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COMPARISON OF THE AGE OF SAPU-SAPU (*Baeckea frutescens* L.) LEAVES BOW DOWN AND UNBOWED ON THE YIELD AND PHYSICAL FEATURES OF OIL USING STEAM-HYDRO DISTILLATION METHODS

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ABSTRAK

Minyak atsiri merupakan minyak yang bersifat volatil, tersusun dari senyawa golongan terpenoid (monoterpen dan seskuiterpen). Salah satu tumbuhan yang berpotensi dijadikan minyak atsiri adalah tumbuhan sapu-sapu (*Baeckea frutescens L.*) Kepulauan Bangka Belitung. Tujuan dari penelitian ini untuk mengetahui perbandingan rendemen, karakteristik, dan komponen senyawa kimia dalam minyak atsiri daun sapu-sapu merunduk dan tidak merunduk pada umur panen di atas dan kurang dari 2 tahun. Metode yang digunakan dalam penelitian ini adalah destilasi uap air. Rendemen minyak atsiri yang dihasilkan dari tumbuhan sapu-sapu daun merunduk di atas 2 tahun (DM+2), daun tidak merunduk di atas 2 tahun (DTM+2), daun merunduk kurang dari 2 tahun (DM-2) dan daun tidak merunduk kurang dari 2 tahun (DTM-2) berturut-turut adalah 0,598%, 0,595%, 0,505% dan 0,544%. Minyak atsiri dari daun sapu-sapu merunduk di atas 2 tahun memiliki aroma dan warna lebih dominan dibandingkan dengan yang lainnya. Komponen senyawa kimia yang dihasilkan dari empat variasi minyak atsiri ini berbeda-beda. Minyak atsiri daun sapu-sapu jenis merunduk di atas 2 tahun memiliki total persentase komponen senyawa kimia area sebesar 97,49% dan merunduk kurang dari 2 tahun sebesar 97,74%. Sedangkan komponen senyawa kimia minyak atsiri daun sapu-sapu jenis tidak merunduk di atas 2 tahun sebesar 98,54% dan tidak merunduk kurang dari 2 tahun sebesar 98,38%.

ABSTRACT

Essential oil is a volatile oil, composed of terpenoid group compounds (monoterpenes and sesquiterpenes). One of the plants that has the potential to be used as an essential oil is the Bangka Belitung Islands sapu-sapu plant (Baeckea frutescens L.). The purpose of this study was to determine the comparison of yield, characteristics, and components of chemical compounds in the essential oil of sapu-sapu leaves, ducking and not ducking at harvest ages above and below 2 years. The method used in this research is the water vapor distillation method. The yield of essential oil produced from sapu-sapu leaves ducked above 2 years (DM+2), leaves not ducked above 2 years (DTM+2), leaves ducked less than 2 years (DM-2) and leaves not ducked less than 2 years (DTM-2) are 0.598%, 0.595%, 0.505% and 0.544% respectively. Essential oil from sapu-sapu leaves ducked over 2 years has a more dominant aroma and color compared to the others. The components of chemical compounds produced from the four variations of essential oil are different. Essential oil of sapu-sapu leaf type aged for more than 2 years has a total percentage of chemical compound components of 97.49%, while that aged for less than 2 years has a total rate of 97.74%. While the chemical compound component of the essential oil of sapu-sapu leaves of the type that does not bow above 2 years is 98.54%, and does not bow less than 2 years is 98.38%.

How to Cite

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INTRODUCTION

Essential oils are volatile vegetable oils with a bitter taste and a distinctive odor that resembles the original plant, which is composed of various terpenoid compounds included in the monoterpene ($C_{10}H_{16}$) and sesquiterpene ($C_{15}H_{24}$) compound groups (Andila et al., 2020; Puspitasari, 2016). Other components of essential oils are phenylpropene compounds (Rahmiyani et al., 2020). Essential oils can be obtained from various plants such as fragrant roots (*Chrysopogon zizanioides*), eucalyptus (*Melaleuca leucadendra*), and citronella (*Cymbopogon nardus* L.) (Puspitasari, 2016). One of the plants that also contains essential oils is the sapu-sapu plant (*Baeckea frutescens* L.), which is also known as ujung atap.

The sapu-sapu plant (*Baeckea frutescens* L.) is a species that is quite widespread in Bangka Belitung. In Bangka Belitung, the sapu-sapu plant is a wild plant that is easy to find because it lives in groups. The sapu-sapu plant is often found in sandy areas such as beaches or highlands that have less fertile soil conditions. Supandi et al. (2019) have conducted research on the characterization of the essential oil of sapu-sapu leaves. Based on this research, the essential oil of sapu-sapu leaves obtained from the forest of Sungai Nanjung Village, Ketapang Regency, West Kalimantan is colored, specific gravity 0.878; refractive index 1.474; optical rotation (+) 2.24; solubility in 96% alcohol (1:8) with an average yield of 0.999% and the main chemical compound components are alpha-pinene (26.95%), beta-pinene (21.55%), 1-8-cineole (18.04%).

