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Histological and Histomorphometric Evaluation of Ginger Oil Influence on Incisional Oral Wound Healing in Rats

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Abstract

Oral mucosal wounds affect the tissues lining the oral cavity and may result from trauma, surgery, burns, infections, or systemic diseases. The oral mucosa heals faster than the skin because of its moist environment, rich blood supply, and saliva. However, healing can be affected by microbial contamination, mechanical irritation, and other underlying health conditions. Ginger (*Zingiber officinale*) is a medicinal plant with anti-inflammatory, antioxidant, and antimicrobial properties that may support oral wound healing. Its active compounds, including gingerols, shogaols, and zingerone, help reduce inflammation, control microbes, and protect tissues from oxidative damage. Ginger also enhances fibroblast activity, collagen production, angiogenesis, and re-epithelialization, which contribute to faster tissue repair and healing of oral mucosal wounds. The goal of this work was to perform histological assessment of the impact of topical ginger oil on the healing of incisional wounds in the oral mucosa of rats. A total of ten adult male Wistar albino rats of 250-350 g weight and ages of 3-5 months were used in the current study. Full-thickness surgical intramuscular incisional wounds were made in the lining buccal mucosal membrane of each rat's cheek. The rats were grouped as follows: control group (incisional wound induction on the left side of the cheek lining buccal mucosa was allowed to heal spontaneously) and study group (incisional wound on the right side of the cheek lining buccal mucosa was treated daily with topical application of ginger oil). At the end of the healing period (3 and 7 days), all rats were sacrificed by an overdose of general anesthetic, and tissue specimens were prepared for clinical histological analysis. The mean wound contraction size, number of inflammatory cells, and epithelial thickness were measured by histological assessment under a light microscope. Inflammatory cell counts were significantly higher in the study group than in the control group on days 3 and 7 (P=0.008). The highest mean value was observed on day 3 in the study group, followed by a gradual decrease over time. Epithelial thickness increased progressively over time in both groups; the study group showed significantly higher epithelial thickness than the control group at both day 3 and 7. Topical application of ginger oil accelerated oral wound healing in rats owing to its anti-inflammatory, antioxidant, and pro-healing properties. These findings suggest that ginger oil may be a promising adjunct therapy for promoting oral mucosal repair.

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Introduction

The mucous membranes that coat the oral cavity consist of an outer layer of keratinocytes reinforced by a layer of connective tissue of varying composition, as viewed under a microscope. The mucosa acts as a defensive barrier by preventing the entry of any external agent that may pose a threat to one's health [1]. Three forms of oral mucosa that vary histologically, clinically, and functionally can be identified: the lining mucosa, masticatory mucosa, and specialized mucosa, which might be keratinized or non-keratinized [2,3].

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Wounds are common in the oral cavity, caused by either trauma or surgery, and wound healing follows the same biological principles as skin healing and begins immediately after injury. Inflammatory phase, proliferation, and maturation are the three steps that make up the wound healing process. The inflammatory phase is characterized by an increase in the number of macrophages and neutrophils in the peripheral blood. The maturation phase is characterized by the emergence of wound healing, while the proliferation phase is characterized by fibroblasts and epithelialization [4,5].

In the wound healing process, platelets interact with exposed collagen, triggering clot formation and initiating the healing cascade. A fibrin clot forms a temporary matrix, whereas inflammatory cells release cytokines and growth factors to regulate tissue repair. Fibroblasts then produce collagen to restore tissue strength and integrity. Disruption of this coordinated process can lead to delayed or chronic wounds [6,7].

Additionally, several herbal formulations, including ginger oil, have shown effective wound-healing properties in wound management [8, 9]. Due to its beneficial antioxidant and anti-inflammatory characteristics, ginger rhizome (*Zingiber officinale Roscoe*), a plant that belongs to the Zingiberaceae family, has been used as a spice and medicinal herb in many different regions of the globe since ancient times. Ginger, in its many forms, including fresh, dried, aqueous, and ethanolic extracts, as well as ginger oil, is increasingly being used for nutritional and therapeutic reasons. There are several therapeutic properties that have been linked to gingerol, which is the primary component of ginger. These effects include analgesic and anti-inflammatory activity [10,11].

Material and Methods

Ginger oil, ketamine 10% (Alfasan, Holland), xylazine 2% (Alfasan, Holland), and distilled water that had been sterilized were the components that were used in this clinical investigation. Ten albino male rats weighing 450 grams and being only two to three months old were housed in the animal house at the Veterinary Clinic in Al-Najaf City from May 2026 to June 2026. The animals were housed in polycarbonate cages, given a regular rat chow pellet meal, and were allowed unrestricted access to tap water. The circumstances of the laboratory were standard, and the temperature was room temperature.

Ten rats were used in this study and divided into two groups. Each rat received two intramuscular incisions (0.6 mm deep × 15 mm long) on both sides of the cheek. The right-side incision was treated with ginger oil, while the left-side incision healed spontaneously as a control. Group A (n = 5): Wound evaluation after 3 days. Group B (n = 5): Wound evaluation after 7 days.

