citronella leaves are found at a salt solution concentration of 4% and microwave power of 450 Watts with a density value of 0.8898 g/mL, a refractive index of 1.456, citronella essential oil is yellow, the L value is 92.61%, the A value is 0.28, B value is 9.90, Hue value is 1.5426o, Chroma value is 0.0990%, and solubility in 80% alcohol is 1:2. The essential oil of citronella leaves obtained can be said to meet SNI 06-3953 of 1995 for quality standards for citronella essential oil.

References

[1] R. A. Herman, E. Ayepa, S. Shittu, S.S. Fometu, J. Wang, Essential Oils and Their Applications -A Mini Review, Advances in Nutrition & Food Science, 4 (2019) 1-13.

[2] I. N. Hidayat, R. Nurhandayani, Ekstraksi Minyak Atsiri Berbahan Sereh Dapur Berbantu Microwave, Prosiding SENTIKUIN, (2018) 1-4.

[3] Sulaswatty, M.S. Rusli, H. Abimanyu, S. Tursiloadi, Minyak Serai Wangi dan Produk Turunannya, Lembaga Ilmu Pengetahuan Indonesia, (2019).

[4] E. Gultom, Hestina, S. Sijabat, Isolasi dan Analisis Komponen Minyak Atsiri Serai Wangi (Cymbopogon Nardus L. Rendre) Melalui Ekstraksi Sokletasi Menggunakan Gas Cromatografy Mass Spectrometry, Jurnal Kimia Saintek dan Pendidikan. 4 (2020) 12-16.

[5] Z. Ma'sum, P. Sasongko, Eksperimen dan Model Ekstraksi Minyak Atsiri dengan Bahan (Cymbopogon Sp.) Menggunakan Hydro Steam Distillation, Jurnal Reka Buana. 2 (2017) 74-76.

[6] I. Ishak, Y. Evama, N. Sylvia, Ekstraksi Minyak Serai Dapur (Cymbopogon citratus) Menggunakan Metode Maserasi, Jurnal Teknologi Kimia Unimal, 10 (2021) 59-67.

[7] N. K. Erliyanti, E. A. Saputro, R. R. Yogaswara, E. Rosyidah, Aplikasi Metode Microwave Hydrodistillation Pada Ekstraksi Minyak Atsiri Dari Bunga Kamboja (Plumeria Alba), Jurnal IPTEK ITATS, 24 (2020) 39-42.

[8] Kumoro, D. H. Wardhani, D. S. Retnowati, K. Haryani, S. Yustika, T. A. Fajar, Extraction Of Essential Oil From Ultrasound PreTreated Citronella Gras (Cymbopogon Nardus) Leaves By Hydro Destilation Method, Chemical Engineering Transaction, 87 (2021) 643-65.

[9] J. Adiandasari, Wusnah, Azhari, Pengaruh Suhu dan Waktu Terhadap Proses Penyulingan Minyak Sereh Wangi, Chemical Engineering Journal Storage, 1 (2021) 22-28.

[10] N. A. Uwar, E. R. Soselissa, Pengaruh penggunaan air pendingin kondensor terhadap hasil destilasi sampah plastik kapasitas 3 kg, Artikel Teknik Mesin dan Manufaktur, 3 (2022) 11-18.

[11] S. Fatimah, D. K. Y. Putri, R. F. , Darmayanti, Essential Oil Extraction from Citronella (Cymbopogon nardus (L.)) Using Solvent Free Microwave Extraction Methode (SFME), Journal of Biobased Chemicals, 2 (2022) 59-64.

[12] B. Gotama, D. F. Rahman, A. Anjarwadi, Intensifikasi Proses Penyulingan Minyak Atsiri Dari Daun Jeruk Purut dengan Metode Ultrasound Following Microwave Assisted Extraction (US-MAE), Indonesian Journal Of Essential Oil, 2 (2017) 29-37.

[13] R. Y. Asworo, H. Widwiastuti, Pengaruh Ukuran Serbuk Simplisia dan Waktu Maserasi terhadap Aktivitas Antioksidan Ekstrak Kulit Sirsak, Indonesian Journal of Pharmaceutical Education, 3 (2023) 256 – 263.

