

Effectiveness of Sea Cucumber (*Holothuria atra*) Extract Ointment from the Talaud Islands on Burn Wound Healing in Mice (*Mus musculus*)

Trivena Vannesa Mumu^{1*} , Verawati Ida Yani Roring¹ , Nonny Manampiring¹ 

Department of Biology, Universitas Negeri Manado, Jl. Kampus Unima, Kel. Tonsaru, Kec. Tondano Selatan, Minahasa, Sulawesi Utara, 95618. Indonesia

*Corresponding Author e-Mail: venamumu917@gmail.com



Article History:

Submitted:

November 5th, 2025

Accepted:

March 6th, 2026

Available online:

March 9th, 2026

Published:

March 20th, 2026

Keywords:

holothuria atra,
ointments,
degree burn.

ABSTRACT

Sea cucumber (*Holothuria atra*) has been traditionally used for wound treatment; however, scientific evidence supporting its effectiveness in burn wound healing remains limited. This study presents a novel investigation of the wound healing potential of *H. atra* extract sourced specifically from the Talaud Islands and formulated into multiple topical ointment concentrations for second-degree burn treatment. The study aimed to evaluate the effectiveness of *H. atra* extract ointment in accelerating second degree burn wound healing in mice. The extract was obtained by maceration using 95% ethanol and formulated into ointments at concentrations of 10%, 15%, and 20%. Twenty-five male mice were randomly assigned to five groups: positive control (1% silver sulfadiazine), negative control, and three treatment groups receiving *H. atra* extract ointments at different concentrations. Parameters observed included wound diameter reduction, physical characteristics of the ointment, phytochemical screening, and pain-related behavioral responses. The results demonstrated that the 15% *H. atra* extract ointment produced the highest wound healing effectiveness, with a wound contraction rate of 96% on day 14, followed by the 10% (84%) and 20% (75%) formulations. Phytochemical analysis revealed the presence of flavonoids, saponins, steroids, and alkaloids, which are associated with anti-inflammatory, antimicrobial, and tissue regenerative activities. The ointment formulations met homogeneity and organoleptic requirements, although their spreadability values were below the recommended standard. These findings highlight the novelty of identifying an optimal concentration (15%) of *H. atra* extract ointment that provides superior burn wound healing activity compared with other tested concentrations. In conclusion, the 15% *H. atra* extract ointment shows potential as an alternative topical therapy for second-degree burn wounds.

Copyright © 2026 to Authors



This article is an open access article distributed under the terms and conditions of Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

How to cite this article:

Mumu T V, Roring V I Y & Manampiring N. (2026). Effectiveness of Sea Cucumber (*Holothuria atra*) Extract Ointment from the Talaud Islands on Burn Wound Healing in Mice (*Mus musculus*). *Rumphius Pattimura Biological Journal*, 8(1), 061-070. <https://doi.org/10.30598/rumphiusv8i1p061-070>

Journal Homepage: <https://ojs3.unpatti.ac.id/index.php/rumphius>

Journal E-mail: rumphiusbiojournal@gmail.com ; rumphius.journal@mail.unpatti.ac.id

Research Article: [Open Access](#)

INTRODUCTION

Burn injuries are defined as damage to skin tissue caused by various factors, including exposure to high temperatures, electricity, radiation, chemical agents, and excessive sunlight (Pangayoman, 2023). Based on the depth and severity of tissue damage, burn injuries are classified into first-degree burns (superficial thickness), second-degree burns (partial thickness), and third-degree burns (full thickness) (Hayati, 2024). According to the World Health Organization (WHO), burn injuries remain a significant global public health problem, causing approximately 180,000 deaths each year, with the majority of cases occurring in low- and middle-income countries, particularly in Africa and Southeast Asia (WHO, 2023). In Indonesia, the prevalence of burn injuries is reported to reach 2.2%, with most incidents occurring in domestic environments and affecting females more frequently than males (Syahabuddin et al., 2023). Pain associated with burn injuries is categorized as acute pain and, if not adequately managed, may exacerbate inflammatory responses, delay wound healing, increase the risk of nosocomial infections, and potentially contribute to higher mortality rates (Yudhanarko et al., 2019). Therefore, appropriate and timely management, including the rational use of antibiotics, is essential in preventing infection in burn wounds. However, irrational antibiotic use, such as inappropriate drug selection, dosage, or duration of therapy, may contribute to the emergence of antibiotic resistance (Putra, 2021).