Based on research conducted by Rocha et al. (2014) regarding the effect of plant age on the content and composition of essential oils in Cymbopogon citratus showed that the levels of essential oil yield at the ages of 3 months, 6 months, 9 months, and 12 months were 2.02%; 2.11%; 2.28%; 2.45%. The older the plant, the greater the yield it produces. Additionally, there are differences in the chemical compound composition of essential oils at various ages. Other research conducted by Aziz et al. (2021) regarding the production of essential oils from basil plants (*Ocimulm basilliculm*) at different harvest ages stated that at the ages of 1 month; 1.5 months; and 2 months, basil leaves produced essential oil yields of 0.017%; 0.040%; and 0.273%, respectively. From the results of this study, it was found that the older the harvest age or age of the plant, the more essential oil would be produced.

In Bangka Belitung, the sapu-sapu plant has two types, namely the sapu-sapu plant with bowed leaves and the sapu-sapu plant with unbowed leaves. Both types were used as samples in this study. The bowed sapu-sapu leaves have the following characteristics: tall and sparse stems, loose leaf spacing, and long branches so that the leaves become drooping. While in the unbowed sapu-sapu leaves, the stems are shorter and denser, the leaf spacing is thick, and the branches are short. The bowed and unbowed sapu-sapu leaves were tested to determine the yield and components of chemical compounds contained in the essential oil of the sapu-sapu leaves in various plant age variations. Essential oils can be obtained using water vapor distillation. In water vapor distillation, the sample is on a perforated filter. The distillation kettle contains water until the water surface is below the filter. In this method, the steam is always wet, and not too hot, and the sample is only in contact with the steam (Ingeswari, 2015). Research by Yuliarto (2012) shows that the yield of essential oil using steam-water distillation is greater than that of the water distillation method. Steam-water distillation has the advantages of relatively short distillation time, cheaper costs, producing greater yields, and better quality of essential oils (Nuraeni and Yunilawati, 2012).

Therefore, an analysis was conducted on the characteristics and components of essential oils contained in the sapu-sapu plant with variations in plant age and leaf type, with samples from Bangka Belitung using Gas Chromatography-Mass Spectrometry (GC-MS).

METHODS

Materials

The materials used in this study were sapu-sapu (*Baeckea frutescens* L.) leaves, both bowed and unbowed, harvested from plants with ages of more than 2 years and less than 2 years, distilled water, and 96% ethanol.

Tools

The tools used in this study were 50 mL Pyrex beaker, 50 mL Pyrex Erlenmeyer flask, separating funnel, measuring cylinder, KERN analytical balance, 10 mL Pyrex pycnometer, wrapping, a set of Zebra Thailand Stainless Steel SUS304 water vapor distillation equipment, dropper, test tube, test tube rack, measuring cylinder, Kruss DR6000 refractometer, Kruss P3000 polarimeter and a set of Shimadzu PQ2010-SE type GC-MS equipment.

Procedure

Sampling and Sample Preparation

The samples used were bowed and unbowed sapu-sapu leaves, harvested at ages above and less than 2 years, collected in the Tuing Hamlet area, Mapur Village, Bangka Regency, Bangka Belitung Islands. The leaves used were still fresh and green. Then the sapu-sapu leaves were cleaned of dirt that was still attached. The leaves still attached to the twigs were chopped into smaller pieces and left overnight.

Steam Distillation of Sapu-Sapu Leaves

A total of 5 kg of sapu-sapu leaves, which have been left overnight, are distilled for 4 hours. The distillation result is a mixture of water and essential oil. The essential oil obtained will be separated using a separating funnel. Then the water-free essential oil is weighed to determine the percentage yield using the following formula:

$$\%\ \text{yield} = \frac{mass\ of\ essential\ oil\ obtained\ (grams)}{mass\ of\ sample\ used\ (grams)} \times 100\% \quad \text{(Eq. 1)}$$

Essential Oils Characteristics

There are four types of essential oils produced from the distillation process, including: essential oil of sapu-sapu leaves that are less than 2 years old, essential oil of unbowed sapu-sapu leaves that are less than 2 years old, essential oil of sapu-sapu leaves that are more than 2 years old and essential oil of unbowed sapu-sapu leaves that are more than 2 years old. Testing the characteristics of essential oils includes testing the physical and chemical properties of sapu-sapu leaf essential oils.

