ORIGINAL ARTICLE
Journal of Indonesia Vascular Access (*INAVA)* 2025, Volume 5, Number 2: 34-39
E-ISSN : 2798-6780 ; P - ISSN : 2807-7032

Published By : IVAA
the Indonesian Vascular Access Association

The wound-healing potential of honey and propolis from stingless bees in acute wounds

Viky Hibatu Wafi[1], Abdul Azis Boenjamin[1*], Ivan Joalsen Mangara Tua[2], Swandari Paramita[3], Endang Sawitri[3], Yudhy Arius[4]

[1]General Surgery Residency Program, Faculty of Medicine, Universitas Mulawarman, Samarinda, Indonesia;
[2]Thoracic, Cardiac and Vascular Surgery Division, Abdul Wahab Sjahranie General Hospital, Samarinda, Indonesia;
[3]Faculty of Medicine, Universitas Mulawarman, Samarinda, Indonesia;
[4]Plastic Surgery Division, Abdul Wahab Sjahranie General Hospital, Samarinda, Indonesia.

*Corresponding to:
Abdul Azis Boenjamin;
General Surgery Residency Program, Faculty of Medicine, Universitas Mulawarman, Samarinda, Indonesia;
aziz.boen@gmail.com

Received: 2025-02-28
Accepted: 2025-08-18
Published: 2025-10-04

ABSTRACT

Introduction: Honey and propolis from stingless bees have been reported to promote wound healing due to their anti-inflammatory, antioxidant, antibacterial, and moisturizing activities. However, variations in compounds and biological activities of these products can arise due to geographical and bee origin differences. This study aimed to investigate the wound-healing potential of stingless bee honey and propolis from East Kalimantan in an acute wound animal model. Honey and propolis from stingless bees have been reported to promote wound healing due to their anti-inflammatory, antioxidant, antibacterial, and moisturizing activities. However, variations of compounds and biological activities of these products can arise due to geographical and bee origin differences. This study aimed to investigate the wound-healing potential of stingless bee honey and propolis from East Kalimantan in an acute wound animal model.

Method: A post-test-only control group design was employed in this study. Fifteen Wistar rats were divided into 3 groups, *i.e.*, a control receiving *tulle* and treatment groups receiving stingless bee honey and propolis, respectively. Wound healing activity was evaluated from wound diameter changes and histological evaluations following a hole punch wound.

Result: Kruskal Wallis test results showed no significant changes in the proliferation phase of wound healing, as reflected by the diameter changes ($p = 0.989$), the rate of histopathological re-epithelization ($p = 0.730$) as well as number of fibroblasts ($p = 0.779$), collagen ($p = 0.779$), and neovascularization ($p = 0.756$) among the groups.

Conclusion: Honey and propolis from stingless bees have the potential to treat acute wounds in the proliferation phase, where their wound healing properties are equivalent to tulle.

Keywords: acute wound, stingless bee, honey, propolis.
Cite This Article: Wafi, V.H., Boenjamin, A.A., Tua, I.J.M., Paramita, S., Sawitri, E., Arius, Y. 2025. The wound-healing potential of honey and propolis from stingless bees in acute wounds. *Journal of Indonesia Vascular Access* 5(2): 34-39. DOI: 10.51559/jinava.v5i2.66

INTRODUCTION

A wound is defined as a disruption in the continuity of the epithelial layer of the skin or mucosa due to physical or thermal damage. Wound healing is a complex and dynamic process supported by various cellular processes that are coordinated to repair damaged tissue efficiently.[1] Skin wound healing shows a unique mechanism of cellular function and involves the interaction of several growth factors, cells, and cytokines. In the wound healing process, there are several stages, *i.e.*, hemostasis, inflammation, angiogenesis, growth, re-epithelialization, and remodeling.[2] Although physiological wound healing is able to restore tissue integrity, in various cases, this process is frequently restricted to wound repair.[3]

According to the length and nature of the healing process, wounds are categorized into acute and chronic wounds.[4] Treatment of acute wounds in patients requires systematic management for optimal results, starting with a physical examination and selection of appropriate wound care interventions.[5-7] Management of acute wounds begins by cleaning the wound, removing dead tissue, and applying wound dressings and topical medications to accelerate the wound healing process. Currently, intensive research is being conducted to find effective agents for wound treatments.[6,7]

