**Original Research Report**

# ANTIOXIDANT ACTIVITIES AND POTENTIAL WOUND HEALING EFFECTS OF *MENIRAN* (*Phyllanthus niruri*) EXTRACT GEL

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## ABSTRACT

Research on the use of medicinal plants to treat numerous diseases has been widely conducted. However, for chronic wound healing, the availability of medicinal plants for treatment remains rare. Gels containing active plant-based compounds may provide a solution. *Phyllanthus niruri*, known as "*meniran*" in Indonesian, is a medicinal plant used traditionally to cure various diseases. This study aimed to examine the antioxidant activities of *Meniran* extract gel, potentially for wound healing. *Meniran* was extracted using 70% methanol and formulated into a gel. The *Meniran* gel was composed of three formulations: 3%, 4%, and 5% sodium carboxymethylcellulose (CMC-Na) supplemented with 5% *Meniran* extract. The quality of the gel was assessed based on homogeneity, spreadability, pH, and viscosity. This study utilized 2,2′-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays to evaluate the antioxidant activity of *Meniran* gel at seven different concentrations through its scavenging capacities. The results were calculated to determine the median inhibitory concentration ($IC_{50}$). Analysis of variance (ANOVA) and post-hoc Tukey's honestly significant difference (HSD) were used for statistical analysis ($p < 0.05$). The three *Meniran* gel formulations showed good quality with spreadability ranging from 5.37 to 5.59 cm, pH levels from 5.90 to 6.03, and viscosity from 9.080 to 9.230 cps. Higher gel concentrations led to an increase in the free radical DPPH- and ABTS-scavenging activities. The highest DPPH and ABTS assays were found at 1,000 µg/mL with $IC_{50}$ values of 69.72 µg/mL and 20.15 µg/mL, respectively. In conclusion, *Meniran* gel formulas exhibit good standards and have antioxidant properties suitable for wound healing therapy.

**Keywords:** Antioxidant; healthy lifestyle; *Meniran* gel; *Phyllantus niruri*; wound healing

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**Highlights:**
1. This study analyzed the potential of *Meniran* extract gel for wound healing therapy, a plant-based medicine that has not been thoroughly researched in the context of promoting a healthy lifestyle.
2. The analysis found that *Meniran* extract gel has antioxidant properties that can be used for wound treatment to improve human health.

## INTRODUCTION

A wound refers to as a disruption in the epithelial lining of the skin or mucosa resulting from a physical or thermal injury. The wound healing mechanism consists of three phases: the inflammatory phase (0–3 days), the proliferative phase (3–14 days), and the tissue remodeling phase (which may start on the eighth day and continues for up to one year) (Dhivya et al. 2015, Siahaan et al. 2017). There are two types of wounds: acute wounds and chronic wounds. Acute wounds heal quickly and in an organized way. Chronic wounds, on the other hand, frequently become stalled in a certain stage of the healing process and fail to heal within four weeks (Monika et al. 2022).

Due to the slow healing process associated with aging, older adults are the most at risk for developing chronic wounds, representing around 2% of all hospitalized patients worldwide. Up to 70% of these wounds can reoccur, and 34% of them are infected (Yao et al. 2020). Wound healing is a multi-step process that involves numerous cells and activities in the context of human health. The development of a blood clot and inflammation are symptoms of the early phases of wound healing. Effective wound care will decrease complications and facilitate a quick recovery to normal function (Demilew et al. 2018, Diller & Tabor 2022). The beneficial therapeutic characteristics of plants have long been recognized, and numerous natural products have advantages for use as medication, especially for wound healing.