Each individual animal was weighed before the surgical procedure was carried out to determine the appropriate dose of general anesthesia. The administration of xylazine 2% (0.4 mg/kg body weight) and ketamine HCL 50 mg (40 mg/kg body weight) by intramuscular injections was the method that was used to produce general anesthesia. An incision was made on the right and left sides of the cheek lining mucosa (Figure 1A) of about 0.6 mm depth and 15 mm length [12]; the wound length was made using a digital vernier caliper. Afterward, a daily local application of 10 µl of ginger oil was applied using a micropipette on the induced incision of the study group [13] (Figure 1B), whereas normal saline was applied for the control group. After the anesthetic stage was achieved, the wound size was measured daily using a digital vernier until the day of sacrifice. The animals were sacrificed by an overdose of an anesthetic solution [14]. At the end of healing durations of 3 and 7 days, the wound area and normal tissue specimens were sectioned longitudinally from the buccal mucosa using a surgical blade (no. 21) and sharp surgical scissors; the area surrounding the wound was cut 5 mm around the wound boundaries on the 3rd and 7th days [15], and finally, the specimens were placed directly in a sterilized plastic tube with 10% freshly prepared formalin [16]. Thereafter, the specimens were prepared for histological analysis.

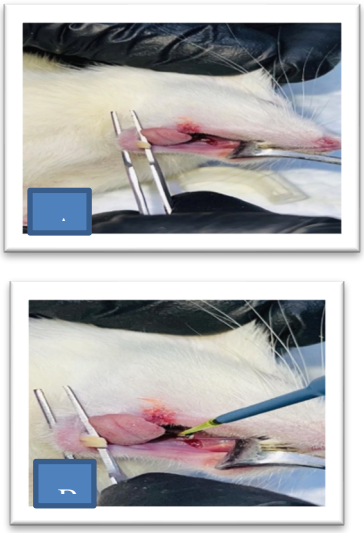


Figure 1. Surgical procedure (A-wound induction, B-oil application).

Histological Parameters of Inflammatory Cells Count

The number of inflammatory cells was counted randomly in five fields for each tissue specimen. Cells were counted using a light microscope under a (×40) lens, as shown in Figure 2. Thereafter, the mean number of cells was calculated using ImageJ software [17,18].

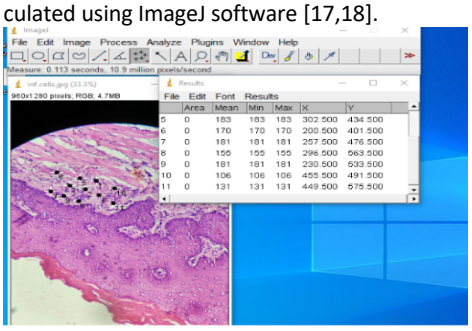


Figure 2. The inflammatory cells counting using ImageJ software.

Ulcer size measurement was done daily by digital vernier caliper in (mm) for all groups with both healing durations [12,19], as shown in Figure 3.



Figure 3. Measurement of wound size during wound healing.

Epithelial thickness was assessed by measuring the distance from the outermost epithelial surface to the deepest layer of the basement membrane at the wound margins. To improve accuracy, two measurements were taken for each sample, and their average value was used for statistical analysis [18,20].

Epithelial thickness was measured using ImageJ software (version 1.54) to accurately determine the distance between the specified epithelial layers on digital images of the wound edges, enabling precise quantitative analysis [21].

Red blood cells were used as a calibration reference for image analysis because the average diameter of rat red blood cells is approximately 6 µm. Their diameters were measured in pixels using the straight line and measure tools in ImageJ software, and the average pixel value was used to determine the image scale for accurate measurements, as shown in Figure 4 [22].

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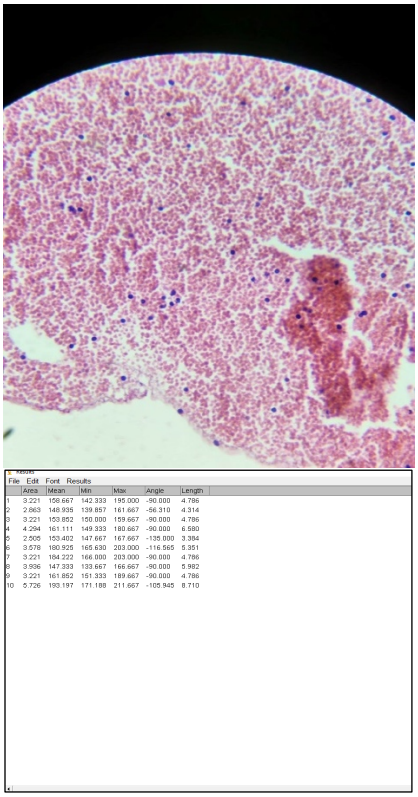


Figure 4. RBC diameter measurement.

After that, the analyze option was chosen, and the set scale option in image software was used to use the average diameter measured in pixels to set the scale (Figure 5).