Sea cucumbers are marine invertebrates widely distributed in Indonesian waters and have long been utilized as traditional remedies for wound healing in East and Southeast Asian countries. These organisms contain various secondary metabolites that play important roles in tissue regeneration and wound repair processes, particularly triterpene glycosides (saponins) and glycosaminoglycans (Arfani et al., 2021). One species that has not been extensively utilized is the black sea cucumber, *Holothuria atra*, which contains several bioactive phytochemical compounds, including saponins, flavonoids, phenolic compounds, and alkaloids. Previous studies have demonstrated that extracts of *Holothuria atra* exhibit antibacterial activity against pathogenic bacteria such as *Escherichia coli* and *Staphylococcus aureus*, suggesting its considerable potential for biomedical and pharmaceutical applications (Dwichayani, 2018).

The development of topical dosage forms derived from natural products has attracted increasing attention in wound management research. Among these formulations, ointments are widely used because they are semi-solid preparations that are easy to apply to the skin surface and can provide prolonged contact between the active compound and the wound area. Ointments also help maintain moisture at the wound site, improve skin hydration, and facilitate the penetration of bioactive compounds into the damaged tissue (Davis et al., 2021). These characteristics make ointment formulations particularly suitable for burn wound treatment, where maintaining a moist environment is essential to support the healing process. Burn wound healing is a complex biological process that involves several overlapping phases, including inflammation, proliferation, and tissue remodeling. During the inflammatory phase, immune cells migrate to the wound site to eliminate pathogens and damaged tissues. This phase is followed by the proliferative phase, characterized by fibroblast proliferation, collagen deposition, and angiogenesis, which collectively contribute to the formation of new tissue. Finally, the remodeling phase occurs, during which the newly formed tissue undergoes maturation and strengthening. Bioactive compounds present in marine organisms such as *Holothuria atra* are believed to support these processes through their antimicrobial, antioxidant, and anti-inflammatory activities.

MATERIALS AND METHOD

This study was conducted at the Biology Laboratory, Universitas Negeri Manado, from January to October 2025. The experimental animals used in this study were 25 male mice (*Mus musculus*), aged 7–8 weeks with body weights ranging from 20–30 g. Male mice were selected to avoid the influence of hormonal fluctuations on the wound healing process. The animals were housed in plastic cages measuring 20 × 30 × 15 cm with rice husk bedding and were provided with standard feed and drinking water ad libitum. The number of experimental animals was determined using Federer's formula, resulting in five treatment groups with five mice in each group. The instruments used in this study included digital and analytical balances, a 1 × 1 cm iron plate, a hot plate, a mortar and pestle, beaker glasses, 1 cc syringes, cotton buds, microscope slides, Petri dishes, sterile gauze, and a pH meter. The materials consisted of sea cucumber (*Holothuria atra*) extract, white petrolatum (vaselin album), lanolin, 1% silver sulfadiazine, anesthetic agents (Castran® and J-PRO), 70%

ethanol, phytochemical screening reagents (Mayer, Dragendorff, Wagner, FeCl₃, Mg, HCl, and H₂SO₄), and distilled water.