Organoleptic Test

The method used is based on visual observation using the senses directly, including color and aroma. 5 mL of sapu-sapu leaf essential oil is put into a test tube, and then the color and aroma are determined visually (Solarbelsain and Pudjihastuti, 2019).

Refractive Index

The refractive index test is carried out using a refractometer. The test is carried out at a constant temperature of 20°C and a reflection temperature of 20°C. Next, readings are taken when the temperature is stable, reaching 20°C. The smaller the refractive index value, the greater the water content (Supandi et al., 2019).

Specific Gravity

In this test, a pycnometer is used. Before use, the pycnometer is washed and cleaned, then rinsed using 96% ethanol. The inside of the pycnometer is dried and left for 3 minutes, then weighed (m). Fill the pycnometer with distilled water and avoid any bubbles in it. Insert the lid and dry the pycnometer. The pycnometer is left in the weighing cabinet for 3 minutes, then weighed with its contents (m_1). Then empty the pycnometer. The pycnometer is washed with ethanol, then dried. Fill the pycnometer with the essential oil obtained and avoid any air bubbles. Insert the lid and dry the pycnometer. Then leave the pycnometer in the weighing cabinet for 3 minutes and weigh as (m_2) (Supandi et al., 2019).

$$\text{Specific gravity} = \frac{m_2 - m}{m_1 - m} \quad \text{(Eq. 2)}$$

Optical Rotation

Optical rotation testing can be done using a polarimeter. The polarimeter tube is cleaned, and then the sample is inserted into the tube until it is full and tightly closed. Then it is inserted into the polarimeter at a temperature of 20°C, and the optical rotation of the oil is read dextro (+) or levo (-) on the scale on the device. (Supandi et al., 2019).

Solubility in Alcohol

A total of 1 mL of the essential oil obtained is pipetted into a 10 mL measuring cylinder, and 96% alcohol is added gradually. At each addition of alcohol, it is shaken and its clarity is observed (Supandi et al., 2019).

Testing of Essential Oils Using GC-MS

Analysis of chemical compound components in essential oils is carried out using GC-MS (Wahyuni et al., 2022). Identification of the components of the essential oil chemical compound groups in each variation of the sapu-sapu leaf sample (*Baeckea frutescens* L.) was carried out using a GC-MS (Gas Chromatography and Mass Spectroscopy) Shimadzu QP2010 SE. A sample of 0.2 µL was injected into the column with the operational conditions of the instrument, namely: Elite Rtx-5 MS fused silica capillary column (30 m × 0.25 mm, film thickness 0.25 µm), ionization energy 70 eV, and mass scan range 40-400 amu. Detector temperature 280°C, injector 220°C, ionization source 230°C and quadrupole is 150°C. The oven temperature was programmed from 35°C for 9 min, ramped to 150°C at 3°C/min, held at 150°C for 10 min, ramped to 250°C at 10°C/min, ramped at 3°C/min to 270°C, and held at 270°C for 10 min. Helium was used as the carrier gas with a flow rate of 0.5 mL/min (Goswami et al., 2016; Flores et al., 2019).

RESULT AND DISCUSSION

Sample Preparation

Samples of sapu-sapu leaves (*Baeckea frutescens* L.) in this study were taken fresh in Dusun Tuing, Mapur Village, Bangka Regency. There are four types of sapu-sapu leaves: bowed and unbowed sapu-sapu leaves that are over 2 years old and less than 2 years old. They have characteristics of bowed leaves, such as tall and sparse stems, loose leaf spacing, and long branches. Meanwhile, in unbowed sapu-sapu leaves, the stems are shorter and denser, the leaves are densely spaced, and the branches are short. Determination of plant age is done by measuring the cambium circumference on the stem. Continuous changes in cambium activity produce cambium circumferences that indicate the age of the plant, the more cambium circumferences, the older the plant (Wang et al., 2020). The cambium circumference on the stems of the sapu-sapu plants obtained was measured for stem diameter using a caliper. The following is the sampling data for sapu-sapu leaves used in this study:.

Table 1. Sampling data of sapu-sapu leaves

Parameter	Sample			
	Bowing over 2 Years (DM +2)	Unbowing over 2 Years (DTM +2)	Bowing less than 2 Years (DM-2)	Unbowing less than 2 Years (DTM-2)
Stem diameter (cm)	7,48 - 13,05	7,48 - 13,05	2,86 - 6,05	2,86 - 6,05
Leaf color	Dark green	Dark green	Light green	Light green
Temperature (°C)	26°C	26°C	26-27°C	26-27°C
Time (WIB)	07.40 - 09.03	07.40 - 09.03	07.50 - 10.00	07.50 - 10.00

Based on Table 1, it is known that the sapu-sapu plant over 2 years has a stem diameter of 7.48 - 13.05 cm while the sapu-sapu plant less than 2 years has a diameter of 2.86 - 6.05 cm. Samples were taken in the morning so that the oil content in the leaves had not evaporated. Maulidya et al. (2016) conducted a study that the most optimal time to produce essential oils with good yields is in the morning, because if harvested during the day, the oil contained in the sample or material will evaporate due to the hot temperature during the day.

