Production Rate Analysis of Citronella Essential Oil Using Distillation Method

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ABSTRACT

Semoyo is one of the districts located in Gunungkidul Regency. The community engages in the cultivation of traditional medicinal plants. One of the area's widely cultivated traditional medicinal plants is citronella. The community produces a significant amount of citronella, but it has yet to be processed into high-value economic products. Currently, citronella has emerged as a promising commodity because it can be used as a raw material to produce essential oil. The production of citronella essential oil is carried out through steam-hydro distillation. This research aimed to test the distillation characteristics to determine the potential production of citronella essential oil. The research aimed to determine the rate and capacity of essential oil production using citronella as the raw material. Based on the test results, the optimal duration for the distillation process of 2,000 grams of citronella was 60 minutes, with a maximum duration of 90 minutes. The yield of citronella essential oil obtained from this test was 0.414%. The resulting citronella essential oil has a density of 0.920 grams/mL, a clear appearance, a distinctive lemongrass aroma, and a light yellow color. These criteria meet the SNI 3953:2019 for citronella essential oil.

KEYWORDS
Citronella;
Essential Oil;
Distillation Method

1. Introduction

Gunungkidul is one of the regencies in the Special Region of Yogyakarta Province, with a total area of 1,485.36 km2 [2]. Gunungkidul Regency has various potential attractions, including cultivating traditional medicinal plants (known as "toga" in Indonesian). Semoyo is located in the Patuk District, covering an area of 575,000 hectares and has an elevation of 350 meters above sea level [3]. The environmental conditions in this area are suitable for traditional medical plant cultivation, so many local communities utilize empty land for growing traditional medicinal plants. One commonly cultivated traditional medicinal plant in the Gunungkidul region is citronella. The local community produces a plentiful supply of citronella plant, but it has yet to be processed into high-value economic products. The citronella plants obtained are only sold in their wet condition, which is then used as a kitchen spice and herbal drink ingredient.

Currently, the citronella plant has become an excellent commodity because it can be used as a raw material to produce essential oil. Essential oil is one of Indonesia's export commodities that has the potential to continue competing in the international market. The main compounds found in citronella essential oil are citronellal, citronellol, and geraniol [4], [5]. These three compounds determine the pleasant aroma of the resulting oil products. Citronella essential oil is widely used in various industries, including food, perfumes, aromatherapy, cosmetics, and herbal medicine [6]. The selling price of pure citronella essential oil ranges from Rp 300,000.00 to Rp 500,000.00 per liter. This price is much higher compared to selling citronella plants directly.

The production of citronella essential oil is typically carried out through distillation [7]. Distillation is a method of separating components of a mixture, whether solid or liquid, based on their differences in boiling points [8][9]. In the distillation process, the oil in the citronella plant evaporates with steam and then is separated through condensation [10][11]. There are three common distillation methods: water

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distillation, steam distillation, and steam-hydro distillation [12][13]. Distillation is a method that yields better quality results compared to pressing and leaching processes [14][15]. Furthermore, distillation is chosen because the required equipment is simple and can be easily carried out by the community. According to the Research and Development Center for Plantation [16][17], the average yield of citronella essential oil obtained using distillation is approximately 0.6% to 1.2%.

Fauzi et al. [18] studied producing essential oil using citronella plant leaves and stems as raw materials, employing the steam-hydro distillation method. The research revealed that the resulting citronella essential oil from the leaves contained citronellol (41.4%), methyl eugenol (80.2%), citronellal (39.7%), d-limonene (40%), and geraniol (36.5%) with a yield of 0.55%. On the other hand, the citronella essential oil obtained from the stems contained α-himachalene (45.34%), citronellol acetate (48.2%), cis-geraniol (57.8%), and endo-borneol (26.2%) with a yield of 0.024%. These results comply with the SNI 3953:2019, exhibiting a clear appearance, distinctive lemongrass aroma, and a light yellow color.

Based on the above data, it is necessary to conduct distillation characteristic testing to determine the potential for citronella essential oil production using the steam-hydro distillation method. The research aims to determine the rate and capacity of essential oil production using citronella as a raw material, thereby potentially increasing the economic value of citronella. This can be a step towards improving and enhancing the local economy of Semoyo.

2. Method

2.1. Materials

This research utilizes the citronella plant as the raw material from cultivating traditional medicinal plants in Semoyo, Patuk, Gunungkidul, Special Region of Yogyakarta.