This study employed a Completely Randomized Design (CRD) consisting of five treatment groups: a positive control (1% silver sulfadiazine), a negative control (no treatment), and three treatment groups receiving *Holothuria atra* extract ointment at concentrations of 10%, 15%, and 20%. Quantitative analysis was conducted by measuring burn wound diameter, while qualitative analysis included physical evaluation of the ointment and phytochemical screening. The *Holothuria atra* extract was obtained through maceration and concentrated using an evaporator by a previous researcher. The ointment was formulated using vaselin and lanolin as the base at concentrations of 10%, 15%, and 20%, then mixed until homogeneous and stored in closed containers. The mice were acclimatized for seven days, after which the dorsal hair was removed over an area of 3 × 3 cm. A second-degree burn wound was induced by applying a heated iron plate to the dorsal skin for 5 seconds following anesthesia. Treatment was administered twice daily for 14 days according to the respective treatment groups. Observations were conducted on days 3, 7, and 14 based on changes in wound diameter and visual wound characteristics. The percentage of wound healing was calculated using the following formula:

$$P\% = \frac{d_1 - d_x}{d_0} \times 100\%$$

where (d₁) is the wound diameter on day 1 and (d_x) is the wound diameter on the observation day.

Physical Evaluation of the Ointment and Phytochemical Screening. The physical evaluation of the ointment included homogeneity, organoleptic properties, spreadability, and pH tests. Phytochemical screening was conducted to identify the presence of flavonoids, steroids/triterpenoids, alkaloids, saponins, and tannins using standard reagents.

Behavioral Response Observation. Pain responses were observed through changes in mice behavior before and after treatment on days 3, 7, and 14.

Data Analysis. The data were analyzed using One Way ANOVA followed by Duncan's multiple range test. If the data were not normally distributed or homogeneous, the Kruskal–Wallis test was applied, followed by the Mann–Whitney test using SPSS IBM 20.

RESULTS AND DISCUSSION

Phytochemical Screening. In a series of tests conducted to identify the bioactive constituents of *Holothuria atra*, the results demonstrated that the extract contained several active compounds, including flavonoids, steroids, alkaloids (detected using Dragendorff's reagent), and saponins. In contrast, the presence of tannins and triterpenoids was not detected in the extract. Phytochemical results can be seen in **Figure 1** below.

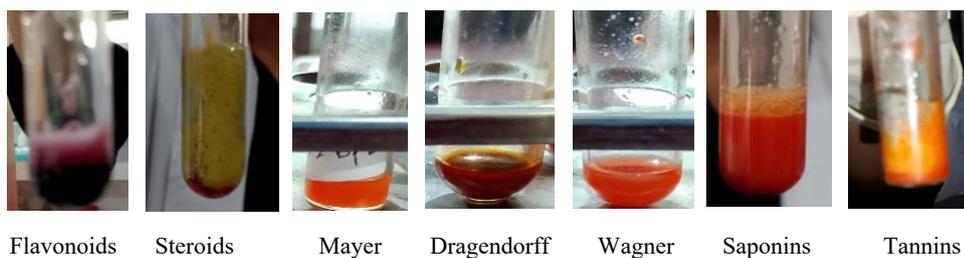


Figure 1. Phytochemical Screening Results

Phytochemical screening is an essential preliminary step in natural product research, as it allows researchers to identify the major classes of secondary metabolites present in biological extracts. These metabolites often play significant roles in various biological activities, including antioxidant, antimicrobial, anti-inflammatory, and wound-healing effects. In marine organisms such as *Holothuria atra*, phytochemical screening is particularly important because marine invertebrates are known to produce a wide range of unique bioactive compounds as part of their defense mechanisms and physiological adaptations to their environment. The results of the phytochemical analysis revealed the presence of several important bioactive compounds in the extract, namely flavonoids, steroids, alkaloids, and saponins. The detection of alkaloids using Dragendorff's reagent indicates the formation of an orange to reddish precipitate, which confirms the presence

of nitrogen-containing secondary metabolites. Alkaloids are well known for their diverse pharmacological properties, including antimicrobial, analgesic, and anti-inflammatory activities. The presence of these compounds suggests that the extract of *Holothuria atra* may possess significant biological potential that could be explored for therapeutic applications.

