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# Essential Oil of Elephant Ginger (*Zingiber officinale* R.), Antioxidant and Sunscreen Activity and Its Formulation Tests as Sunscreen Cream

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One of the plants that produces abundant essential oil is elephant ginger (*Zingiber officinale* Roscoe). Elephant ginger essential oil has a variety of benefits that have the potential to be developed. Based on the structure of its constituent components, it has the potential as an antioxidant and sunscreen so it can be applied as a sunscreen cream. Research related to elephant ginger essential oil as a sunscreen cream preparation has never been done. The study aims to isolate the elephant ginger essential oil, characterize physical properties, identify components, antioxidant activity, sunscreen activity, and formulate it in the form of sunscreen cream. This research was done in an experimental laboratory through six stages, namely: 1) isolation of elephant ginger essential oil, 2) characterization of its physical properties, 3) identification of its components, 4) antioxidant activity using DPPH method, 5) sunscreen activity using spectrophotometry method, and 6) formulation and evaluation of sunscreen cream contain elephant ginger essential oil. Isolation of elephant ginger essential oil obtained with a yield of 0.08%. This oil color is yellow, liquid, with ginger odor, density is 0.897 $g.cm^{-3}$, boiling point is 119°C, refractive index is 1.492 (25 °C), and specific rotation is +2.48° $dm^{-1}.g^{-1}.mL$. The major components of elephant ginger essential oil are geranial (35.74%), neral (23.81%), eucalyptol (12.88%), camphene (5.78%), zingiberene (2.36%), and α-farnesene (2.01%). The antioxidant activity of elephant ginger essential oil has an $IC_{50}$ value of 1071.018 $\mu g.mL^{-1}$ with a weak category. The sunscreen activity of elephant ginger essential oil has SPF 8.5090 with a maximum protection category. The stability of the sunscreen cream formulation of elephant ginger essential oil is 150 minutes until the active ingredient runs out for both formulas but has not met the minimum requirements based on its SPF value.

**Keywords**: Elephant ginger essential oil; antioxidant; sunscreen cream

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Elephant ginger (*Zingiber officinale* R.) is one of the plants used as medicines or cooking spices. In Indonesia, this plant is relatively abundant and easy to cultivate. The part of the elephant ginger plant that is often used is the rhizome. Elephant ginger rhizome can produce a distinctive aroma because of its essential oil content [1]. In general, elephant ginger essential oil can be obtained by hydro-distillation technique. This essential oil is generally used as medicine, flavor enhancer, and seasoning [2, 3].

According to ISO 16928:2014, several components found in elephant ginger essential oil are β-pinene, camphene, neral, geraniol, geranial, β-elemene, β-sesquiphellandrene, β-curcumene, β-bisabolene, and zingiberene. Zingiberene is the largest component of elephant ginger essential oil. This compound belongs to the sesquiterpene group [4]. Some literature reveals that elephant ginger essential oil has the potential as an antioxidant, antimicrobial, antifungal, and anti-inflammatory [5–7].

Exposure to pollution in the environment and/or ultraviolet radiation from the sun can generate free radicals. One way to reduce the formation of free radicals is with an antioxidant [8]. Antioxidants work by reacting with a radical to produce another, more stable radical [9, 10]. Antioxidant compounds are characterized by the presence of hydroxyl groups (at C-primary, -secondary, or -tertiary), aldehydes, and C=C double bonds Based on structure of its components, elephant ginger essential oil has the potential as an antioxidant. This potential is supported by previous research showing that elephant ginger essential oil acts as an antioxidant [12].

Sunscreen, especially chemical sunscreen, is a substance that can absorb or reflect ultraviolet radiation from sunlight. Long-term exposure to ultraviolet radiation can cause sunburn and skin cancer [13]. Compounds that have the potential as sunscreens are compounds that can absorb UV radiation [14]. The characteristics of compounds that have the potential as

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sunscreens are conjugated double bonds. The conjugated double bond system occurs in the aromatic system, between C=C bonds, or C=C bonds with carbonyl groups [15, 16]. Previous study showed that essential oil from different plant source which are peppermint oil, tulisi oil, and lemon grass oil shown sunscreen activity by SPF value which are 6.668, 6.571, and 6.282 respctively [17]. Thus, elephant ginger essential oil may has the potential as a sunscreen. Information regarding the sunscreen activity of elephant ginger essential oil has not been reported.

Based on its potential as an antioxidant and sunscreen, elephant ginger essential oil was tried to be applied as a sunscreen product. In addition to providing a distinctive aroma, elephant ginger essential oil has good potential. The success of this research can be used as an innovative application of elephant ginger essential oil. This research was conducted to develop the potential of elephant ginger essential oil in the form of sunscreen cream preparations. Sunscreen cream acts to protect the skin from the negative effects of sunlight. Use it in the form of a cream because it is practical and can last a long time. Research related to elephant ginger essential oil as a sunscreen cream preparation has never been done before. The aim of this study is to isolate the elephant ginger essential oil, characterize physical properties, identify components, antioxidant activity, sunscreen activity, and formulate in the form of a sunscreen cream.