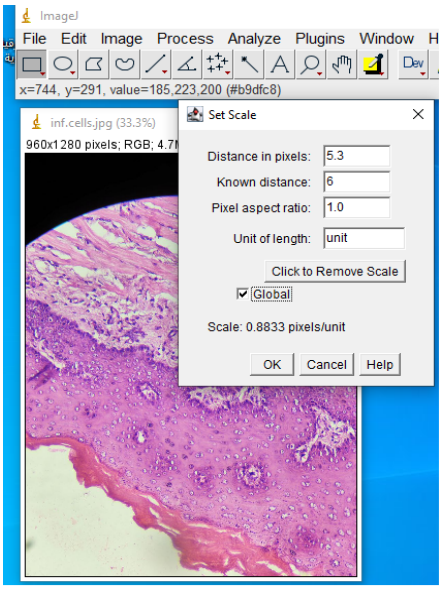


Figure 5. Set the calibration scale in ImageJ to convert pixel measurements.

Following scale adjustment, epithelial thickness was measured by drawing a line extending from the epithelium's outermost layer to the deepest region of the basement membrane. The distance was measured from the epithelium's outermost layer to the deepest region of the basement membrane, expressed in micrometers. The procedure was performed twice, and the mean of both measurements was obtained to ensure precision, as shown in Figure 6.

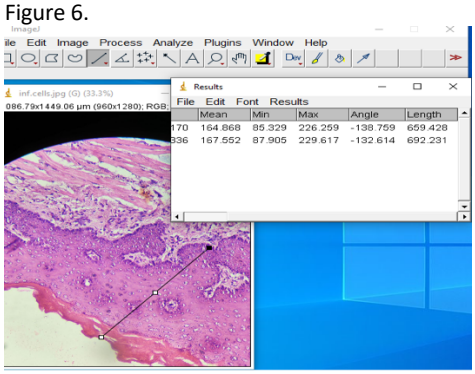


Figure 6. Epithelial thickness measurement.

Results

The microphotograph at 3 days shows prominent regenerative changes, including the movement of epithelial cells from the margins of the wound to facilitate re-epithelialization. The connective tissue stroma exhibits a pronounced inflammatory infiltrate along with significant fibroblastic activity and extensive vascular proliferation. Furthermore, the initial deposition of collagen fibers is observable, indicating the early organization of granulation tissue within the injury site (see Figures 7 and 8).

The photomicrograph of the wound site in the study group reveals closure of the surface by a newly formed epithelial bridge, indicating successful re-epithelialization. Beneath this layer, the lamina propria shows an advanced stage of tissue repair, characterized by the arrangement of collagen fibers and active fibroblasts. Furthermore, the area is highly vascularized with numerous blood vessels (BV) and contains a localized infiltration of inflammatory cells, all of which reflect a robust regenerative process at the injury site, as shown in Figures 9 and 10. Microscopic assessment of the wound site in the control group on day 7 revealed the formation of a delicate, keratinized epithelial layer that successfully spans and seals the wound surface. The subjacent lamina propria exhibited signs of maturation, including well-arranged collagen bundles and active fibroblasts. Additionally, newly formed blood vessels and organized connective tissue indicate progression into the remodeling stage of healing, as shown in Figures 11 and 12.

Microscopic examination of the wound site revealed re-epithelialization with a thickened, newly formed epithelium. The lamina propria exhibited features of granulation tissue, including collagen fiber deposition, proliferating fibroblasts, and a rich network of blood vessels, as shown in Figures 12 and 13.

The descriptive statistics of mean, standard deviation (SD), standard error (SE), minimum (min), and maximum (max) values of the wound size on days 3 and 7 are shown in Table 1 and Figure 14. The mean values of wound size decreased with time in both groups, and the least value was recorded in the study group after 7 days.

No significant difference was observed between the groups regarding the wound size at day 3 and 7 (P = 0.4 and 0.383, respectively), as shown in Table 2.

It was found that the inflammatory cells were significantly higher in the study group as compared with the control group at day 3 (P=0.008) and at day 7 (P=0.008), as listed in Table 4.

The descriptive statistics for the standard deviation, mean, minimum, and maximum values of the epithelial thickness at days 3 and 7 for both the subjects of the study and the control group are shown in Table 5 and Figure 16, respectively. The result illustrates an increase in the mean value of epithelial thickness in all groups with time; the lowest mean value was recorded in the control group at the 3rd day, and the highest mean value was recorded in the study group at the 7th day of healing intervals.

The descriptive statistics for the standard deviation, mean, minimum, and maximum values of the epithelial thickness at days 3 and 7 for both the subjects of the study and the control group are shown in Table 5 and Figure 16, respectively.

Discussion

The skin and oral mucosa act as the body's first line of defense against infection, but wounds in these tissues are susceptible to bacterial invasion, which can delay healing. While skin wound healing is well understood, knowledge of intraoral wound healing remains limited, creating challenges in developing effective treatments [23]. Proper wound care and antibiotic therapy are important for accelerating healing, and herbal medicines are increasingly used as complementary therapies due to their effectiveness and relatively mild side effects [24].