Flavonoids and saponins detected in the extract also contribute to the potential biological activities of the organism. Flavonoids are widely recognized for their strong antioxidant capacity, which plays an important role in neutralizing free radicals and protecting tissues from oxidative stress. This property is particularly relevant in the wound-healing process, as oxidative stress can delay tissue regeneration. Meanwhile, saponins are known for their ability to enhance immune responses, promote cell proliferation, and exhibit antimicrobial effects, all of which are beneficial in accelerating tissue repair and preventing infection in damaged tissues. In addition, the presence of steroid compounds in the extract indicates potential anti-inflammatory activity, which is crucial in the early stages of wound healing. Steroids may help regulate inflammatory responses and support the stabilization of cell membranes during tissue recovery. On the other hand, the absence of tannins and triterpenoids in the extract suggests that these compound classes may not be present in significant concentrations in the tested sample or may require different extraction methods for detection. Overall, the phytochemical screening results highlight that the extract of *Holothuria atra* contains several bioactive compounds that may contribute to its pharmacological potential, particularly in supporting wound healing and other therapeutic applications.

Table 1. Phytochemical Screening Results

Bioactive Compounds	Reagents	Observation	Result
Flavonoids	Concentrated HCl + 0.2 g Mg	Formation of red-colored solution	Positive (+)
Steroids/ Triterpenoids	Sulfuric acid (H ₂ SO ₄)	Steroids: green-colored solution observed	Positive (+)
		Triterpenoids: no red/orange coloration observed	Negative (-)
Alkaloids	2 N H ₂ SO ₄ + Mayer reagent	No white/yellow precipitate formed	Negative (-)
	2 N H ₂ SO ₄ + Dragendorff reagent	Red precipitate formed	Positive (+)
	2 N H ₂ SO ₄ + Wagner reagent	No brown precipitate formed	Negative (-)
Saponins	Distilled water + HCl	Stable foam persisted for 3 minutes	Positive (+)
Tannins	FeCl ₃ 1%	No green, blue, or purple color change	Negative (-)

Flavonoids act as potent antioxidants by scavenging free radicals generated during the inflammatory phase of wound healing, thereby preventing further tissue damage. In addition, flavonoids inhibit pro-inflammatory enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX), which contributes to the reduction of edema and erythema at the wound site (Maharani *et al.*, 2021). Steroids possess astringent and antimicrobial properties, as well as anti-inflammatory and analgesic activities, which contribute to wound healing by preventing prolonged inflammation (Samodra, G., & Kaaffah, S., 2024). Furthermore, steroids support wound repair by enhancing tensile strength and promoting collagen synthesis (Gohil, 2010). Alkaloids

are known for their analgesic and antimicrobial activities, which contribute to pain reduction and the prevention of bacterial infection at the wound site. The presence of alkaloids in wound formulations has also been reported to accelerate epithelial cell migration and tissue regeneration (Laila *et al.*, 2025). Saponins possess cleansing and antiseptic properties that contribute to the elimination of pathogens and the inhibition of microbial growth commonly present in wounds, thereby reducing the risk of severe infection. (Mawarsari, 2015).

Homogeneity. The homogeneity test results showed that all ointment formulations exhibited homogeneous characteristics, which represent an important indicator of formulation quality. Homogeneity reflects the uniform distribution of active ingredients and excipients, thereby ensuring therapeutic effectiveness, application comfort, and product aesthetic quality (Suryani *et al.*, 2024).

Table 2. Results of Ointment Homogeneity Test

Formula	Test Result
K3	No coarse particles observed
K4	No coarse particles observed
K5	No coarse particles observed

Caption: K3: Mice treated with 10% sea cucumber (*Holothuria atra*) ointment, K4: Mice treated with 15% sea cucumber (*Holothuria atra*) ointment, K5: Mice treated with 20% sea cucumber (*Holothuria atra*) ointment.

Organoleptic. The ointment formulations produced were semisolid in nature and exhibited three nearly similar colors. This variation is attributed to differences in extract concentration, as higher extract concentrations result in a more intense or brighter ointment color, which may serve as a visual indicator of product consistency and quality. Hydrocarbon-based ointments, such as those containing petrolatum or paraffin, offer advantages in maintaining wound moisture and reducing water evaporation from the skin surface. Such formulations have been shown to effectively retain active compounds, including flavonoids, tannins, and saponins, at the wound site, thereby prolonging their duration of action to support re-epithelialization and collagen formation (Wijaya *et al.*, 2014; Maharani *et al.*, 2021). Stable moisture at the wound surface has also been demonstrated to enhance fibroblast proliferation and collagen synthesis during the wound healing process (Rustiani *et al.*, 2022).