[14] D. K. Y. Putri, S. N. Oktavia, B. A. Fachri, Pengaruh Pretreatment Bahan Pada Ekstraksi Minyak Atsiri Dari Daun Serai Wangi dengan Metode Solvent-Free Microwave Extraction: Studi Karakteristik Fisik, Kolokium Hasil Penelitian dan Pengabdian kepada Masyarakat, (2022) 115 – 122.

[15] A. Martina, J. R. Witono, G. K. Pamungkas, Willy, Pengaruh Kualitas Bahan Baku Dan Rasio Umpan Terhadap Pelarut Pada Proses Pemurnian Garam Dengan Metode Hidroekstraksi Batch, Jurnal Teknik Kimia USU, 5 (2016) 1-6.

[16] M, Sarah, D. Ardiansyah, E. Misran, I. Madinah, Extraction of citronella oil from lemongrass (Cymbopogon winterianus) by sequential ultrasonic and microwave-assisted hydro-distillation, Alexandria Engineering Journal, 70 (2023) 569-583.

[17] L., Pratiwi, M. S. Rachman, N. Hidayah, Ekstraksi Minyak Atsiri dari Bunga Cengkeh dengan Pelarut Etanol dan N-Heksana, The 3rd University Research Coloquium, (2016) 131 – 137

[18] A. S. V. Augustia, N. Charfadz, R. Akbar, Diana, Effect of Extraction Time, Ingredient/Solvent Ratio, and Microwave Power on Extraction Results of Lemongrass Oil with Microwave Assistance, Jurnal Teknik Kimia USU, 10 (2021) 51-57

[19] B. O. Hananta, P. Pratama, A. Aswan, Fatria, Zurohaina, Pengaruh Daya Microwave Terhadap Rendemen Minyak Kayu Manis (Cinnamomum Burmannii) Dengan Metode Microwave Hydrodistillation, Jurnal Kinetika, 11(2020) 40-45.

[20] S. Mulyani, Liliasari, Wiji, Model Mental Calon Guru Kimia Mengenai Sifat Koligatif Larutan Melalui Pembelajaran Berbasis TIK, Jurnal Pendidikan Matematika dan Sains Tahun III, 1 (2015) 124-128.

[21] N Hidayati, H. Syahnandiaratri, Analisis Pengaruh Daya Microwave Pada Proses Pengambilan Minyak Atsiri Daun Kelor (Moringa Oleifera) Dengan Metode Microwave Assisted Extraction (MAE), Simposium Nasional RAPI XVII – 2018 FT UMS, (2018) K124-K129.

[22] S. Nurjanah, I. Sulistiani, A. Widyasanti, S. Zain, Kajian Ekstraksi Minyak Atsiri Bunga Melati (Jasminum Sambac) Dengan Metode Enfleurasi", IJCCS. 1 (2016) 12-20.

[23] R. Omar, N. Zghaibi, S.M.M. Kamal, D.A.A. Biak, R. Harun, Microwave-Assisted Brine Extraction for Enhancement of the Quantity and Quality of Lipid Production from Microalgae Nannochloropsis sp, Molecules. 24 (2019) 5.

[24] F. Yulistiani, R. K. Azzahra, Y. A. Nurhafshah, Pengaruh Daya dan Waktu Terhadap Yield Hasil Ekstraksi Minyak Daun Spearmint Menggunakan Metode Microwave Assisted Extraction, Jurnal Teknik Kimia Lingkungan, 4 (2020) 1-6.

[25] K. S. Nugraheni, L. U. Khasanah, R. Utami, & B. K. Ananditho, Pengaruh Perlakuan Pendahuluan dan Variasi Metode Distilasi Terhadap Karakteristik Mutu Minyak Atsiri Daun Kayu Manis (C. Burmanii, Jurnal Teknologi Hasil Pertanian IX, (2016) 51-64.