Comparison of Age to Essential Oil Yield

Yield is a comparison of the weight of the essential oil produced to the weight of the sample or raw material used. According to Dewatisari (2018), the amount of yield is related to the amount of bioactive content in plants. According to Chemat (2010) in Ingeswari (2015), the average yield of essential oils produced by plants ranges from 0.005% to 10%. Research conducted by Supandi et al. (2019) found that the average yield of essential oils from sapu-sapu leaves or ujung atap from West Kalimantan is 0.999%. Based on the distillation process, the yield data for essential oils is obtained as in Figure 1 below.

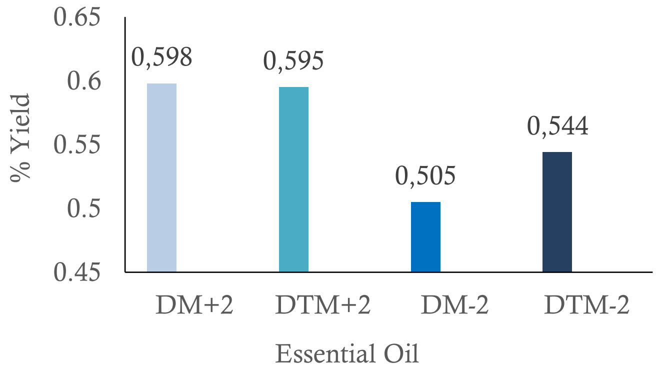


Figure 1. Graph of the percentage of essential oil yield

Figure 1 shows that essential oil from sapu-sapu leaves over 2 years old has a higher yield compared to essential oil from sapu-sapu leaves less than 2 years old because older plants have more time to accumulate chemical compounds in their tissues (Supandi et al., 2019). At an age of over 2 years, bowed sapu-sapu leaves have a higher yield compared to unbowed sapu-sapu leaves, while at an age of less than 2 years, unbowed sapu-sapu leaves have a higher yield compared to bowed leaves. One factor that can affect the yield of essential oil is the biological aspect of the sample, such as the age of the tree or plant. The leaf growth phase can affect the amount of essential oil. The optimal phase for producing essential oil is the accumulation and oil saturation phase. A plant has different optimal phases depending on the physiological age of the tree or plant (Li et al. 2013). In a study by Rocha et al. (2014), it was shown that lemongrass essential oil at the age of 3 months produced a yield of 2.02%, while at the age of 12 months the yield was 2.45%. However, a plant can produce optimal essential oil yields, depending on the physiological age of the plant according to research conducted by Shiferaw et al. (2019) showed that the yield of eucalyptus essential oil at the age of 3 years (1.32%) was greater than that of eucalyptus essential oil aged 100 years (0.95%).

Comparison of Age and Quality of Essential Oils

Characteristics of Essential Oils of Sapu-sapu Leaves

The quality of essential oils can be seen based on their physical and chemical properties. Observations of these physical properties can be seen from the color, smell or aroma, while chemical properties can be known from the content of chemical compounds contained in the essential oil (Aryani et al., 2020). The quality of an essential oil is observed based on its quality standards. However, the essential oil of sapu-sapu leaves or ujung atap does not yet have a quality standard that can be used as a reference for the quality of the essential oil. Based on SNI 06-3954-2006, the quality of an essential oil can be seen from several things such as color, aroma or smell, specific gravity, refractive index, optical rotation, and solubility in ethanol and the chemical compound components contained. The following data on the quality test results of sapu-sapu leaf essential oil are in Table 2.

Table 2. Characteristic data of essential oil from sapu-sapu leaves

Parameter	Sample			
	Bowing over 2 Years (DM +2)	Unbowing over 2 Years (DTM +2)	Bowing less than 2 Years (DM-2)	Unbowing less than 2 Years (DTM-2)
Color	Clear yellow	Kuning muda, bening	Kuning muda, bening	Kuning muda, bening
Aroma	The distinctive smell of sapu-sapu, pungent	Typical sapu-sapu smell, less pungent	Typical sapu-sapu smell, not overpowering	Typical sapu-sapu smell, not overpowering
Refractive Index (nD20°)	1,4770	1,4730	1,4720	1,4750
Specific Gravity	0,8799 g/mL	0,8761 g/mL	0,8722 g/mL	0,8776 g/mL
Optical Rotation	-10,76°	+8,006°	+2,533°	+7,952°
Solubility in Alcohol 96%	1 : 24	1 : 25	1 : 24	1 : 25