Table 3. Results of Ointment Organoleptic Test

No	Formula	Texture	Color	Odor
1	K3	Semi-solid	Pale orange	Characteristic extract odor
2	K4	Semi-solid	Bright orange	Characteristic extract odor
3	K5	Semi-solid	Neon orange	Characteristic extract odor

Caption: K3: Mice treated with 10% sea cucumber (*Holothuria atra*) ointment, K4: Mice treated with 15% sea cucumber (*Holothuria atra*) ointment, K5: Mice treated with 20% sea cucumber (*Holothuria atra*) ointment.

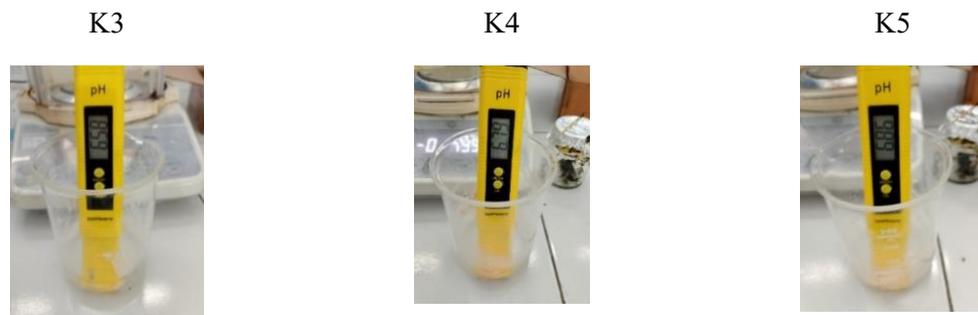
Spreadability of the Ointment. An ointment preparation that is comfortable for topical application should have a spreadability of 5–7 cm, as adequate spreadability allows rapid contact between the drug and the skin (Hernawan *et al.*, 2020). The results of the spreadability test showed that the 10% formulation had an average spreadability of 3.43 cm. The 15% formulation exhibited an average spreadability of 3.63 cm, while the 20% formulation produced an average spreadability of 3.37 cm. Therefore, when these values are compared with the standard spreadability range considered comfortable for skin application (5-7 cm), it can be concluded that none of the formulations met the required spreadability criteria for ointment preparations.

Table 4. Results of Ointment Spreadability Test

Formula	Replication	Spreadability (cm)	Mean ± SD (cm)
K3	1	3.1	3.43 ± 0.31
	2	3.5	
	3	3.7	
K4	1	3.9	3.63 ± 0.25
	2	3.4	
	3	3.6	
K5	1	3.4	3.37 ± 0.25
	2	3.1	
	3	3.6	

Caption: K3: Mice treated with 10% sea cucumber (*Holothuria atra*) ointment, K4: Mice treated with 15% sea cucumber (*Holothuria atra*) ointment, K5: Mice treated with 20% sea cucumber (*Holothuria atra*) ointment.

pH. Based on the pH testing, the 10% formulation exhibited a pH value of 6.58, indicating that it falls within the acceptable pH range for human skin. In contrast, the 15% and 20% formulations showed pH values of 6.78 and 6.86, respectively, which do not fully meet the criteria for skin-compatible pH. Although these values are not far from the normal range, they tend to approach alkaline conditions, which may cause discomfort or irritation, particularly in sensitive skin (Suryani *et al.*, 2024).

**Figure 2.** Results of Ointment pH Test

Based on the pH testing results, the formulation containing 10% extract showed a pH value of 6.58, which is relatively close to the physiological pH of the skin. This indicates that the formulation has good potential for topical application because it is less likely to disrupt the natural acid mantle of the skin. The acid mantle plays a crucial role in protecting the skin from pathogenic microorganisms and environmental contaminants. Therefore, a formulation with a pH that closely matches the natural skin environment can help maintain skin balance and support the healing process. In contrast, the formulations containing 15% and 20% extract exhibited slightly higher pH values of 6.78 and 6.86, respectively. Although these values are still relatively close to the normal skin pH range, they tend to shift toward slightly alkaline conditions. An increase in pH toward alkalinity may potentially disturb the skin barrier function and reduce the effectiveness of certain natural defense mechanisms of the skin. As a result, individuals with sensitive skin may experience mild irritation, dryness, or discomfort when using formulations with higher pH levels.