## EXPERIMENTAL

This research was conducted in an experimental laboratory at the Organic Chemistry Research Laboratory, Department of Chemistry, Universitas Negeri Malang. This study consisted of six stages, namely 1) isolation of elephant ginger essential oil, 2) characterization of physical properties, 3) identification of components, 4) antioxidant activity test, 5) sunscreen oil activity test, 6) formulation and evaluation of sunscreen cream.

### Equipment and Materials

The equipment used in this research are a set of glassware, a set of steam-water distillation tools, alcohol thermometer 200 °C, universal indicator, mechanical stirrer, ohaus balance, analytical balance brand Dura Scale DAB200 with an accuracy of 0.001 g, refractometer ABBE Atago Japan, digital polarimeter series BK-P2S Biobase Biodustry, Gas Chromatography-Mass Spectrometer (GC-MS) series QP2010S SHIMADZU, UV-Visible spectro-photo-meters UV-1700 series SHIMADZU, and Spectronic-Genesys 20 Visible Spectrophotometer Thermo Fischer Scientific.

The materials used in this study are fresh elephant ginger rhizome (collected in Malang), distilled water, anhydrous magnesium sulfate (technical grade), DPPH (2,2-diphenyl-1-picrylhydrazyl) (Sigma-Aldrich), ascorbic acid (Merck, pro analysis), methanol (Merck, pro analysis), ethanol (Merck, pro analysis), stearic acid (technical grade), cetyl alcohol (technical grade), liquid paraffin, BHT (Butylated hydroxytoluene) (technical grade), triethanolamine (technical grade), and glycerin (technical grade).

### Procedures

#### Isolation of Elephant Ginger Essential Oil

Elephant ginger essential oil was isolated using hydro-distillation technique. Approximately 7 kg of fresh and clean elephant ginger pieces were put into a hydro-distillation apparatus and then distilled until the oil ran out. Distillation was stopped after there were no visible drops of oil in the distillate container. The essential oil in the distillate container is separated and then dried by adding anhydrous magnesium sulfate. The dry essential oil is separated and then weighed to determine the yield.

#### Characterization of Elephant Ginger Essential Oil

Characterization of the isolated elephant ginger essential oil included phase, color, boiling point, density, refractive index, and optical rotation. Characterization of phase and color was done by organoleptic observation. The measurement of the boiling point was carried out using a boiling point measuring device using the percolator technique. Density was determined using a 10 mL pycnometer. The refractive index was measured using an Abbe refractometer. Measurement of optical rotation using a solution of 5% elephant ginger essential oil in methanol, then converted to obtain a specific rotation.

#### Identification of Components in Elephant Ginger Essential Oil

The chemical components of elephant ginger essential oil were identified using the GC-MS instrument by SHIMADZU QP2010S series at the Chemical Laboratory, Gadjah Mada University under GC conditions are column DB-5MS (length 30 m, internal diameter 0.25 mm, film 0,25 μm), injector temperature 300 °C, oven temperature 50 °C, Helium carrier gas at flow rate 0.62 mL/min at 300 °C, split ratio 129.9, pressure 21.0 kPa, and EI ionization technique 70 eV. MS conditions are time analysis 5.20–50.00 minutes, analysis time 0.50 seconds, scanning speed 1250, and m/z between 28.00–600.00. Each peak in the GC measurement chromatogram was analyzed for its mass spectra, interpreted, and then referred to the database on the instrument.

#### Antioxidant Activity Test of Elephant Ginger Essential Oil

Antioxidant activity test was carried out by radical scavenging technique using DPPH (2.2-diphenyl-1-picrylhydrazil). A total of 25 mg of essential oil was

dissolved in 25 mL of methanol (a stock solution with a concentration of 1000 μg.mL$^{-1}$). This stock solution was diluted to obtain solutions with concentrations of 100, 200, 300, 400, and 500 μg.mL$^{-1}$ which were used as sample solutions tests. Ascorbic acid solutions with concentrations of 1, 2, 3, 4, and 5 μg.mL$^{-1}$ were used as positive controls. Experiments were carried out by mixing 0.5 mL of the sample solution and 4.5 mL of DPPH solution at each concentration. The absorbance of this solution was then measured at a wavelength of 497, 517, and 537 nm at minute 30. The antiradical capacity (radical scavenging) of DPPH was measured from the scavenging of the purple-red color of DPPH at 517 nm with the following formula:

$$A_{calc} = A_{517} - \frac{A_{497} + A_{537}}{2}$$

$$\%\ DPPH\ radical\ scavenging = \frac{A_o - A_t}{A_o} \times 100$$

which $A_{497}$, $A_{517}$, and $A_{537}$ are absorbances at 497, 517, and 537 nm respectively. While $A_0$ is calculated absorbance for the blank, and $A_t$ is calculated absorbance of the sample. In addition, the obtained absorbance is made a calibration curve and a linear regression equation y = ax + b, where x is the concentration and y is the percentage of DPPH radical reduction. The obtained linear regression equation was used to determine the $IC_{50}$ of the sample.