Based on Table 2, it is known that the characteristics of essential oils have results that are close to previous research by Supandi et al. (2019), which showed that the essential oil of sapu-sapu merung leaves over 2 years is clear yellow, has a distinctive pungent sapu-sapu aroma, a refractive index of 1.4770, and a specific gravity of 0.8799 g/mL. However, the results of the optical rotation were negative, and the solubility in 96% alcohol (1:24). One of the parameters of the quality of essential oils is color. The essential oil produced from the sapu-sapu leaves is clear yellow to clear light yellow. The color of the essential oil produced is shown in Figure 2 below.

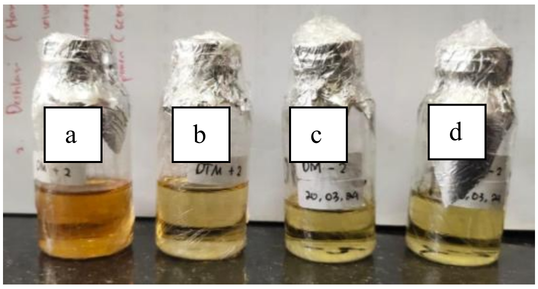


Figure 2. Essential oils (a) bowed leaves over 2 years (b) unbowed leaves over 2 years (c) bowed leaves less than 2 years (d) unbowed leaves less than 2 years

Based on Figure 2, the essential oil of the sapu-sapu plant with bowed leaves over 2 years is clear yellow. Judging from the type of leaf, the bowed leaves have a more dominant color compared to the unbowed leaves. Meanwhile, when viewed from the science of plants, sapu-sapu over 2 years old have a more dominant color compared to sapu-sapu less than 2 years old. Based on the results obtained, it can be said that the older the age of the sapu-sapu plant, the darker the color of the essential oil produced. The difference in color occurs due to differences in the content of chemical compounds contained in essential oils (Khulna and Syarif, 2018). According to the analysis results, this is attributed to the composition of the compound content, specifically *β-Pinene* compounds. From a study conducted by Fajri (2023), the essential oil of cinnamon leaves at the age of 6 years was brighter than the oil of cinnamon leaves at the age of 4 years.

The aroma of a plant's essential oil is distinctive from the plant that produces it (Aryani et al., 2020). Based on Table 2, there are differences in the aroma of the four essential oils produced by the leaves of the sapu-sapu plant over a 2-year period, which have a distinctive pungent aroma compared to the other three types of essential oils. This is due to the chemical compound components contained in it. Several studies have shown that the chemical compound components in essential oils that produce aroma are monoterpene compounds, including *α-Pinene, β-Pinene, 1,8-Cineole*, and *Humulene* (Supandi et al., 2019; Wahyuni et al., 2022; and Murningsih, 2009).

The refractive index value is directly proportional to the specific gravity. The higher the specific gravity value of a substance, the higher the refractive index value, due to molar refractivity (Khusna et al., 2017). Based on Table 2, the largest refractive index value of sapu-sapu essential oil is found in sapu-sapu leaves over 2 years, at 1.477. The smallest refractive index value of essential oil is found in sapu-sapu merung leaves, less than 2 years, with a value of 1.472. This is due to the high water content; the higher the refractive index, the lower the water content (Aryani et al., 2020), and the difference of 1 to 2 chemical compounds contained in the essential oil of sapu-sapu. The research conducted by Pujiarti et al. (2011) showed that as the age of eucalyptus plants increases from 5 years, 10 years, and 15 years, the content of compounds such as *1.8 Cineole* decreases while β-*Caryophyllene* increases. These changes can affect the refractive index value of essential oils. Essential oils containing long-chain compounds will obtain a relatively high refractive index value, because they affect the density of the essential oil and will make it difficult to refract light (Ingeswari, 2015).