The increase in pH observed in the higher concentration formulations may be influenced by the chemical characteristics of the extract or the interaction between the extract and other components of the formulation. Higher concentrations of bioactive compounds can sometimes alter the overall chemical balance of the product, leading to slight changes in acidity or alkalinity. Therefore, optimization of the formulation is necessary to maintain a pH level that remains within the acceptable range for topical applications while still preserving the therapeutic benefits of the active ingredients (Suryani *et al.*, 2024).

Table 5. Results of Ointment pH Test

No	Formula	pH (Acidity Level)
1.	K3	6.58
2.	K4	6.79
3.	K5	6.86

Caption: K3: Mice treated with 10% sea cucumber (*Holothuria atra*) ointment, K4: Mice treated with 15% sea cucumber (*Holothuria atra*) ointment, K5: Mice treated with 20% sea cucumber (*Holothuria atra*) ointment

Effectiveness of *Holothuria atra* Extract Ointment in Burn Wound Healing in Mice. The effectiveness test of the prepared ointment variations, the ointments were applied daily from the first day to the fourteenth day, with a 12-hour interval, twice a day.

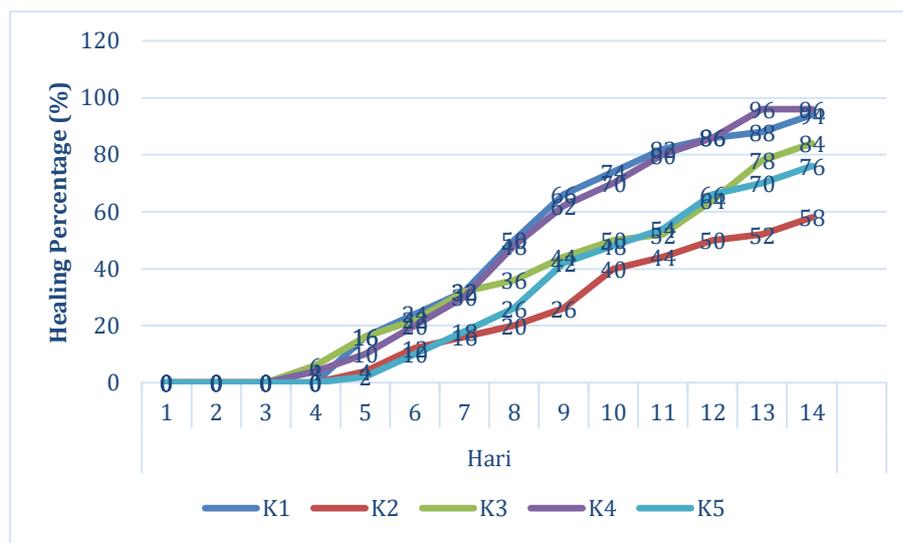


Figure 3. Wound Healing Percentage

Caption: K1: Negative control treated with 1% silver sulfadiazine, K2: Negative control without treatment, K3: Mice treated with 10% sea cucumber (*Holothuria atra*) ointment, K4: Mice treated with 15% sea cucumber (*Holothuria atra*) ointment, K5: Mice treated with 20% sea cucumber (*Holothuria atra*) ointment.