**Analysis of UV Spectrophotometry and Sunscreen Activity of Elephant Ginger Essential Oil**

UV spectrophotometric analysis was performed using a 5% solution of essential oil in methanol. Measurements were made at a wavelength of 200–400 nm. The sunscreen activity test is carried out by determining the SPF (Sun Protection Factor) value through analysis and calculation of the UV spectrum. Calculation of sunscreen activity using absorbance at a wavelength of 290–320 nm at interval 5 nm. Sunscreen activity is calculated using the following equation [18]:

$$SPF = CF \times \sum_{290}^{320} EE_\lambda \times I_\lambda \times A_\lambda$$

with CF is correction factor = 10, $EE_\lambda$ is spectrum erythema effect, $I_\lambda$ is sunlight intensity, and $A_\lambda$ is absorbance of the sample. The value of $EE_\lambda$ x $I_\lambda$ is a constant as listed in Table 1.

**Formulation and Evaluation of Sunscreen Cream of Elephant Ginger Essential Oil**

The formulation of sunscreen cream preparations was done by dividing two types of ingredients, which are oil phase (soluble in oil) and aqueous phase (soluble in water). The oil phase is stearic acid, cetyl alcohol, liquid paraffin, and BHT. The aqueous phase ingredients are glycerin, triethanolamine, methylparaben, and distilled water. The oil and water phases were each homogenized by heating at a temperature of 70 °C. The water phase was poured into the oil phase under hot conditions and stirred with a mechanical stirrer until cream formed at room temperature. The essential oil was added and stirred until homogeneous. The compositions of formulations are shown in Table 2.

Evaluation of sunscreen product preparations was carried out by organoleptic, homogeneity, pH, and SPF. An organoleptic evaluation was carried out by observing the phase, color, aroma, and homogeneity visually and tactilely. The stability test of the active ingredients was carried out by spreading 0.1 g of cream on filter paper, and then weighing every 30 minutes until the weight was constant. The measurement of pH was carried out by dissolving 0.5 g of cream into 50 mL distilled water and then measuring the pH using a universal indicator [19]. The SPF value was tested using the spectrophotometric method, by dissolving the cream in ethanol to obtain concentration 200 μg.mL$^{-1}$, then measure the absorbance using a UV spectrophotometer at a wavelength of 290–320 nm with 5 nm intervals [18].

**Table 1.** Constant $EE_\lambda$ x $I_\lambda$ [18].

| Wavelength (nm) | EE x I |
|---|---|
| 290 | 0.0150 |
| 295 | 0.0817 |
| 300 | 0.2874 |
| 305 | 0.3278 |
| 310 | 0.1864 |
| 315 | 0.0839 |
| 320 | 0.0180 |

**Table 2.** Sunscreen Cream Formulation Composition.

| Ingredients | Composition (%) | |
|---|---|---|
| | F1 | F2 |
| Stearic acid | 7 | 7 |
| Cetyl alcohol | 2 | 2 |
| Liquid paraffin | 2 | 2 |
| BHT | 0.2 | 0.2 |
| Glycerin | 7 | 7 |
| Triethanolamine | 1 | 1 |
| Methyl paraben | 0.2 | 0.2 |
| Ginger essential oil | 5 | 10 |
| Distillate water | 75.6 | 70.6 |
| **Total** | **100** | **100** |

**Table 3.** Elephant Ginger Essential Oil Yield**.**

| Experiment | Mass (g) | | Isolation Time | Yield (%) |
|---|---|---|---|---|
| | Sample | Elephant Ginger Essential Oil | | |
| 1 | 7268 | 3.009 | 24 hours | 0.04 |
| 2 | 7191 | 6.802 | 24 hours | 0.10 |
| 3 | 7225 | 7.420 | 24 hours | 0.10 |
| 4 | 7571 | 6.806 | 24 hours | 0.09 |
| **Average** | | | **24 hours** | **0.08** |


**Figure 1.** Elephant Ginger Essential Oil.

**Table 4.** Physical Properties Comparison of Elephant Ginger Essential Oil.

| No. | Properties | Physical Properties | | | |
|---|---|---|---|---|---|
| | | This research | SNI 06-1312-1998 | Reference [20] | Reference [21] |
| 1. | Color | Yellow | Yellow | Yellow | Yellow |
| 2. | Phase | Liquid | Liquid | Liquid | Liquid |
| 3. | Aroma | Ginger aroma | Ginger aroma | Ginger aroma | Ginger aroma |
| 4. | Density ($g.cm^{-3}$) | 0.897 | 0.8720–0.8890 | 0.9033 (30 °C) | 0.8680-0.8830 (20 °C) |
| 5. | Boiling Point | 119–122 °C | | | |
| 6. | Refractive Index | 1.492 (25 °C) | 1.4853–1.4920 | 1.487 ± 0.00 (30 °C) | 1.4850-1.4950 (20 °C) |
| 7. | Optical Rotation | -12.48° | (-32°)–(-14°) | -39.41° | - |