2.2. Apparatus

The research uses steam-hydro distillation equipment, including a steam boiler, condenser, refrigerator, thermocouple, and data logger [19]. The arrangement of the steam-hydro distillation apparatus is shown in figure 1 [20]. From this figure it can be seen that the Steam-hydro distillation scheme consists of Measuring glass, Boiler, Funnel glass, Ball condenser, Cooling water outlet, Cooling water inlet, Container and Pump [21].

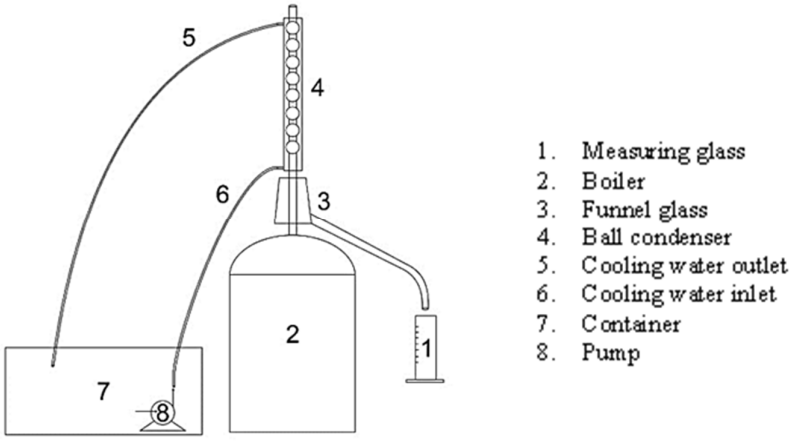

Fig. 1. Steam-hydro distillation scheme

2.3. Procedures

This research utilizes the steam-hydro distillation method to obtain citronella essential oil [22]. The steam-hydro distillation method was chosen in this research because it requires a relatively shorter distillation time and yields higher essential oil yield with better quality compared to water distillation (boiling) [23][24]. The steam-hydro distillation method is conducted using water as the steam

generator[25]–[29] The citronella plant, which will be distilled for its oil, is cut into smaller pieces to facilitate the process [30]. The distillation of citronella essential oil is carried out for 3 hours at a constant temperature [31]. In the distillation process, the oil contained in the citronella plant evaporates along with steam, and then it is separated through condensation [32]. The production of essential oil is measured periodically every 10 minutes [33]. The separation of oil and water from the condensed mixture by allowing it to settle for a moment [34]–[37]. The data on essential oil production is processed to analyze the rate and capacity of production. The resulting citronella essential oil is subjected to organoleptic observation, including physical appearance, color, and aroma [38]–[42]. Determining the density of the citronella essential oil product is also conducted. The observed criteria are compared with SNI 3953:2019 to assess the quality of citronella essential oil.

2.4. Equation and Mathematics

The analysis of the oil reduction rate is conducted using the following equation [43]:

$$\frac{dM}{dt} = -k \tag{1}$$

$$\int dM = \int -k\, dt \tag{2}$$

$$Mt - Mo = -kt \tag{3}$$

$$Mt = Mo - kt \tag{4}$$

The above equation calculates the oil content at the initial and final phases [22], [44]. In the initial phase, the reduction of oil content occurs steadily and continuously. When the equilibrium oil content is reached, the rate of oil reduction will decrease. In this phase, the oil content in the sample can be calculated using an equation derived from the oil content ratio equation.

$$\frac{dMt}{dt} = -k\,(Mt - Me) \tag{5}$$

$$MR = \frac{(Mt - Me)}{(Mo - Me)} = e^{-kt} \tag{6}$$

$$\ln\frac{(Mt - Me)}{(Mo - Me)} = -kt \tag{7}$$

$$Mt - Me = (Mo - Me) \cdot e^{-kt} \tag{8}$$

$$Mt = (Mo - Me) \cdot e^{-kt} + Me \tag{9}$$

3. Results and Discussion

The distillation testing of the citronella plant for 3 hours resulted in 9 mL of essential oil product. This test used a wilted citronella plant and cut it into smaller pieces for easier handling. The citronella plant mass used as the essential oil's raw material was 2,000 grams. The data on the reduction of citronella plant mass during the distillation process is shown in Fig. 2.