Notable among them is ginger, also known as *Zingiber officinale Roscoe*, which has garnered interest because of the anti-inflammatory, antibacterial, antioxidant, and anticancer qualities that it has. Its bioactive compounds, including gingerols, zingerone, shogaols, and sesquiterpenes, are mostly responsible for these therapeutic actions. These elements help the reduction of inflammation and the promotion of wound healing [25]. In this study, the results

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of clinical observation revealed that there were obvious reductions in wound size over time in both groups (control and study). The most obvious reductions in wound size were observed in the study group on the seventh day. This finding is in agreement with Mahmood, Al-Kazzaz [26], who discovered that ginger powder can enhance the healing of induced aphthous ulceration in rabbits. This was demonstrated by clinical reduction of the size of the wound as well as histological evidence. This might be because ginger has various impacts on all the potential causes of aphthous ulcers, such as bacterial flora, immune system issues, or inflammatory responses. As a result, ginger was probably able to speed up the healing process of the lesion in several different ways.

Up to 2 days following injury, neutrophil migration typically increases; afterward, it gradually decreases if no infection is present [13]. In this study, both groups (control and study) showed variable degrees of inflammatory reaction at all healing intervals, with a marked increase in the number of neutrophils that infiltrated wound sites in the study group at 3 and 7 days. The values of neutrophils decreased with time for both the control and study groups. In the beginning, the reason why neutrophils have the highest number because they constitute the largest proportion of white blood cells in the peripheral blood. Through both phagocytic and non-phagocytic processes, neutrophils perform the process of clean the inflammatory region of infectious and toxic agents, as well as debris from the tissue.

In the wound healing process, the presence of neutrophil activity indicates that it is in the inflammatory phase. Ginger contains flavonoids, oleoresin, gingerol, and shogaol. They are also present. In addition to their anti-inflammatory and anticancer properties, gingerol and shogaol, which are phenolic components of ginger, have been shown to have antitumor and anticancer properties. Consequently, the quantity of prostaglandin that acts as an inflammatory mediator decreases because of this active substance's ability to limit the activity of cyclooxygenase. This drop in inflammatory mediators will result in a reduction in the number of neutrophils, and this conclusion of the current research is consistent with the findings of Rahayu, Suharto [27], who investigated the impact of ginger extract on the number of neutrophils in incisional wounds in rats.

In the current research, it was shown that the re-epithelialization rate for both the control group and the study group rose over the course of time, reaching a high mean value on day 7. Because the mean values of epithelial thickness were higher than those in the control and progressively increased with time, the re-epithelialization was significantly faster in both the control and the study groups. This indicates that the epithelial cells in both groups are rapidly proliferating and progressing, as evidenced by an increase in the amount of neovascularization, the number of fibroblast cells, and the formation of collagen fibers. His finding agrees with Rahayu, Suharto [27], who suggested that wounds treated with extracted ginger showed more proliferation of fibroblast cells, epithelial degeneration, and normal epidermal cell proliferation in induced skin wounds in rats.

Conclusion

Based on the findings of the present study, ginger oil demonstrated beneficial effects on the healing of experimentally induced oral mucosal wounds in rats. The histological and clinical observations indicated enhanced tissue repair and progression of the wound-healing process. The use of ginger oil led to improved wound healing, reduced inflammation, and accelerated restoration of epithelial integrity, revealing a significant improvement in the healing process without generating any complications. Topical application of ginger oil proved successful as a therapeutic strategy for experimentally generated buccal mucosal wounds in rats. This was accomplished by accelerating the proliferative activity of inflammatory cells and advancing oral wound healing.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Originality

The manuscript is original, has not been published previously, and is not under consideration for publication elsewhere.