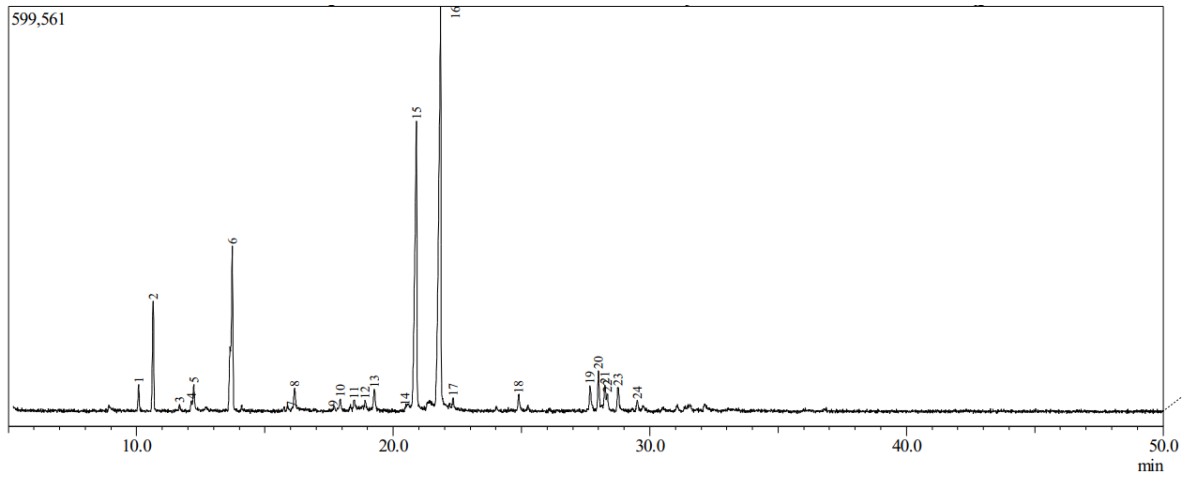


**Figure 2.** Gas Chromatogram of Elephant Ginger Essential Oil.

## RESULTS AND DISCUSSION

### Isolation of Elephant Ginger Essential Oil

The elephant ginger essential oil was obtained with an average yield of 0.08%. Essential oils isolated from elephant ginger rhizomes are listed in Table 3. Yield obtained in this study is lower than the other previous study, around 0.1–2.4% [6, 12]. The yield of elephant ginger essential oil can be influenced by the growing environment, climatic conditions, cultivation process, harvest age, and isolation method [4, 6]. The isolated elephant ginger essential oil is shown in Figure 1.

### Physical Properties Characterization of Elephant Ginger Essential Oil

Characterization of physical properties was used to determine the quality of elephant ginger essential oil. The characterizations include color, phase, aroma, density, boiling point, refractive index, and optical rotation. The measurement results obtained were compared with SNI (Standar Nasional Indonesia, Indonesia National Standard) 06-1312-1998 and previous studies. A comparison of the physical properties of elephant ginger essential oil in this study with SNI and previous studies is listed in Table 4.

Based on the comparison of the physical properties of elephant ginger essential oil in Table 4, some of the physical properties follow the results of previous studies. The result of the characterization that is not suitable is the optical rotation of the elephant ginger essential oil. The value of optical rotation is influenced by the presence of chiral groups in a compound. The difference in optical rotation in this study can be caused by the number of chiral compounds in the constituent components of elephant ginger essential oil.

### Identification of Elephant Ginger Essential Oil Component

Identification of the components of the elephant ginger essential oil resulted in a gas chromatogram and mass spectrum for each peak in the chromatogram. There were twenty-four peaks detected in the gas chromatogram of the elephant ginger essential oil. The gas chromatogram of elephant ginger essential oil is shown in Figure 2.

Identification of the components of the elephant ginger essential oil resulted in a gas chromatogram with 24 peaks. Based on the analysis, 24 peaks appeared on the chromatogram, which showed that there were 24 components of the elephant ginger essential oil. Among the 24 chromatogram peaks that appeared, the 16$^{th}$ peak was the highest peak, indicating the component with the largest concentration, namely geranial or *trans*-citral.

The results of the separation from gas chromatography are then measured in a mass spectrometer. Analysis of the mass spectrometer produces a mass spectrum. The mass spectrum obtained was matched with the WILEY229.LIB, NIST62.LIB, and NIST12.LIB libraries. The results of matching the readings with the library then obtained a mass spectrum that has a relevant resemblance to the detected mass spectrum. The similarity of the mass spectra is indicated by the similarity index. The components of elephant ginger essential oil are listed in Table 5.

The compound structure of the six largest components in elephant ginger essential oil, namely camphene, eucalyptol, neral (*cis*-citral), geranial (*trans*-citral), zingiberene, and α-farnesene are listed in Figure 3.