*Phyllanthus niruri*, or *Meniran*, as it is called in Indonesian, has a long history of being used to treat numerous illnesses. The entire plant of *Meniran* has been used to cure dysentery, vaginitis, diabetes, influenza, tumors, jaundice, kidney stones, and dyspepsia, in addition to being used as diuretics. This plant is found in America and Asia, mainly China and India. The use of this plant is common in traditional Chinese medicine, Indonesian *jamu*, and Indian *ayurveda* (Geethangili & Ding 2018). *Meniran* extract has numerous biological activities, according to multiple previous studies conducted by Rusmana et al. (2017), Sunitha (2017), and Puspita & Alhebshi (2019). These studies have demonstrated the anticancer, antioxidant, anti-microbial, and antidiabetic activities of *Meniran* extract. Furthermore, a separate study has shown that *Meniran* possesses hepatoprotective capacity (Ezzat et al. 2020). Phytochemicals such as lignans, coumarins, tannins, terpenoids, flavonoids, saponins, and alkaloids in *Meniran* have been linked to its biological activity. Additionally, the plant contains common lipids, sterols, and flavonols (Mediani et al. 2017).

Increased levels of free radicals or oxidative stress at the wound site contribute to low and protracted wound healing. This could prolong the duration of the healing process (Sanchez et al. 2018). Therefore, it is essential to maintain the balance of reactive oxygen species (ROS) levels. New therapies have been centered on antioxidant dressings that can regulate this balance. Oxidative stress and inflammation are the critical factors attributed to delays in the wound-repairing process (Ghuman et al. 2019, Comino-Sanz et al. 2021). The utilization of natural plants for medicinal purposes has gained popularity, particularly among locals, because of the fewer side effects.

*Meniran* can play a role as an antioxidant by scavenging excessive free radicals, or ROS. It can also enhance the regeneration of injured tissues. *Meniran* is recognized for having multiple biological functions. *Meniran* in gel form may offer several advantages in comparison to ointments. Gels have a greater potential for use as a delivery system for topical medications because of their reduced stickiness, simpler formulation process, and superior application properties, stability, and visual appeal (Patil et al. 2019). The procedures of 2,2′-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays were be applied to measure the antioxidant activity of *Meniran* extract gel. Antioxidant testing is commonly used due to its simple steps and high reproducibility. Furthermore, ABTS is preferred because it can detect both hydrophilic and lipophilic samples (Shah & Modi 2015). Thereby, this study aimed to examine the potential of *Meniran* gel for wound healing by assessing its antioxidant activity. This examination may provide information on the pharmacological activity of *Meniran*.

## MATERIALS AND METHODS

### Formulation of *Meniran* extract gel

The *Meniran* extract was produced in Indonesia by PT Borobudur in Semarang, Indonesia (6°57'50"S 110°24'42"E) with a batch number of 049PT01.1, based on the Indonesian current Good Manufacturing Process (cGMP). The gel base was manufactured by CV Zweena Adi Nugraha in Sukoharjo, Indonesia (-6°89'49"S, 107°58'15"E). The 70% ethanol solvent and excipient maltodextrin were used for the extraction (Hasanah et al. 2022). The *Meniran* extract gel was formulated using *Meniran* extract, sodium carboxymethylcellulose (CMC-Na) (Sigma Aldrich, C4888, St. Louis, USA), propylene glycol (Merck, W294004, St. Louis, USA), glycerin (Merck, 1040940500, Darmstadt, Germany), methylparaben (Merck, 47889, St. Louis, USA), and 100% distilled water.

The *Meniran* extract was dissolved in a small amount of distilled water, while the gel base was prepared by heating it to a temperature of 50°C. The CMC-Na was heated with the remaining distilled water on a magnetic stirrer at a temperature of 70°C and a speed of 400 rpm, then methylparaben was added until it dissolved. This combination was labeled as mixture 1. The combination of glycerin and propylene glycol was labeled as mixture 2. The two mixtures were combined and then added to the liquefied extract and continually agitated until a gel formed (Maulina & Sugihartini 2015, Sayuti 2015). The composition of *Meniran* extract gel is depicted in Table 1.

Table 1. Three different formulations of *Meniran* gel.

| Materials | Concentrations (%) | | |
|---|---|---|---|
| | MGI | MGII | MGIII |
| *Meniran* extract | 5 | 5 | 5 |
| CMC-Na | 3 | 4 | 5 |
| Glycerin | 10 | 10 | 10 |
| Methyl paraben | 0.25 | 0.25 | 0.25 |
| Propylene glycol | 15 | 15 | 15 |
| Distilled water | 100 | 100 | 100 |

Legends: MG=*Meniran* extract gel.