On the third day of observation, all treatment groups still exhibited relatively similar wound conditions, as the percentage of burn wound healing in K1, K2, K3, K4, and K5 remained at 0%. This finding is consistent with the characteristics of the early phase of wound healing, during which tissue regeneration has not yet occurred significantly. On the seventh day of observation, wound healing progression became clearly apparent in several groups. The positive control group (K1) showed a relatively high healing improvement of 32%. The K2 group, which did not receive any ointment or healing agent, exhibited the lowest improvement, at 16%. The K3 group treated with *H. atra* ointment demonstrated comparable results to the positive control, with a healing percentage of 32%. The K4 group recorded a healing percentage of 30%, while the K5 group showed a lower progression of 18%. By the fourteenth day of observation, all groups exhibited a much more significant improvement in wound healing. The positive control group (K1) continued to show very high results, with a healing percentage of 94%. The K4 group treated with *H. atra* ointment demonstrated the highest healing percentage, reaching 96%. Meanwhile, the K3 group achieved a healing rate of 84%, and the K5 group reached 76%. In contrast, the negative control group (K2), which did not receive any ointment treatment, showed the lowest healing percentage, at 58%.

Behavioral Response. Based on the research findings, the mean values observed before drug administration tended to be higher than those recorded after treatment. One possible contributing factor to this difference is the increased stress level experienced by mice when they were transferred for treatment administration. This finding is consistent with the study by Gouveia and Hurst (2017), which reported that handling mice using a cupped-hand method can reduce anxiety and improve animal–handler interaction compared to tail handling. Therefore, during ointment application, the experimental animals were handled using the cupped-hand technique, which helped maintain a calmer state throughout the treatment process. Following drug administration, the mice exhibited more relaxed behavior. This condition may also be influenced by variations in drug formulations, as different formulations can affect behavioral outcomes, pain assessment, and pain management in animal studies, considering the potential adverse effects associated with the drugs used (Suryani et al., 2024). The Kruskal-Wallis test revealed significant differences in wound healing over time ($p < 0.001$). Mean ranks were 60.90 on day 3, 39.60 on day 7, and 13.50 on day 14, indicating a gradual and significant improvement in wound condition from day 3 to day 14.

CONCLUSION

Wound healing over 14 days demonstrated that the ointment containing 10% *Holothuria atra* extract (K3) produced a final healing rate of 84%, the 15% concentration (K4) showed an effectiveness of 96%, and the 20% concentration (K5) showed an effectiveness of 76%. Wound healing in the positive control group treated with silver sulfadiazine reached 94%, while the negative control only achieved 58%. These results indicate that the most effective concentration for burn wound healing using *Holothuria atra* extract is 15%.

AUTHORS CONTRIBUTION

Trivena Mumu, Verawati Roring Nonny Manampiring research designed, data analyzed, data interpretation, and manuscript finalization, references searching, data visualization, and manuscript preparation.

CONFLICT OF INTEREST

The authors declare no conflicts of interest, and will take full responsibility for the content of the article, including implications of AI-generated art.

REFERENCES

- Arfani, A., Raif, A., Ginting, C. N., & Ikhtiar, R. (2021). Evaluation of wound healing potential of sea cucumber (*Actinopyga mauritiana*) extract in mice (*Mus musculus*). *Jurnal Natural*, 21(3), 168–174. <https://shorturl.at/UY4So>
- Davis, S. E., Tulandi, S. S., Datu, O. S., Sangande, F., & Pareta, D. N. (2021). Formulation and evaluation of ethanol extract ointment of hibiscus leaves (*Hibiscus rosa-sinensis* L.) using various ointment bases. *Program Studi Farmasi, Fakultas MIPA, Universitas Kristen Indonesia Tomohon*. <https://journal.fmipaukit.ac.id/index.php/jbt/article/view/362/197>
- Dwicahyani, T., Sumardianto, S., & Rianingsih, L. (2018). Bioactivity test of black sea cucumber (*Holothuria atra*) extract as an antibacterial agent against *Staphylococcus aureus* and *Escherichia coli*. *Jurnal Pengolahan dan Bioteknologi Hasil Perikanan*, 7(1), 15–24. <https://ejournal3.undip.ac.id/index.php/jpbhp/article/view/20384/19216>
- Gohil, J. K., Patel, J. A., & Gajjar, A. K. (2010). Pharmacological review on *Centella asiatica*: A potential herbal cure-all. *Indian Journal of Pharmacological Sciences*, 72(5), 546–556. https://www.brettelliott.com/wp-content/uploads/2021/08/Gotu-Kola-Pharmacological-Review-on-Centella-asiatica_-A-Potential-Herbal-Cure-all.pdf
- Gouveia, K., & Hurst, J. L. (2017). Optimising reliability of mouse performance in behavioural testing: The major role of non-aversive handling. *Scientific Reports*, 7(1), 44999. <https://pmc.ncbi.nlm.nih.gov/articles/PMC5359560/>