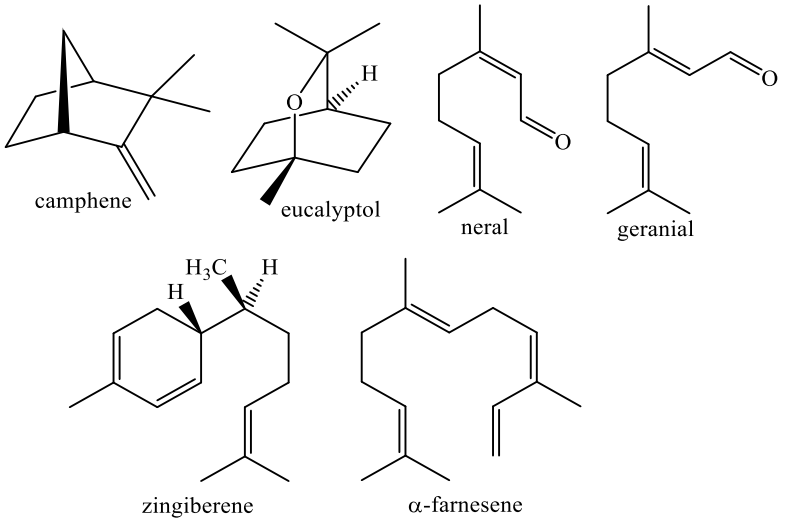


**Figure 3**. Structure of six major components of elephant ginger essential oil.

**Table 5.** Chemical Component of Elephant Ginger Essential Oil.

| Peak | Content (%) | Compound | |
|---|---|---|---|
| | | IUPAC name | Trivial name and Synonym |
| 1 | 1,47 | 3,7-dimethyl-1,3,7-octatriene | ocimene |
| 2 | 5,78 | 2,2-dimethyl-3-methylenbicyclo[2.2.1]heptane | camphene |
| 3 | 0,27 | 6,6-dimethyl-2-methylenbicyclo[3.1.1]heptane | β-pinene |
| 4 | 0,6 | 6-methyl-5-hepten-2-on | - |
| 5 | 1,56 | 7-methyl-3-methylen-1,6-octadiene | myrcene |
| 6 | 12,88 | 1,3,3-trimethyl-2-oxabicyclo[2.2.2]octane | eucalyptol |
| 7 | 0,23 | Unknown | - |
| 8 | 1,38 | 3,7-dimethyl-1,6-octadien-3-ol | linalool |
| 9 | 0,27 | Unknown | - |
| 10 | 0,62 | 3,7-dimethyl-6-octenal | citronellal |
| 11 | 0,52 | 1,7,7-trimethylbicyclo[2.2.1]heptan-2-ol | isoborneol |
| 12 | 0,49 | 9,12-octadecadienal | - |
| 13 | 1,31 | 2-(4-methylcyclo-3-hexenyl)propan-2-ol | α-terpineol |
| 14 | 1,11 | 3,7-dimethyl-6-octen-1-ol | citronellol |
| 15 | 24,81 | (2Z)-3,7-dimethyl-2,6-octadienal | neral, cis-citral |
| 16 | 35,74 | (2E)-3,7-dimethyl-2,6-octadienal | geranial, trans-citral |
| 17 | 0,58 | 4-methyl-2-hexanone | - |
| 18 | 0,84 | (2E)-3,7-dimethyl-2,6-octadienyl acetate | geranyl acetate |
| 19 | 1,63 | 1-(1,5-dimethyl-4-hexenil)-4-methylbenzene | α-curcumene |
| 20 | 2,36 | 2-methyl-5-(6-methyl-5-hepten-2-yl)cyclohexa-1,3-diene | zingiberene |
| 21 | 2,01 | 3,7,11-trimethyl-1,3,6,10-dodecatetraene | α-farnesene |
| 22 | 1,05 | 1-methyl-4-(5-methyl-1-methylen-4-hexenil) cyclohexene | β-bisabolene |
| 23 | 1,68 | 4,11,11-trimethyl-8-methylenbicyclo[7.2.0]undec-4-ene | trans-caryophyllene |
| 24 | 0,8 | 2-(5-methyl-5-(4-methylcyclohex-3-enyl)tetrahydrofuran-2-yl)-2-propanol | α-bisabolol oxide B |

A comparison of component levels in elephant ginger essential oil in this study with previous studies showed differences in the main components. The main component of elephant ginger essential oil in this study was geranial, similar results were shown in the study of Widodo et al. (2020) [22]. The main component of elephant ginger essential oil in other studies is zingiberene [4]. Differences in the main components can be caused by the growing environment, climatic conditions, cultivation process, harvest age, and isolation method [4, 6].

Based on the structure of the constituent components of elephant ginger essential oil in Figure 3 and Table 5, shows that elephant ginger essential oil contains unsaturated terpenoid compounds. The constituent components of elephant ginger essential oil in this study have the potential as anti-oxidants and absorb UV radiation. This is confirmed by the presence of conjugated C=C double bonds and the aldehydic group of these compounds. Based on the characteristics, elephant ginger essential oil has the potential as an antioxidant and sunscreen.