**Measurement of *Meniran* gel quality**

The qualities of the *Meniran* gel were measured according to its homogeneity, spreadability, pH, and viscosity. The homogeneity assay was conducted by putting the top, middle, and bottom parts of the *Meniran* gel on a transparent glass. Subsequently, the three parts were observed using a microscope. The absence of coarse granules in the *Meniran* gel preparation indicated homogeneity (Sayuti 2015).

For the measurement of the spreadability quality, 0.5 g of *Meniran* gel was placed at the center of a spherical glass scale. Afterwards, an additional round glass and weights were put on top until the total weight reached 150 g. They were left to stand for a minute, and then the diameter of the spread was recorded (Maulina & Sugihartini 2015).

According to Mappa et al. (2013), the pH test was conducted to ensure that the gel had a safe acidity level. The pH meter was initially calibrated using a standard neutral buffer with a pH of 7.00. Afterwards, the *Meniran* gel was exposed to an acidic buffer with a pH of 4.00 until its pH was shown. The electrode was dipped into the base of the gel until it displayed a consistent pH. The pH of the preparation was represented by the reading on the pH meter. Gels generally have a pH range of 4 to 6 (Slamet et al. 2020).

The viscosity of the *Meniran* extract gel was measured by immersing the viscometer spindle until it was submerged in the sample. The spindle was adjusted to rotate at a speed of 50 rpm (Nurlely et al. 2021). The reading on the viscometer indicated the quality of the *Meniran* gel in terms of its viscosity.

**DPPH- and ABTS-scavenging activities of *Meniran* gel**

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) test was carried out using DPPH reagent (Sigma Aldrich, D9132, St. Louis, USA), dymethil sulfoxide (DMSO) (Supelco, 1029522500, Berlington, USA), and methanol absolute (Merck, 1060092500, Darmstadt, Germany). A stock solution was prepared by dissolving 10,000 g of *Meniran* extract gel in 1 mL of double-distilled water (ddH2O) to achieve a concentration of 10,000 µg/mL. Furthermore, the extract was diluted to concentrations of 50, 25, 12.5, 6.25, 3.125, 1.56, and 0.78 µg/mL for the ABTS assay and 1,000, 500, 250, 125, 62.5, 31.25, and 15.625 µg/mL for the DPPH assay. A total of 50 µL of *Meniran* extract gel (0260621-C071) and 200 µL of 0.077 mmol DPPH were combined in the sample well. Additionally, 200 µL of ABTS and DMSO were added to the blank and control wells, respectively. The plate was then stored at room temperature and incubated for 30 minutes in a dark environment. A microplate reader set at 517 nm was used to determine the absorbance. The DPPH-scavenging activities were calculated using the formula provided by Widowati et al. (2022).

$$\% = \frac{control\ absorbance - sample\ absorbance}{control\ absorbance} \text{ x } 100$$

The ABTS reduction assay was performed following the methods outlined in the study conducted by Widowati et al. (2022). The materials used were 2,2′-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) reagent (Sigma, A1888, St.Louis, USA), distilled water, ddH2O, 1X phosphate-buffered saline (PBS) (Gibco 1740576), potassium persulfate (Merck, 1.05091.0250, Darmstadt, Germany), and DMSO (Supelco, 1.02952.1000, Berlington, USA). A total of 2 µL of *Meniran* gel working solution and 198 µL of ABTS solution were combined in the sample well. Additionally, 200 µL of ABTS and DMSO were added to the blank and control wells, respectively. The well was incubated for 6 minutes at a temperature of 37°C. The absorbance was measured at a wavelength of 745 nm using a spectrophotometer (Rusmana et al. 2017, Prahastuti et al. 2020). The ABTS reduction activity was calculated using the following formula:

$$\% = \frac{control\ absorbance - sample\ absorbance}{control\ absorbance} \text{ x } 100$$

The statistical data were analyzed using one-way analysis of variance (ANOVA), followed by a post-hoc Tukey's honestly significant difference (HSD) test. In IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, N.Y., USA), a value of $p<0.05$ was interpreted as statistically significant. The results were presented as mean ± standard deviation (SD) (Widowati et al. 2016).