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References

1. Chuhuaicura P, Rodríguez-Niklitschek C, Oporto GH, Salazar LA. Distinct molecular mechanisms in oral mucosal wound healing: translational insights and future directions. Int J Mol Sci. 2025;26(21):10660. doi: 10.3390/ijms262110660.
2. Ibáñez-Cortés M, Martín-Piedra MÁ, Blanco-Elices C, García-García ÓD, España-López A, Fernández-Valadés R, et al. Histological characterization of the human masticatory oral mucosa. A histochemical and immunohistochemical study. Microsc Res Tech. 2023;86(12):1712-24. doi: 10.1002/jemt.24398.
3. Wertz PW. Roles of lipids in the permeability barriers of skin and oral mucosa. Int J Mol Sci. 2021;22(10):5229. doi: 10.3390/ijms22105229.
4. Trivedi K, Paliwal A, Dwivedi J, Garg D. Study and development for the property of ginger in wound healing and ulcerogenic activity. Int J Modern Pharm Res. 2022;6(8):39-50.
5. Ngeow WC, Tan CC, Goh YC, Deliberador TM, Cheah CW. A narrative review on means to promote oxygenation and angiogenesis in oral wound healing. Bioengineering. 2022;9(11):636. doi: 10.3390/bioengineering9110636.
6. Sharma A, Khanna S, Kaur G, Singh I. Medicinal plants and their components for wound healing applications. Future J Pharm Sci. 2021;7(1):53. doi: 10.1186/s43094-021-00202-w.
7. Burnham AJ, Toma AI, Shah D, Cha T, Kaimari S, Behara M, et al. FTY720P-treated macrophages in PEG-4MAL hydrogels promote oral wound healing. Cytotherapy. 2025;27(3):338-49. doi: 10.1016/j.jcyt.2024.11.002.
8. Ibrar M, Ayub Y, Nazir R, Irshad M, Hussain N, Saleem Y, et al. Garlic and ginger essential oil-based neomycin nano-emulsions as effective and accelerated treatment for skin wounds' healing and inflammation: In-vivo and in-vitro studies. Saudi Pharm J. 2022;30(12):1700-9. doi: 10.1016/j.jsps.2022.09.015.
9. Cheshfar F, Bani S, Mirghafourvand M, Hasanpour S, Javadzadeh Y. The effects of ginger (zingiber officinale) extract ointment on pain and episiotomy wound healing in nulliparous women: a randomized clinical trial. J Caring Sci. 2023;12(3):181-7. doi: 10.34172/jcs.2023.31842.
10. Javdani M, Aali A, Mohebi A, Heydarpour F, Bigham-Sadegh A. Oral administration of ginger rhizome powder and postoperative inflammation indices in ovariohysterectomized dogs. Iran J Vet Surg. 2021;16(2):91-9. doi: 10.30500/ivsa.2021.286032.1258.
11. Bouchama C, Zinedine A, Rocha JM, Chadli N, El Ghadraoui L, Chabir R, et al. Effect of phenolic compounds extracted from turmeric (curcuma longa L.) and ginger (zingiber officinale) on cutaneous wound healing in wistar rats. Cosmetics. 2023;10(5):137. doi: 10.3390/cosmetics10050137.
12. Kumar A, Chomwal R, Kumar P, Sawal R. Anti inflammatory and wound healing activity of curcuma aromatica salisb extract and its formulation. J Chem Pharm Res. 2009;1(1):304-10.
13. Kamil NB, Al-Ghaban NM. Evaluation of effect of local exogenous application of

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myrrh oil on healing of wound incisions of facial skin (histochemical, histological and histomorphometrical study in rabbits). J Bagh Coll Dent. 2019;31(4):71-8. doi: 10.26477/jbcd.v31i4.2724.
14. Lee CM, Hussain Q, Chuang KP, Minh H. Enhancement of oral mucosal regeneration using human exosomal therapy in SD rats. Biomedicines. 2025;13(7):1785. doi: 10.3390/biomedicines13071785.
15. Ryu HS, Abueva C, Padalhin A, Park SY, Yoo SH, Seo HH, et al. Oral ulcer treatment using human tonsil-derived mesenchymal stem cells encapsulated in trimethyl chitosan hydrogel: an animal model study. Stem Cell Res Ther. 2024;15(1):103. doi: 10.1186/s13287-024-03694-4.
16. Dantas TS, Barros Silva PG, Lima Verde MEQ, Ribeiro Junior AL, Cunha M, Mota MRL, et al. Role of inflammatory markers in prognosis of oral squamous cell carcinoma. Asian Pac J Cancer Prev. 2019;20(12):3635-42. doi: 10.31557/APJCP.2019.20.12.3635.
17. Santoso AW, Amalia E, Sari KI, Takarini V, Sufiawati I. Histopathological evaluation of wound healing and anti-inflammatory effects of granola potato peel ethanol extract in rat oral mucosa. J Exp Pharmacol. 2024;16(1):377-95. doi: 10.2147/JEP.S487373.
18. Neto RSM, Silva LVd, Araújo CLd, Valente AGF, Coelho AA, Caetano CFF, et al. Activation of peroxisome proliferator-activated receptor (PPAR) by pioglitazone in oral traumatic ulcers in female rats. Toxicol Rep. 2025;15:102147. doi: 10.1016/j.toxrep.2025.102147.
19. Paul J, D'lima JP, Thomas S, Karim S, Thomas P, Ramakrishnan BP, et al. Histological evaluation of epithelial thickness, microvasculature and number of mast cells in the gingiva of smokers and non-smokers with chronic periodontitis. J Clin Diagn Res. 2017;11(11):18-21. doi: 10.7860/JCDR/2017/29112.10886.
20. Gu J, Liao J, Zhang T, Zhang Y, Shepherd S, Macluskey M, et al. Quantitative characterization of undulation patterns and regional features of the oral basement membrane zone using optical coherence tomography. J Biophotonics. 2025;18(10):e202500252. doi: 10.1002/jbio.202500252.
21. Mukhopadhyay A, Rajput M, Barui A, Chatterjee SS, Pal NK, Chatterjee J, et al. Dual cross-linked honey coupled 3D antimicrobial alginate hydrogels for cutaneous wound healing. Mater Sci Eng C Biomim Mater Sens Syst. 2020;116:111218. doi: 10.1016/j.msec.2020.111218.
22. Mazo G. QuickFigures: a toolkit and ImageJ PlugIn to quickly transform microscope images into scientific figures. PLoS One. 2021;16(11):e0240280. doi: 10.1371/journal.pone.0240280.
23. Vivcharenko V, Trzaskowska M, Przekora A. Wound dressing modifications for accelerated healing of infected wounds. Int J Mol Sci. 2023;24(8):7193. doi: 10.3390/ijms24087193.
24. Maver T, Maver U, Stana Kleinschek K, Smrke DM, Kreft S. A review of herbal medicines in wound healing. Int J Dermatol. 2015;54(7):740-51. doi: 10.1111/ijd.12766.
25. Auranwiwat C, Madardam J, Nakpheng T, Intawong S, Kaewiad K. Synergistic anti-inflammatory activity of ginger extract and phlai oil on lipopolysaccharide-induced inflammatory mediators. J Health Sci Med Res. 2023;42(1):e2023995. doi: 10.31584/jhsmr.2023995.
26. Mahmood AS, Al-Kazzaz SG, Al-Saffar MT. Histological assessment of the effect of ginger on the healing of chemically-induced aphthous ulceration in rabbits. Rev Clin Pharmacol Pharmacokinet, Int Ed. 2024;38(3):283-9. doi: 10.61873/DERC5205.
27. Rahayu KIN, Suharto IPS, Etika AN, Nurseskasatmata SE. The effect of ginger extract (Zingiber officinale Roscoe) on the number of neutrophil cells, fibroblast and epithelialization on incision wound. J Phys Conf Ser. 2020;1569(3):032063. doi: 10.1088/1742-6596/1569/3/032063.