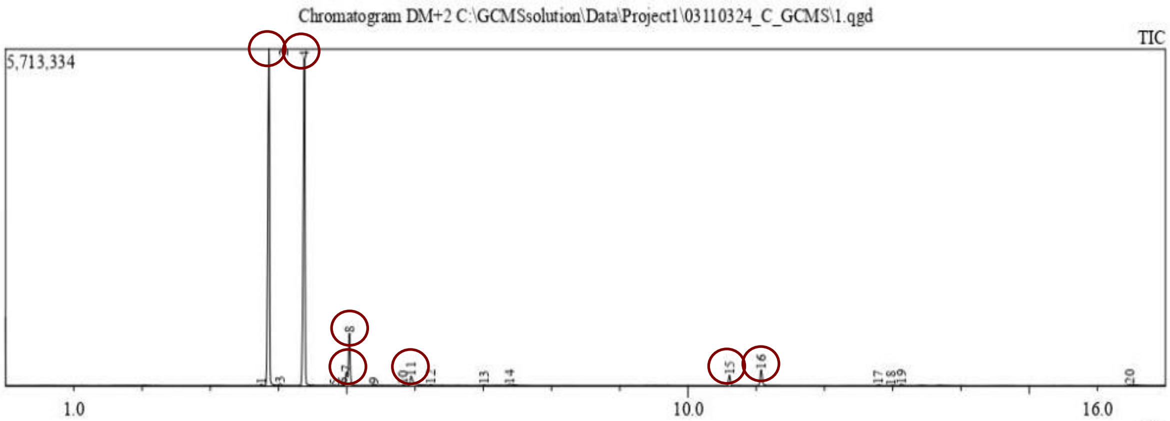
Measuring the specific gravity is also one of the analyses that can determine the purity of the essential oil (Aryani et al., 2020). Table 2 shows that the specific gravity of essential oils is directly proportional to the refractive index produced according to the statement of Kusyanto et al. (2017). The largest specific gravity value of essential oils is found in essential oils of sapu-sapu leaves over 2 years of 0.8799 g/mL, while the smallest specific gravity value of essential oil is found in essential oil of sapu-sapu leaf that is less than 2 years old at 0.8776 g/mL. Generally, the density or specific gravity of essential oils ranges from 0.696 to 1.188 g/mL or below 1,000 g/mL (Nugraheni, 2016). The value of the specific gravity is related to the weight fraction of the components contained in the essential oil. The difference in the specific gravity value of the essential oil of the sapu-sapu leaf produced is thought to be due to the difference in the levels of *α-Humulene* contained in the essential oil of the sapu-sapu leaf. There is no significant difference in the levels of *α-Humulene* in essential oils over 2 years old. However, there is a decrease in the levels of *α-Humulene* in the essential oil of sapu-sapu leaf that is less than 2 years old. Research conducted by Houng et al. 2020) shows that high levels of eugenol (59.448%) affect the specific gravity of essential oil from basil plants by 0.9645 g/mL.

The optical rotation value of an essential oil is used to determine the purity of the essential oil (Supandi et al., 2019). Research conducted by Supandi et al. (2019) found that the optical rotation value of the essential oil of the sapu-sapu leaf is (+) 2.2. Based on Table 2, the optical rotation value at the age of plants over 2 years from the essential oil of the sapu-sapu leaf is (-) 10.76, and the essential oil of the unbowed leaf has an optical rotation value of (+) 8.006. While at the age of plants less than 2 years, the essential oil of the sapu-sapu leaf has an optical rotation value of (+) 2.533, and the essential oil of the unbowed leaf has an optical rotation value of (+) 7.952. The difference in optical rotation values is influenced by the composition of the chemical compounds. From the results of the analysis of the difference in rotation direction in the essential oil of the sapu-sapu-sapu-sapu leaves over 2 years, which produced a negative value, it is suspected that the content of *α-Pinene* and *β-Pinene* compounds is much different compared to other essential oils. According to Supandi's research (2019), the essential oil of the roof-tip leaves shows changes in the composition of compounds that can affect the optical rotation value.

Essential oils can dissolve in alcohol with certain ratios and concentrations. Based on SNI 06-2386-2006, the solubility of vetiver essential oil in 95% ethanol that meets the standard is 1:1 with a clear liquid, and so on. The results of the study are shown in Table 2, the solubility of essential oil of the sapu-sapu leaves over 2 years and less than 2 years in 96% alcohol with a ratio of 1:24 (1 mL of essential oil: 24 mL of 96% alcohol). Meanwhile, the essential oil from bowed leaves, aged over 2 years and less than 2 years, is soluble in 96% alcohol with a ratio of 1:25 (1 mL of essential oil to 25 mL of 96% alcohol). Based on the results, the essential oil obtained from sapu-sapu leaves is difficult to dissolve in 96% alcohol due to its high content of α-Pinene and β-Pinene. Essential oils containing "oxygenated terpene" compounds are more easily soluble in alcohol than essential oils containing terpene compounds (Hirzi et al., 2022). Research by Supandi (2019) shows that the solubility of the essential oil of the ujung atap plant varies; the content of chemical compounds such as α-Pinene, β-Pinene, and 1,8-Cineole, which vary, causes the solubility of essential oils in alcohol to also vary. Chemical Compound Components of Essential Oil of Sapu-sapu Leaves.