**RESULTS**

The qualities of *Meniran* gel formulations 1, 2, and 3 are shown in Table 2. The results indicated that

*Meniran* gels with 3%, 4%, and 5% CMC-Na compositions exhibited stable gel qualities that met the criteria for use as a topical drug ingredient. *Meniran* gel with CMC Na 3%, 4%, and 5% compositions had gel qualities that met the criteria so that they were stable and could be used as topical drug ingredients.

Table 2. Results of quality analysis of *Meniran* gel.

| Assay | Standard | MG I | MGII | MGIII |
|---|---|---|---|---|
| Homogeneity | Homogenous | Homogenous | Homogenous | Homogenous |
| Spreadability | 3–5 cm (semisolid) 5–7 cm (semifluid) | 5.59±0.75 | 5.37±0.25 | 5.59±0.42 |
| pH | Skin pH: 4.5–6.5 | 6.03±0.29 | 5.90±0.13 | 5.95±0.13 |
| Viscosity | Max. value: < 10,000 cps | 9,230±5.25 | 9,160±5.89 | 1,206±13.28 |

Legends: MG=*Meniran* extract gel.

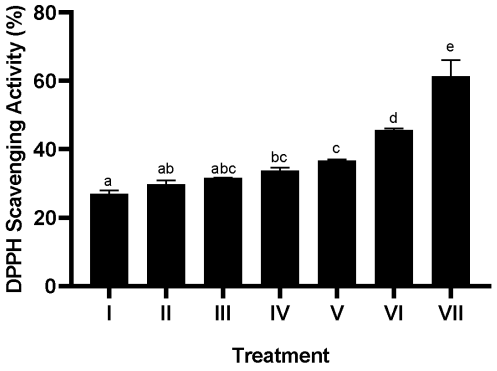


Figure 1. Effects of different concentrations of *Meniran* gel on DPPH-scavenging activity.

Legends: The data are displayed as mean±SD. The assay was conducted in triplicate for each treatment. Different letters (a, ab, abc, bc, c, d, and e) represent significant differences between treatments ($p<0.05$). The concentrations of the *Meniran* gel were as follows: (I) 15.625 µg/mL, (II) 31.25 µg/mL, (III) 62.5 µg/mL, (IV) 125 µg/mL, (V) 250 µg/mL, (VI) 500 µg/mL, and (VII) 1,000 µg/mL.

Figure 1 shows the DPPH-scavenging activity of *Meniran* gel at various concentrations. The results demonstrated a concentration-dependent effect. The strongest DPPH-scavenging activity was observed at a concentration of 1,000 µg/mL, with a value of 61.31±4.76%. It exhibited significant differences in comparison to the other concentrations ($p<0.05$). The $IC_{50}$ result was 632.33±69.72 µg/mL with a linear regression of y=0.3452x+0.5699. The results of the DPPH assay indicated that *Meniran* gel has the capacity to scavenge free radicals.

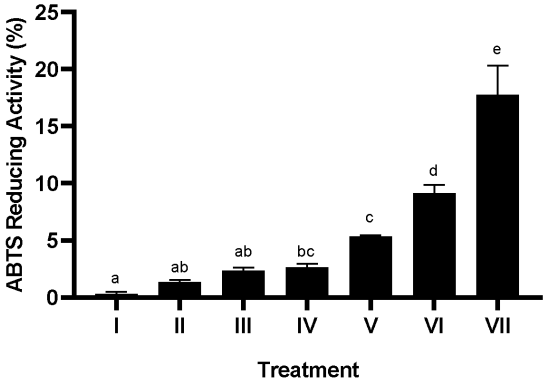


Figure 2. Effects of different concentrations of *Meniran* gel on ABTS-reduction activity.