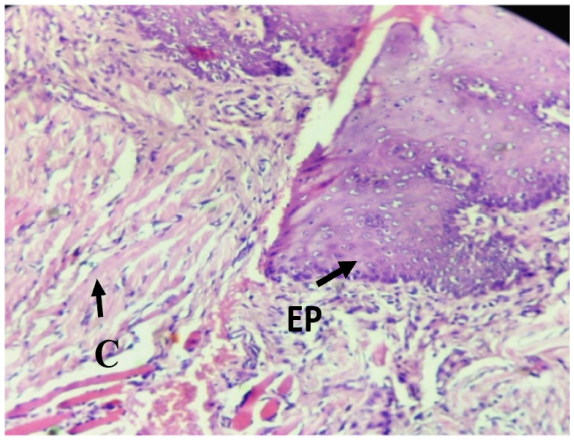


Figure 7. Microphotograph of the epithelium margin (EP), and collagen fibers (C). H&Ex20.

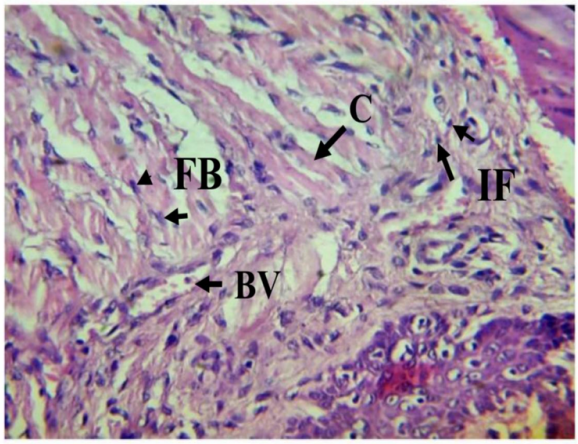


Figure 8. Microphotograph of the epithelium margin (EP), and (collagen fibers (C). H&E x10.

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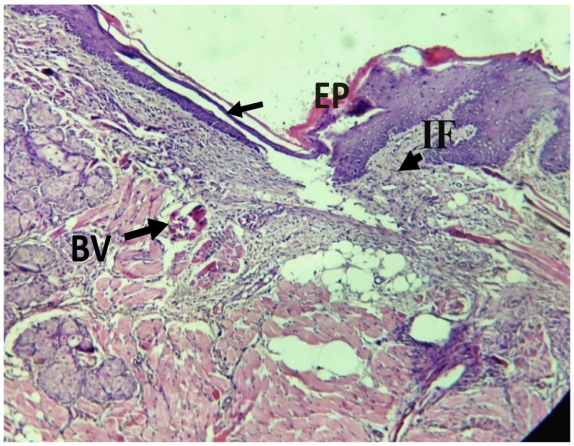


Figure 9. Wound surface sealed with newly epithelium (EP), BV, inflammatory cells (IF), H&E in x10.

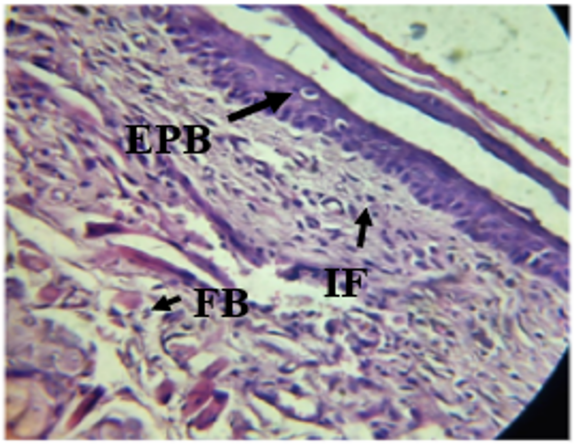


Figure 10. Magnified view of the epithelial bridge (EPB), fibroblasts (FB), inflammatory cells (IF), and BV. H&E in x40.