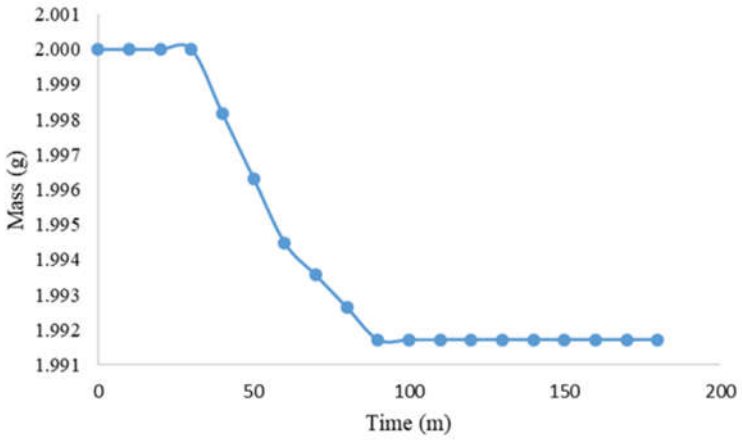

Fig. 2. Graph of citronella plant mass reduction

Fig. 2 illustrates the reduction in citronella plant mass during the 3 hours of testing. The data indicate no further decrease in citronella plant mass after the 90th minute. In the initial phase of the distillation process, there was a rapid and constant reduction in mass. This is indicated by the constant "k" value, which equals 0.184. The constant "k" value was obtained from the gradient of the mass reduction curve from the 30th to the 60th minute. Fig. 3 shows the value of the constant "k" in the initial phase of the distillation process.

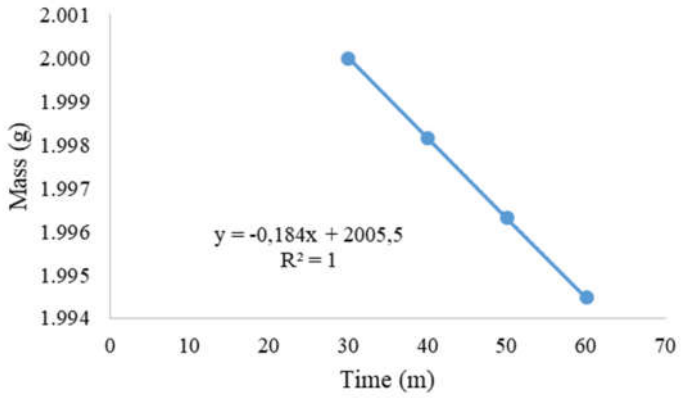

Fig. 3. Determination of the constant "k"

After the 60th minute, the citronella plant mass reduction rate decreased due to the decrease in oil content in the sample. By the 100th minute, the mass of the citronella plant no longer decreased, and no more essential oil was produced. Fig. 4 shows the value of the constant "m" in the final phase of the distillation process. The obtained value of the constant "m" is 0.046. This value indicates that since the 70th minute, essential oil production was no longer significant, although some essential oil was still produced until the 90th minute.

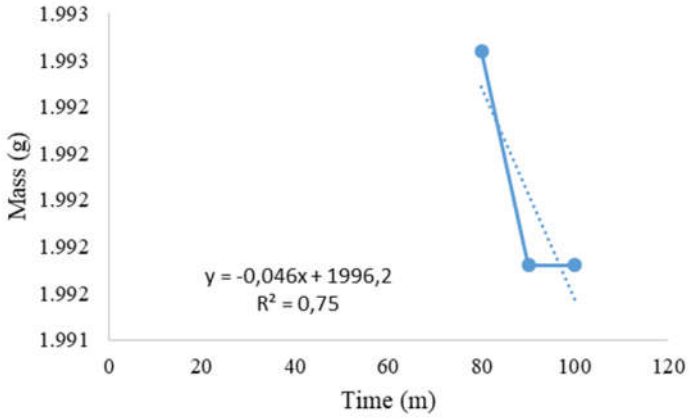

Fig. 4. Determination of the constant "m"

The physical properties testing of the essential oil product revealed a density value of 0.920 grams/mL, a clear appearance, a distinctive lemongrass aroma, and a light yellow color. These physical properties meet the requirements of SNI 3953:2019 for citronella essential oil.

4. Conclusion

From the distillation testing of citronella essential oil using the steam-hydro distillation method for 3 hours, the following results were obtained is the optimal duration for the distillation process of 2,000 grams of citronella plant is 60 minutes based on the constant "k" calculation. The maximum duration for the distillation process of 2,000 grams of citronella plant is 90 minutes. The yield of citronella

essential oil obtained in this testing is 0.414%. The quality of the citronella essential oil produced meets the requirements of SNI 3953:2019 in terms of density, appearance, color, and aroma.

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Author Contribution

This research utilizes the citronella plant as the raw material from cultivating traditional medicinal plants in Semoyo, Patuk, Gunungkidul, Special Region of Yogyakarta.

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Conflict of Interest

The authors declare no conflict of interest.

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