Notes: The data are displayed as mean±SD. The assay was conducted in triplicate for each treatment. Different letters (a, ab, bc, c, d, and e) represent significant differences between treatments ($p<0.05$). The concentrations of the *Meniran* gel were as follows: (I) 0.78 µg/mL, (II) 1.56 µg/mL, (III) 3.125 µg/mL, (IV) 6.25 µg/mL, (V) 12.5 µg/mL, (VI) 25 µg/mL, and (VII) 50 µg/mL.

The diammonium salt ABTS+ assay was employed to analyze the ABTS-reduction capacity of *Meniran* gel. In this experiment, ABTS was produced by combining an oxidizer with ABTS salt. The results demonstrated that the ABTS-reducing activity was closely associated with the sample concentrations. In other words, as the sample concentration increased, the ABTS salt decreased. Significant differences were found between treatments using various concentrations (Figure 2). The strongest ABTS-reducing activity was found at a concentration of 500 µg/mL, with a value of 17.73±2.60%. Meanwhile, the lowest ABTS-reducing activity was observed at a concentration of 0.781 µg/mL, with a value of -0.32±0.17%. The $IC_{50}$ result was 143.19±20.16 µg/mL with a linear regression of y=0.3452x+0.5699 (Table 3).

Table 3. $IC_{50}$ values of *Meniran* extract gel.

| Assay | Linear regression | $R^2$ | $IC_{50}$ (µg/mL) |
|---|---|---|---|
| DPPH | y=0.0331x+28.534 | 0.99 | 632.33±69.72 |
| ABTS | y=0.3452x+0.5699 | 0.99 | 143.19±20.16 |

Legends: The data are displayed in mean±SD. The coefficient of regression ($R^2$) and median inhibitory concentration ($IC_{50}$) were calculated by linear regression.

## DISCUSSION

### Qualities of *Meniran* extract gel in wound healing

Wound healing is defined as the process of repairing the cellular structures and layers of damaged tissues to their normal conditions. The *Meniran* plant is traditionally used as herbal medicine in several countries, notably Indonesia. The phytochemical analysis of *Meniran* methanol extract showed that

the plant has high total phenolic and flavonoid compounds. One mg of the plant extract has a total phenol content equivalent to 28.05 g of gallic acid. Additionally, 1 mg of the plant extract was found to have 61.41 g of flavonoids equivalent to quercetin (Ramandeep et al. 2017). Phenols, flavonoids, and tannins are major compounds present in *Meniran* that contribute to its antioxidant and antimicrobial activities. However, directly applying the extract to the afflicted wound does not provide the desired effect since it cannot stay on the damaged skin of the experimental animals for an extended period of time. Gel formulations have more advantages than ointments for wound healing due to their stability and ease of handling (Rusmana et al. 2017, Demilew et al. 2018, Patil et al. 2019).

Homogeneity testing in this study was carried out to ensure that the gel preparation was free of particles that were still clumping and that the coarse granules had an even color. The results indicated that the gel ingredients had been completely dissolved and mixed (Sayuti 2015). Additionally, a pH test was conducted to determine the suitability of the gel preparation for topical application to the skin. The optimal pH for gels applied to the skin was between 4.5 and 6.5 (Kartini et al. 2017, Kharisma & Safitri 2020). In this study, the pH of the gel was within a safe range and did not cause skin irritation. The results were in line with previous studies conducted by Maulina & Sugihartini (2015) and Tarigan et al. (2019). The investigations showed that the pH ranges for mangosteen rind ethanol extract and *melinjo* leaf ethanolic extract gel were found to be 3.5–5 and 5–6, respectively. Balanced pH levels are important, especially when it comes to pharmaceuticals. Lower pH can irritate the skin, whereas higher pH can result in dry skin (Das et al. 2013).