Identification of chemical compounds in essential oils was carried out using Gas Chromatography-Mass Spectroscopy (GC-MS). Analysis with GC-MS was carried out to determine the number of components and the content of chemical compounds contained in the essential oil of Sapu-sapu leaves. The chromatograms produced from four types of essential oils of Sapu-sapu leaves are shown in Figure 3 below:

(a)



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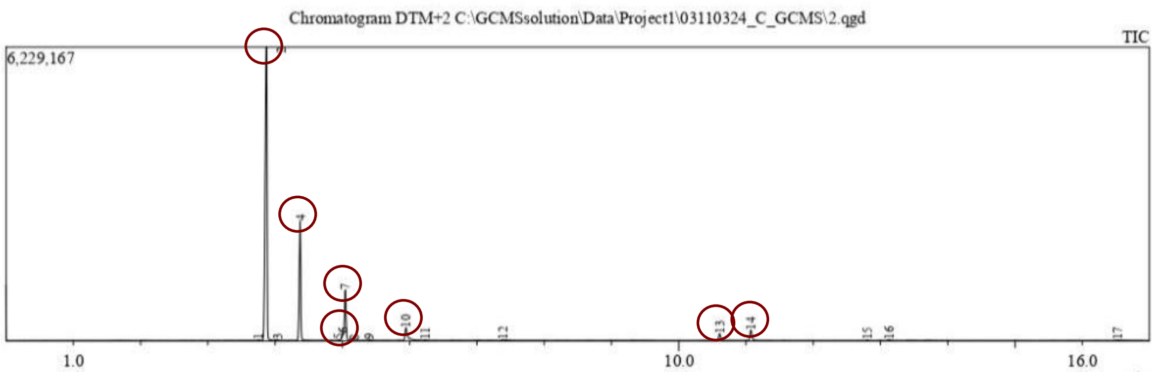
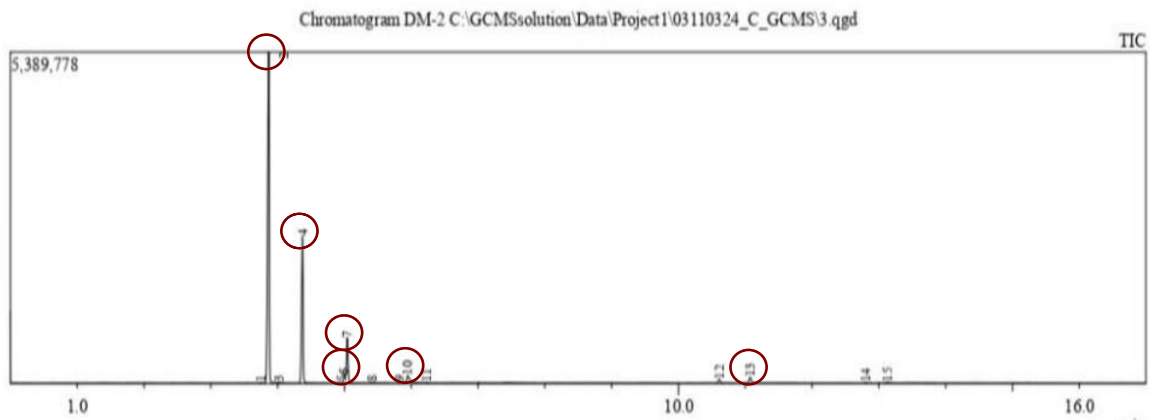


(c)



(d)