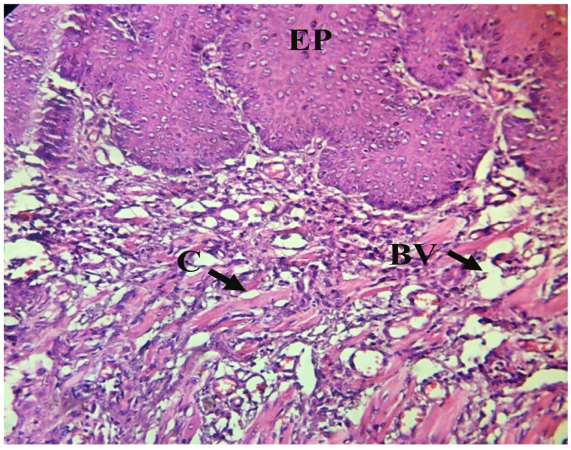


Figure 11. Newly epithelium (EP), collagen fibers (C) and BV. H&E in x20.

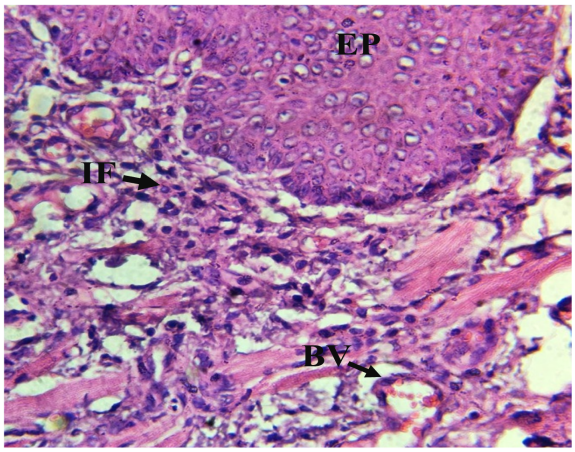


Figure 12. Magnified view of epithelium (EP), inflammatory cells (IF), and BV. H&E in x40.

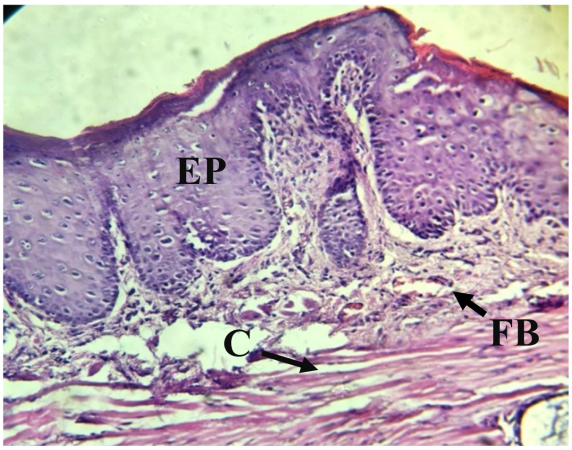


Figure 12. Keratinized epithelium (EP), fibroblasts (FB), collagen fibers (C), and BV. H&E in x20 (IF).

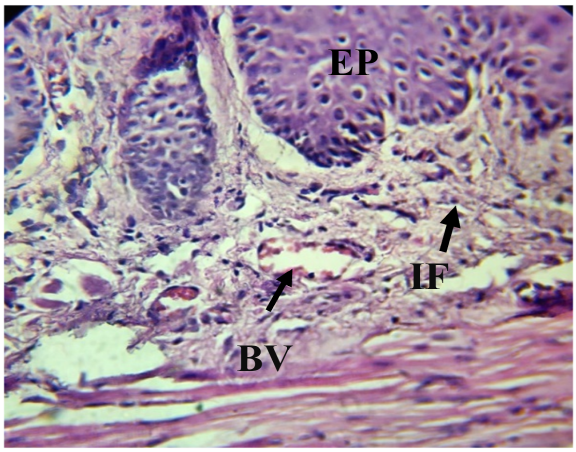


Figure 13. Magnified view of epithelium (EP), inflammatory cells (IF), and BV H&E in x40.

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Table 1. Wound size during the study period.