In addition to homogeneity and pH tests, a spreadability test was conducted to evaluate the ability of *Meniran* gel to disperse. The purpose of the spreadability test was to examine how the gel spreads on the skin. The greater the area of dispersion, the more efficient it is to apply the gel to the skin, maximizing gel absorption (Maulina & Sugihartini 2015). Lastly, a viscosity measurement was performed to assess the viscosity level of *Meniran* gel. An optimal gel viscosity should be less than 10,000 cps. The viscosity of the gel was influenced by CMC-Na concentrations. CMC-Na contributes to the formation of the gel matrix, which affects the viscosity of the gel (Sayuti 2015). In this study, the three gel formulations exhibited constant viscosity levels at around 9,080–9,230 cps. The results aligned with a prior study on arabica coffee gel preparation, which reported a viscosity range of 3,405.97–4,604.96 cps (Nurman et al. 2019).

**The antioxidant activity and wound-healing mechanism of *Meniran* gel**

In this study, gel base was mixed with *Meniran* extract as the active ingredient. The DPPH and ABTS antioxidant assays were chosen to determine the antioxidant activity of *Meniran* extract gel. The results demonstrated antioxidant activity in a concentration-dependent manner. The DPPH assay measures the effectiveness of antioxidant compounds in scavenging free radicals (Pyrzynska & Pękal 2013). DPPH is distinguished as a stable free radical due to the delocalization of the spare electron across the whole molecule, preventing it from dimerizing unlike other free radicals. When free-radical DPPH reacts with antioxidant molecules, it creates non-radical DPPH, which is marked by a color fading from purple to yellow (Widowati et al. 2018, 2022). The DPPH assay method offers advantages in terms of cost, simplicity, speed, and accuracy. The *Meniran* extract gel has shown DPPH-scavenging activity according to its IC50 value. Prior research has also demonstrated the DPPH-scavenging activity of *Phyllanthus niruri* extract with an IC50 value of 4.24±0.02 µg/mL (Rusmana et al. 2017). Another study conducted by Giribabu et al. (2014) found that the aqueous acetone extract of *Phyllanthus niruri* has antioxidant properties. However, the study revealed a higher IC50 value of 90.65 µg/mL through the DPPH-scavenging assay.

The free radical assay of the diammonium salt was carried out to analyze the ABTS-reduction capacity of *Meniran* gel. An oxidizer and ABTS salt were combined to produce ABTS for use in this investigation. The hydrogen-donating antioxidant was utilized to diminish the blue-green ABTS radical-colored solution. An antioxidant compound can produce a green-blue color that indicates the ability to decrease ABTS salt levels (Widowati et al. 2018, Girsang et al. 2020). The *Meniran* gel could reduce the ABTS salt, as evident from the green color observed in the sample well. The results were consistent with a prior study that reported a great ABTS-reducing activity of *Phyllanthus niruri*, as shown by its low IC50 value of 1.53±0.03 µg/mL (Rusmana et al. 2017). Another study conducted by Sukweenadhi et al. (2020) documented that *Phyllanthus niruri* extract exhibited strong antioxidant activity in the ABTS test, with an IC50 value of 20 µg/mL. Antioxidant tests typically use extract samples. However, this study used gel forms to examine the antioxidant activity of a plant extract gel. Therefore, the effectiveness of the *Meniran* gel could be assessed through the utilization of ready-to-use products. The results of this study suggested that *Meniran* gel had antioxidant properties, as indicated by the DPPH and ABTS assays. *Meniran* extract gel can potentially be used as a wound-

healing remedy.

Wound healing becomes challenging when microbial contamination, prolonged inflammation, and excessive production of ROS and cytokines are present. At low concentrations, ROS is crucial for the healing process of wounds, defense against invasive pathogens, and cell survival signaling. However, a high level of ROS results in cytotoxicity and inhibits wound healing (Dunnill et al. 2017, Casado-Diaz et al. 2022). It is crucial to eliminate excess ROS, especially for chronic wound healing. Oxidative damage is the key contributor to chronic wounds that do not heal due to excessive ROS production or inadequate ROS detoxification (Sanchez et al. 2018, Bilgen et al. 2019). *Meniran* gel contains antioxidants that can protect tissues from oxidative damage. Endogenous antioxidants have a defense mechanism that protects tissues against the harmful effects of ROS (Khorsandi et al. 2022).