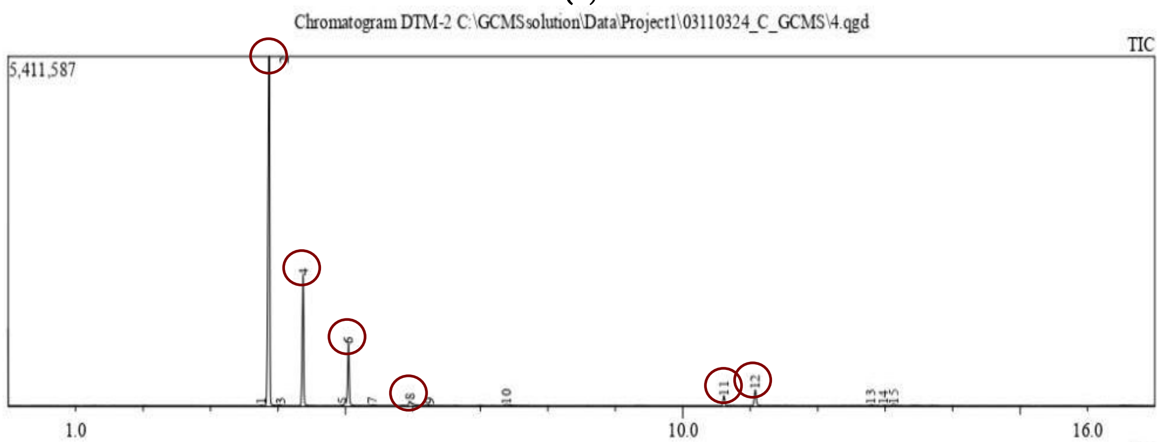


Figure 3. GC-MS chromatogram of essential oil of sapu-sapu leaves, (a) bowed over 2 years; (b) unbowed over 2 years; (c) bowed less than 2 years; and (d) unbowed less than 2 years

The GC-MS chromatogram shows that the leaves of the sapu-sapu plant over 2 years old have more chemical compound components compared to the leaves of sapu-sapu less than 2 years old. In the essential oils of the leaves of bowed and unbowed plants over 2 years old, there are seven main chemical compound components (chromatograms a and b). While in the essential oils of the leaves of bowed and unbowed plants less than 2 years old, there are six main chemical compound components (chromatograms c and d). A comparison of the main chemical compound components of the four types of essential oils is shown in Table 3 below.

Table 3. Comparison of the main chemical compound components of four types of essential oils

Chemical Compounds	Area%			
	Bowed over 2 Years (DM +2)	Unbowed over 2 Years (DTM +2)	Bowed less than 2 Years (DM-2)	Unbowed less than 2 Years (DTM-2)
α -Pinene	42,93	62,90	61,77	63,16
β-Pinene	41,41	18,97	23,09	18,79
Limonene	1,66	1,07	-	-
1,8-Cineole	6,01	8,65	1,45	10,23
Linalool	1,98	3,27	2,27	1,11
Trans-Caryophyllene	1,15	1,44	-	1,97
α-Humulene	2,35	2,24	1,39	3,12
γ-Terpinene	-	-	7,77	-
Total	97,49	98,54	97,74	98,38

Based on Table 3, the main chemical compound components of the four types of essential oils with the highest total area percentage are shown in the essential oil of the unbowed leaf sapu-sapu plant over 2 years, with 98.54% found in chromatogram b, corresponding to peak numbers 2, 4, 6, 7, 10, 13, and 14. This is due to differences in the percentage area of the main chemical compound components in the essential oils obtained. Differences in the percentage of chemical compound components in various types of leaves are influenced by the secondary metabolism process in each leaf, which synthesizes chemical compound components that function in defense and interaction with the environment, resulting in variations in the chemical compounds produced (Tinungki et al., 2018). Based on the results of the study, it was found that the older the age of the sapu-sapu plant, the chemical compound *α-Pinene*, as the most dominant compound, first decreased with increasing age of the plant (Shiferaw et al., 2019).

CONCLUSION

Essential oil of sapu-sapu leaves aged over 2 years has a higher yield compared to essential oil of sapu-sapu leaves aged less than 2 years. When viewed from the type of leaves at the age of over 2 years, the leaves of sapu-sapu bowed have a higher yield (0.598%) compared to leaves of sapu-sapu unbowed (0.595%), while at the age of less than 2 years, leaves of sapu-sapu unbowed have a higher yield (0.544%) compared to bowed leaves (0.505%). The characteristics of essential oil of sapu-sapu leaves aged over 2 years are clear yellow; distinctive aroma; refractive index 1.4770; specific gravity 0.8799 g/mL; optical rotation (-); and solubility in 96% ethanol (1:24). While the essential oil of sapu-sapu leaves aged less than 2 years is clear light yellow; distinctive aroma; refractive index 1.4720; specific gravity 0.8722 g/mL; optical rotation (+); and solubility in ethanol 96% (1:24). The characteristics of essential oil of leaves of sapu-sapu leaves that are not bent over 2 years are light yellow clear; distinctive aroma; refractive index 1.4730; specific gravity 0.8761 g/mL; optical rotation (+); and solubility in ethanol 96% (1:25) While essential oil of leaves of sapu-sapu leaves that are not bent over less than 2 years are light yellow clear; distinctive aroma; refractive index 1.4750; specific gravity 0.8776 g/mL; optical rotation (+); and solubility in ethanol 96% (1:25). The chemical compound components of essential oil of unbowed leaves sapu-sapu over 2 years have a total percentage area of 97.49% while in leaves of sapu-sapu leaves that are not bent over less than 2 years the total percentage area is 97.74%. The chemical compound components of the essential oil of the unbowed leaves of the sapu-sapu over 2 years, with a total area percentage of 98.54%, while in the unbowed leaves over 2 years, with a total area percentage of 98.38%.

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