**Antioxidant Activity of Elephant Ginger Essential Oil**

Testing of antioxidant activity using the principle of radical reduction with the DPPH method by visible spectrophotometry at wavelengths of 497, 517, and 537 nm. Ascorbic acid was used as a standard or positive control. The absorbance obtained was calculated to obtain the calculated absorbance and percentage of DPPH inhibition. The absorbance of DPPH inhibition by elephant ginger essential oil is shown in Table 6, and the graph of inhibition of DPPH is shown in Figure 4. Ascorbic acid was tested for antioxidant activity for standard. The absorbance of DPPH inhibition by ascorbic acid is shown in Table 7, and the graph of percent DPPH inhibition is shown in Figure 5.

**Table 6.** Absorbance and % DPPH Radical Scavenging of Elephant Ginger Essential Oil.

| Solution ($\mu g.mL^{-1}$) | $A_{497}$ | $A_{517}$ | $A_{537}$ | $A_{calc}$ | % DPPH Radical Scavenging |
|---|---|---|---|---|---|
| 100 | 0.500 | 0.580 | 0.496 | 0.082 | 14.583 |
| 200 | 0.497 | 0.573 | 0.491 | 0.079 | 17.708 |
| 300 | 0.491 | 0.562 | 0.488 | 0.073 | 24.479 |
| 400 | 0.487 | 0.555 | 0.482 | 0.071 | 26.562 |
| 500 | 0.471 | 0.539 | 0.469 | 0.069 | 28.125 |
| Blank | 0.509 | 0.621 | 0.541 | 0.096 | - |

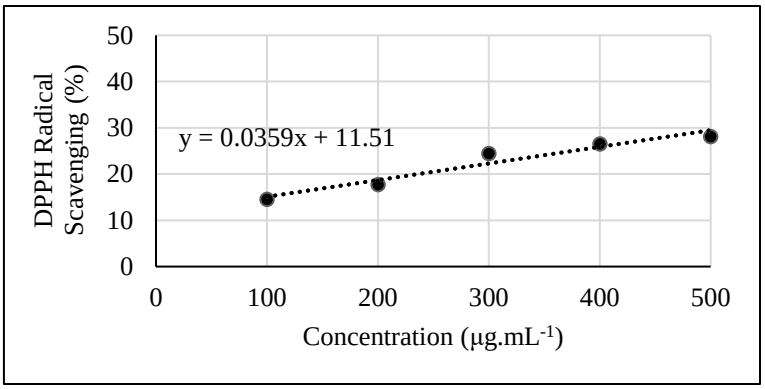


**Figure 4.** Graph of % DPPH Radical Scavenging Against Elephant Ginger Essential Oil.

**Table 7.** Absorbance and % DPPH Radical Scavenging of Ascorbic Acid.

| Test Solution ($\mu g.mL^{-1}$) | $A_{497}$ | $A_{517}$ | $A_{537}$ | $A_{calc}$ | % DPPH Radical Scavenging |
|---|---|---|---|---|---|
| 1 | 0,476 | 0,551 | 0,476 | 0,075 | 21,875 |
| 2 | 0,474 | 0,548 | 0,474 | 0,074 | 22,917 |
| 3 | 0,432 | 0,495 | 0,431 | 0,064 | 33,854 |
| 4 | 0,414 | 0,474 | 0,414 | 0,060 | 37,500 |
| 5 | 0,385 | 0,440 | 0,384 | 0,056 | 42,188 |
| Blank | 0,509 | 0,621 | 0,541 | 0,096 | - |

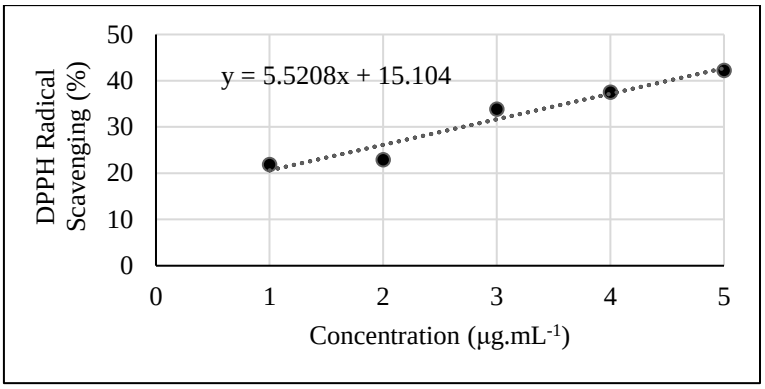


**Figure 5.** Graph of % DPPH Radical Scavenging Against Ascorbic Acid.

**Table 8.** $IC_{50}$ Antioxidant Activity of Elephant Ginger Essential Oil and Ascorbic Acid.

| Sample | $IC_{50}$ (µg.mL$^{-1}$) |
|---|---|
| Elephant ginger essential oil | 1071.014 |
| Ascorbic acid | 6.321 |

The linear regression equation was used to calculate $IC_{50}$ of its antioxidant activity. The $IC_{50}$ values for samples of elephant ginger essential oil and ascorbic acid are listed in Table 8.