- Hayati, S. M., Kartika, A., & Madani, U. (2024). Health education on first aid management of burn injuries in Gulo Village, Darul Hasanah District, Southeast Aceh Regency. *Jurnal Pengabdian Bidang Kesehatan*, 2(2), 55–63. <https://journal.ppniunimman.org/index.php/jpbidkes/article/view/70/81>
- Hernawan, J. Y., Kurniawan, H., & Lestari, A. P. (2020). Stability test of garlic extract ointment formulation. *Jurnal Permata Indonesia*. <https://jurnal.permataindonesia.ac.id/index.php/JPI/article/view/76/62>
- Laila, W. K., Firsty, G. R., & Sunardi, K. S. (2025). Review article: The potential of taro as a wound healing agent. *Kunir: Jurnal Farmasi Indonesia*, 3(1), 30–39. <https://www.ejournal.bhamada.ac.id/index.php/KJFI/article/view/808/543>
- Maharani, D., Wirasti, W., & Slamet, U. W. (2021). Comparative wound healing activity of n-hexane fraction, methanol fraction, and taro leaf extract (*Colocasia esculenta* (L.) Schott). *Seminar Nasional Kesehatan*, 562–569. <https://jurnal.umpp.ac.id/index.php/prosiding/article/view/714/479>
- Mawarsari, T. (2015). Burn wound healing activity of ethanol extract of Japanese taro (*Colocasia esculenta* (L.) Schott var. *antiquorum*) tuber in male Sprague Dawley rats (*Rattus norvegicus*) (Undergraduate thesis). UIN Syarif Hidayatullah Jakarta. <https://repository.uinjkt.ac.id/dspace/bitstream/123456789/29331/1/TITIS%20MAWARSARI-FKIK.pdf>
- Pangayoman, S. G. D. (2023). Comparison of binahong leaf extract ointment (*Anredera cordifolia* (Tenore) Steenis) and silver sulfadiazine 1% ointment on second-degree burn wound contraction in male white rats (*Rattus norvegicus*). *Health Information: Jurnal Penelitian*. <https://myjurnal.poltekkes-kdi.ac.id/index.php/hijp/article/view/891/835>
- Rustiani, E., Suliawati, L., & Nurmala, S. (2022). In vivo wound healing potential of taro leaf extract (*Colocasia esculenta* L.) emulgel in diabetic rat models. *FITOFARMAKA: Jurnal Ilmiah Farmasi*, 12(2). <https://journal.unpak.ac.id/index.php/fitofarmaka/article/view/FJIF.v12i2.4770>
- Samodra, G., & Kaaffah, S. (2024). Effectiveness of *Catharanthus roseus* leaf extract on incision wound healing in rabbit dorsal skin. *Journal of Pharmaceutical and Sciences*, 7(4), 608–615. <https://doi.org/10.36490/journal-jps.com>
- Syahabuddin, S., Yusra, A., & Subki, S. (2023). Knowledge and attitudes of mothers regarding first aid for minor burns in Tanjung Mulieng Village, Syamtalira Aron District. *Indonesian Trust Health Journal*, 6(1), 29–34. <https://jurnal.murniteguhuniversity.ac.id/index.php/ithj/article/view/141/131>
- Wijaya, B. A. (2014). Potential of ethanol extract of taro petiole (*Colocasia esculenta* [L.]) as an alternative wound healing agent in rabbits (*Oryctolagus cuniculus*). *Pharmacon*, 3(3). file:///C:/Users/Advan/Downloads/jm_pharmacon,+13..pdf
- World Health Organization. (2023, October 23). Burn injuries. <https://www.who.int/news-room/factsheets/detail/burns>