[26] R Karneta, R. Wahyuni, Karakteristik Minyak Sereh Wangi dengan Umur Panen Daun, Prosiding Seminar Nasional Lahan Suboptimal Ke-8, (2020).

[27] D. Azalia, I. Rachmawati, S. Zahira, F. Andriyani, T. M. Sanini, Supriyatin, N. R. Aulya, Uji Kualitatif Senyawa Aktif Flavonoid dan Terpenoid Pada Beberapa Jenis Tumbuhan Fabaceae dan Apocyniae Di Kawasan TNGPP Bodogol, Jurnal Biologi Makassar, 8 (2023) 32-40.

[28] A. N. Fitrah, M. S. Rusli, D. Setyaningsih,, A. Riyanto, N. Hidayat, Purification Of Rhodinol From Citronella Oil Using Spinning Band Distillation, Jurnal Teknologi Industri Pertanian, 30 (2020) 129-130

[29] Slamet, Ulyarti, S. L. Rahmi, Pengaruh Lama Fermentasi Daun Nilam Menggunakan Ragi Tempe terhadap Rendemen dan Mutu Fisik Minyak Nilam (Pogostemon cablin benth, Jurnal Teknologi dan Industri Pertanian Indonesia, 11 (2019) 19-25

[30] F. Aryani, Noorcahyati, Arbainsyah, Pengenalan Atsiri (Melalueca cajuputi), Politeknik Pertanian Negeri Samarinda, (2020).

[31] D. P. Wibowo, A. Rustamsyah, Y. Kurniawan, Karakterisasi Dan Aktivitas Repelen Minyak Atsiri Sereh Wangi (Cymbopogon Nardus L), Akar Wangi (Vetiveria Zizanoides L.), Nilam (Pogestemon Cablin), Cengkeh (Syzgium Aromaticum) Asal Kabupaten Garut Terhadap Nyamuk Aedes Aegypti Betina, Jurnal Ilmu Farmasi & Farmasi Klinik, 13 (2016) 1- 6

[32] A. N. Artanti, N. Prabawati, F. Prihapsara, R. Rakhmawati, Pengaruh Variasi Konsentrasi Natrium Klorida Dalam Formulasi Sediaan Facial Wash Kombinasi Ekstrak Spirulina (Spirulina platensis) dan Minyak Nyamplung (Chalophyllum inophyllum), Jurnal Farmasi Udayana. 10 (2021) 93 – 99.

[33] N. Islamyco, D. Nurba, Mustaqimah, Pengaruh Suhu dan Waktu Penyangraian Terhadap Warna Bubuk Kopi Arabika, Jurnal Ilmiah Mahasiswa Pertanian. Jurnal Keteknikan Pertanian, 26 (2022) 53-59.

[34] A. Souripet, Komposisi, Sifat Fisik Dan Tingkat Kesukaan Nasi Ungu, Jurnal Teknologi Pertanian. 4 (2015) 25-32.

[35] Sukarman, D. A. Astuti, N. B. P. Utomo, Evaluasi Kualitas Warna Ikan Klown Amphiprion Percula Lacepède 1802, Jurnal Riset Akuakultur, 12 (2017) 231-239.

[36] A. Kaemba, E. Suryanto, Mamuaja, Karakteristik FisikoKimia Dan Aktivitas Antioksidan Beras Analog Dari Sagu Baruk (Arenga Microcarpha) Dan Ubi Jalar Ungu (Ipomea Batatas L. Poiret), Jurnal Ilmu dan Teknologi Pangan, 5 (2017) 1-8

[37] P. Kusumo, A. Shobib, R. Luthfi, Essential Oil Extraction From Citronella Stems (Cymbopogon winterianus) By Vacuum Distillation, International Conference on Chemical and Material Engineering (ICCME), (2020) 1-6.

[38] Zaituni, R. Khathir, R. Agustina, Penyulingan Minyak Atsiri Sereh Dapur (Cymbopogon Citratus) Dengan Metode Penyulingan AirUap, Jurnal Ilmiah Mahasiswa Pertanian Unsyiah, 1 (2016) 1009-1016.