Antioxidant activity is expressed by the $IC_{50}$ value. The $IC_{50}$ value is the sample concentration required to reduce 50% of the total DPPH radical, the smaller the $IC_{50}$ value, the stronger the antioxidant activity [23]. The $IC_{50}$ value of elephant ginger essential oil was 1071.014 µg.mL$^{-1}$. The antioxidant level of elephant ginger essential oil in this study is reviewed in Table 9, including in the weak category. The antioxidant activity of elephant ginger essential oil in this study was compared with previous studies. The $IC_{50}$ value of elephant ginger essential oil in this study was smaller than the previous study by 1218.70 µg.mL$^{-1}$ [12].

The antioxidant activity of elephant ginger essential oil in this study was higher than previous studies. The measurement of the antioxidant activity of ascorbic acid was used as a positive control or standard in the measurement of antioxidants. The $IC_{50}$ value of ascorbic acid in this study was 6.321 µg.mL$^{-1}$. The antioxidant power of ascorbic acid is reviewed in Table 9, which is included in the very strong category. From the $IC_{50}$ value, the antioxidant power of elephant ginger essential oil in this study was 190 times weaker than ascorbic acid.

**UV Spectrophotometric Analysis and Sunscreen Activity of Elephant Ginger Essential Oil**

The results of UV spectrophotometry analysis of elephant ginger essential oil at 200–400 nm obtained $\lambda_{max}$ at 330 nm with an absorbance of 1.8771. The UV spectrum of elephant ginger essential oil is shown in Figure 6.

**Table 9.** Classification of Antioxidant Level [10].

| Antioxidant Category | $IC_{50}$ Value (µg.mL$^{-1}$) |
|---|---|
| Very Strong | <50 |
| Strong | 50–100 |
| Medium | 101–150 |
| Weak | >150 |

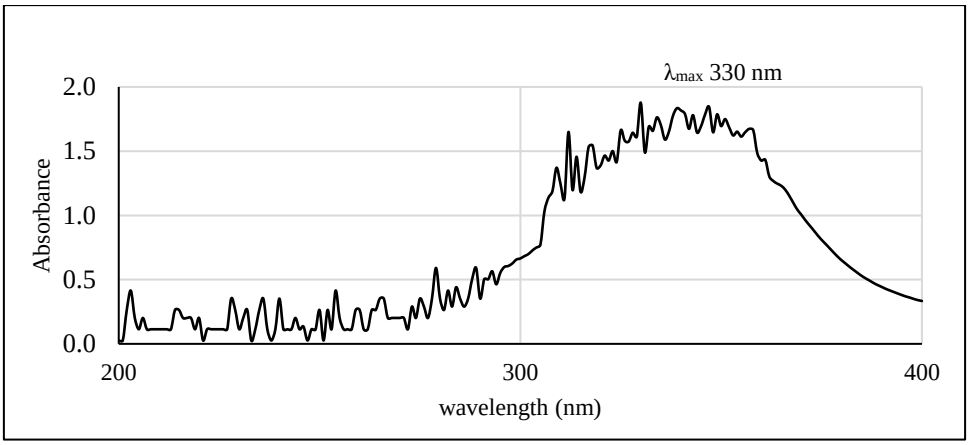


**Figure 6.** UV Spectrum of Elephant Ginger Essential Oil.

UV spectrophotometric analysis provides information indicating the presence of a chromophore group, at a wavelength of 330 nm with an absorbance of 1.8771. The possible transitions that occur are the $n \rightarrow \pi^*$ transition (R band) in atoms that have a nonbonding electron pair, namely the C=O group, and the $\pi \rightarrow \pi^*$ transition (K band) in the conjugated C=C double bond system. The presence of these two types of transitions or two bands indicates that they can absorb UV radiation so elephant ginger essential oil has the potential to be active as a sunscreen.

Testing the sunscreen activity of elephant ginger essential oil using absorbance obtained through UV spectrum analysis. The absorbance used was at a wavelength of 290–320 at 5 nm intervals. Sunscreen activity was calculated using the constants in Table 1 so that the SPF value of elephant ginger essential oil was 8.5090, which is completely listed in Table 10. Sunscreen activity was expressed by the SPF value. The SPF value indicates the level of sun radiation protection. The test results show that elephant ginger essential oil activity as a sunscreen with an SPF value of 8.5090. The sunscreen category based on Table 11 is included in the maximum protection category. Maximum protection on sunscreen activity, indicating that elephant ginger essential oil has the maximum ability to reduce UV radiation. The effectiveness in reducing UV light is indicated by a high SPF value. Thus, elephant ginger essential oil has its potential activity as a sunscreen, it can be used as an active ingredient in sunscreen creams.