Phytochemicals present in *Meniran* extract gel work through multiple mechanisms during wound healing, particularly by accelerating epithelialization to promote regeneration. Injured tissues are susceptible to infection by various pathogens, especially through pathogen-associated molecular patterns (PAMPs), which trigger the recruitment of inflammatory cells (Martin & Nunan 2015, Pallavali et al. 2017, Yazarlu et al. 2021). *Meniran* gel can act as an antimicrobial agent by fighting microbes and accelerating the process of epithelial cell regeneration. Re-epithelialization in molecular mechanisms involves the migration of keratinocytes stimulated by various growth factors (Seeger & Paller 2015, Sunitha 2017). Keratinocyte migration is an early stage of re-epithelialization. Mitogen-activated protein kinase (MAPK) signaling facilitates this migration, particularly through the acceleration induced by extracellular signal-regulated kinase (ERK) (Lee et al. 2018).

The activation of the MAPK/ERK signaling pathway is stimulated by some growth factors, especially transforming growth factor beta (TGF-β). TGF-β is essential for effective re-epithelialization in keratinocyte migration. It also regulates inflammation, angiogenesis, and tissue formation (Ramirez et al. 2014). Flavonoid groups can boost the expression and regulation of TGF-β. Furthermore, the bioactive compounds found in *Meniran* serve as antioxidants, effectively safeguarding tissues against oxidative damage by restoring the balance in ROS homeostasis (Gopalakrishnan et al. 2016). Flavonoids, as non-enzymatic antioxidants, have the ability to transfer electrons to other molecules, such as ROS, while also preventing the molecules from stealing electrons from proteins or DNA. The flavonoid present in *Meniran* gel can function as a wound-healing agent by increasing TGF-β expression, regulating ROS levels, and activating MAPK/ERK to facilitate the wound healing process (Dunnill et al. 2017). However, further clinical and molecular research is required to identify the precise underlying mechanisms of *Meniran* gel that impact wound healing.

Plant extracts with potent antioxidant activity are essential for a successful wound healing process and addressing dermatological problems. The need for products related to wound healing is rising, as it is a significant problem that affects the quality of life (Ghuman et al. 2019). This research suggests that *Meniran* gel could improve the effectiveness of wound treatment in the context of human health. The topical application of *Meniran* gel can be used as a material for future in vivo testing in animal models.

### Strength and limitations

This study proposed the potential of *Meniran* extract gel as a wound-healing therapy due to its antioxidant properties derived from local plant resources. However, this study has limitations because *Phyllanthus niruri* in gel form has lesser antioxidant activity compared to *Phyllanthus niruri* extract, as evident from the DPPH and ABTS assays. The reduced antioxidant activity was caused by the limited active ingredients contained in the gel formulation. The addition of a gel base might affect the antioxidant activity of the *Meniran* gel. Therefore, more active compounds must be added to the gel base to increase the antioxidant activity of the *Meniran* gel.

## CONCLUSION

*Meniran* extract gel has potential as a wound-healing remedy due to its antioxidant properties. The gel shows DPPH- and ABTS-scavenging activities, suggesting a beneficial effect on wound healing.

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### Conflict of interest

None.

## Ethical consideration

The Health Research Ethics Committee of Universitas Prima Indonesia, Medan, Indonesia, issued the ethical approval for this study (No. 054/KEPK/UNPRI/IX/2023 dated 26/9/2023).

## Funding disclosure

None.

## Author contribution

JA contributed to the conception and design, analysis and interpretation of the data, and drafting of the article. ANN and WW contributed to the conception and design as well as the drafting of the article. SWN and NSMD contributed to the analysis and interpretation of the data as well as the drafting of the article. HSWK contributed to the drafting of the article.

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