Wound size						
Day	Group	N	Mean±SD	SE	Minimum	Maximum
Day 3	Study	5	10.9±4	2.3	7.1	15
	Control	5	13.2±1.8	1	11.5	15
Day 7	Study	5	5.2±5.6	2.1	0	15
	Control	5	7.8±5.3	2	1.4	15

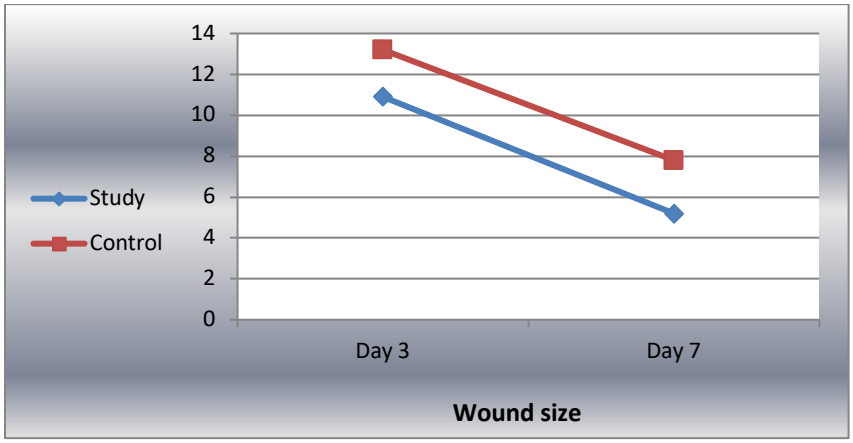


Figure 14. Distribution of the mean values of wound size on days 3 and 7.

Table 2. Group comparison of wound size during each study period.

Variable	Duration	Group comparison	
		Statistical value	P-value
Wound size	3 days	0.886	0.4
	7 days	0.961	0.383

Mann-Whitney U test used.

Table 3. Descriptive statistics of mean values of inflammatory cell.

Inflammatory cells						
Day	Group	N	Mean±SD	SE	Minimum	Maximum
Day 3	Study	5	36.7 ± 4.1	1.8	30.1	40.4
	Control	5	21.4 ± 1.8	0.8	19.4	23.9
Day 7	Study	5	19.9 ± 1.8	0.8	17.9	21.7
	Control	5	10.9 ± 0.8	0.4	9.9	12.1

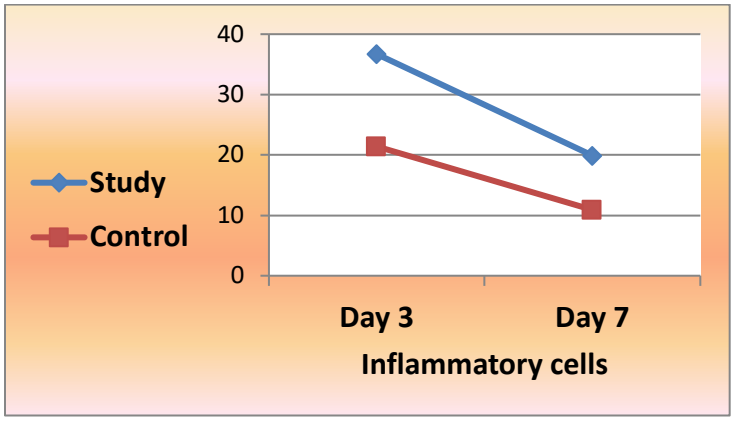


Figure 15. Distribution of the mean value of inflammatory cell count for different durations.

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Table 4. Group comparison of inflammatory cells during each study period.

Variable	Duration	Group comparison	
		Statistical value	P-value
Inflammatory cells	3 days	2.611	0.008*
	7 days	2.611	0.008*

*Significant result, Mann-Whitney U test used.

Table 5. Statistical analysis of the mean value of epithelial thickness (µm) during the study period.

Epithelial thickness						
Day	Group	N	Mean±SD	SE	Minimum	Maximum
Day 3	Study	5	837.7±117.1	52.4	683.5	953.2
	Control	5	445.1±85.3	38.1	387.7	594.5
Day 7	Study	5	1303.6±92.9	41.5	1181.3	1401.8
	Control	5	870.2±137.8	61.6	656.6	1027.1

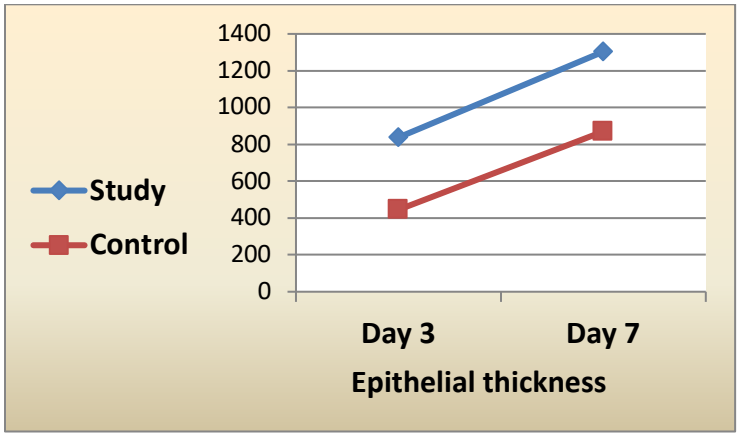


Figure 16. Distribution of mean value according to epithelial thickness in different durations.

Table 6. Group comparison of epithelial thickness during each study period.

Variable	Duration	Group comparison	
		Statiatical value	P-value
Epithelial thickness	3 days	2.611	0.008*
	7 days	2.611	0.008*

*Significant result, Mann-Whitney U test used.