**Table 10.** Sunscreen Activity of Elephant Ginger Essential Oil.

| Wavelength (nm) | EE x I | Absorbance | SPF |
|---|---|---|---|
| 290 | 0.0150 | 0.3522 | 0.0528 |
| 295 | 0.0817 | 0.5522 | 0.4511 |
| 300 | 0.2874 | 0.6647 | 1.9103 |
| 305 | 0.3278 | 0.7714 | 2.5286 |
| 310 | 0.1864 | 1.2463 | 2.3231 |
| 315 | 0.0839 | 1.1835 | 0.9930 |
| 320 | 0.0180 | 1.3888 | 0.2500 |
| | **SPF Value** | | **8.5090** |

**Table 11.** Classification of Sunscreen Protection [16].

| Protection Level | SPF Value |
|---|---|
| Minimum protection | 1–4 |
| Medium protection | 4–6 |
| Extra protection | 6–8 |
| Maximum protection | 8–15 |
| Ultra protection | >15 |

**Table 12.** Evaluation of Sunscreen Cream.

| Formulation | Organoleptic Test | | Active Ingredients Stability | pH | SPF |
|---|---|---|---|---|---|
| | Appearance | Description | | | |
| F1 |  | Phase: semi-solid<br>Color: white<br>Aroma: aroma of elephant ginger essential oil<br>Homogeneity: homogeneous | 150 minutes | 5 | 0.1981 |
| F2 |  | Phase: semi-solid<br>Color: white<br>Aroma: aroma of elephant ginger essential oil<br>Homogeneity: homogeneous | 150 minutes | 5 | 0.3651 |

**Formulation and Evaluation of Sunscreen Cream Preparation of Elephant Ginger Essential Oil**

Elephant ginger essential oil is formulated into a sunscreen cream with other ingredients that act as support. The function of the ingredients used for sunscreen creams based on the Handbook of Pharmaceutical Excipients are stearic acid as a cream base, cetyl alcohol as a cream base, liquid paraffin as an emollient, BHT as an antioxidant, glycerin as an emulsifier, methylparaben as a preservative, and triethanolamine as an alkalizing agent [24].

The cream variant of this sunscreen preparation is divided into two based on the amount of elephant ginger essential oil added, namely Formula 1 as much as 5%, and Formula 2 as much as 10%. The formulation of the sunscreen cream formulation of elephant ginger essential oil was evaluated through organoleptic, homogeneity, stability, pH, and SPF tests. The results of the evaluation of the elephant ginger essential oil sunscreen cream are listed in Table 12.

The stability test of sunscreen cream in Formula 1 and Formula 2, indicated the resistance of elephant ginger essential oil in a preparation when applied until it evaporated completely. The stability of the active ingredients in Formula 1 shows that the essential oils in Formula 1 when applied can last for 150 minutes. The stability of the active ingredients in Formula 2 shows that the essential oils in Formula 2 when applied can last for 150 minutes. SNI 16-4399-1996 states that the quality parameter of sunscreen cream has a homogeneous appearance, pH ranges from 4.5 to 8, and SPF $\geq$ 4. Formula 1 has organoleptic and pH test results that comply with SNI but do not meet the minimum SPF value requirements. Formula 2 has organoleptic and pH test results that comply with SNI but do not meet the minimum SPF value requirements.

## CONCLUSION

Elephant ginger essential oil was isolated using the hydro distillation method with a yield of 0.08%. This oil is liquid, light yellow, has a characteristic ginger aroma, density of 0.897 $g.cm^{-3}$, boiling point of 119 °C, refractive index of 1.492 (25 °C), and specific optical rotation -12.48° $dm^{-1}.g^{-1}.mL$. The major components were geranial (35.74%), neral (23.81%), eucalyptol (12.88%), camphene (5.78%), zingiberene (2.36%), and α-farnesene (2.01%). The antioxidant activity of this oil has an $IC_{50}$ 1071.018 $\mu g.mL^{-1}$ with a weak category. Elephant ginger essential oil can protect from UV rays that are shown by sunscreen activity with the SPF 8.5090 with the maximum protection category. The evaluation result of sunscreen cream that has been made in this research based on SNI 16-4399-1996 is meet requirements for organoleptic and pH test, but do not meet requirements for SPF value. The stability of the sunscreen cream formulation of elephant gingers essential oil for 150 minutes until the active ingredients ran out for both formulas but did not meet the minimum requirements based on the SPF value. The lack of this research include the formulation of sunscreen cream, where in this study only used one active ingredient, so it may not cover extensive protection against UV rays. Generally, the active ingredients used for sunscreen cream usually consist of various kinds of ingredients, both organic and inorganic, so that the sunscreen cream has broad coverage protection against UV rays. The importance of this research is to provide information regarding the relationship between antioxidant and sunscreen activity in elephant ginger oil, where the results of this research show that antioxidant compounds can play a role in absorbing UV rays. Elephant ginger essential oil can be developed further related to other potentials so that it can increase the use value and selling value of elephant ginger into useful products.

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