Bees produce propolis and honey, which are non-timber forest products that are full of benefits. Many types of bees can produce honey, one of which is the stingless bee (*Heterotrigona iitama*), also known as Meliponini.[8] Stingless bee honey differs from other local honey species, as it is reported to have more potent antioxidant activity and higher phenolic content. The better antioxidant activity and higher phenolic content lead to their potential to treat numerous medical conditions, including infections and cancer.[9] Further, propolis and honey from stingless bees have been reported to exert therapeutic properties, such as anti-inflammatory, antioxidant, and antibacterial properties. They are also natural moisturizers. The high amount of polyphenolic compounds in propolis and stingless bee honey can promote cell proliferation, protect cell structure, and fight free radicals in injured areas.[10]

Although various studies have examined the wound-healing activities

Table 1. Scoring system for histopathological evaluation[18]

No	Parameter	Description	Score
1.	Epithelialization	Complete and mature epithelialization	+3
		Epithelialization is complete but immature	+2
		Partial epithelialization	+1
		No epithelialization	0
2.	Fibroblast	The number of fibroblasts is > 50% of the wound tissue The number of fibroblasts is < 50% of	+3
		the wound tissue	+2
		Fibroblasts only exist in the perivasculature	+1
		No fibroblast	0
3.	Collagen	Large amount of collagen	+3
		Medium amount of collagen	+2
		Small amount of collagen	+1
		No collagen	0
4.	Neovascularization	≥ 10 new blood vessels	+3
		6-10 new blood vessels	+2
		1-5 new blood vessels	+1
		No new blood vessels	0

of propolis and stingless bee honey, there have been no studies investigating the wound-healing properties of propolis and stingless bee honey from Indonesia in acute wounds.[10-13] Moreover, previous research reported variations in the physicochemical properties, content, and biological activities of propolis and stingless bee honey due to geographical differences and the origin of the bees.[11,14,15] This highlights the importance of conducting studies on products originating from Indonesia. Therefore, this study aimed to evaluate the wound-healing activity of honey and propolis from Indonesia's stingless bee in an animal model of acute wounds. This aim was achieved by examining changes in wound diameter, speed of re-epithelialization, and the number of fibroblasts, collagen, and neovascularization through histological observations. The results of this research can become the basis for scientific evidence of stingless bee honey's and propolis's wound healing properties, enabling them to be developed until they can finally be used clinically.

METHODS

Animals

The test animals used were Wistar rats aged 8-10 weeks with a body weight of 200-400 grams. Fifteen rats were used in the experiment and fed with rat chow of 15 grams each and water ad libitum. They were kept for two weeks during acclimatization under standard conditions (temperature of 22 ± 4°C with relative humidity of 55 ± 15% and 12-h light-dark cycle).

Experimental Design

The research was conducted using a post-test-only control group design, which was carried out at the Pharmacology Laboratory, Faculty of Medicine, Universitas Mulawarman, Samarinda, East Kalimantan. The 15 test animals were randomly assigned to three groups, *i.e.,* control (C), stingless bee honey (T1), and stingless bee propolis (T2). Before the acute wound was created, the prophylactic antibiotic cefotaxime 100 mg/kg body weight (BW) was given intraperitoneally, followed by anesthesia using ketamine 20 mg/kg BW intraperitoneally.[16] A sterile puncher with a diameter of 1.5 cm was used to create 2 punch-hole wounds aseptically on the back of the rat that was previously shaved.[17] Scalpel blade no.11 was also used to help in completely removing the skin. After making the wound, group C was given a wound dressing with tulle, group T1 was given a wound dressing with 1 ml of stingless bee (*H. itama*) honey, and group T2 was given a wound dressing with 1 ml of stingless bee (*H. itama*) propolis. All wounds were then closed using sterile gauze and plaster. The honey and propolis, products of the Faculty of Forestry, Mulawarman University, used in the tests were dissolved in normal saline in a ratio of 1:1 (v/v).

Wound measurement

Wistar rats were treated back in their original cage after wound infliction, and then the wounds were measured on day 0, -2, and -14.

Histological evaluation

After measuring the wounds on day-14, the rats were culled by injecting ketamine 80 mg/kg BW intraperitoneally.[16] Back wound tissues were extracted and fixed in 10% formalin for histological observation.[17] The tissues were dehydrated in alcohol gradients, embedded in paraffin, and cut into 5 μm-thick sections using a microtome (Leica, Germany). Next, the sections were stained using hematoxylin and eosin (H & E). Histological examination was conducted to assess the level of re-epithelialization and the number of fibroblasts, collagen, and neovascularization. This examination was performed using a microscope (Olympus Type CX 21) with 40x and 100x magnifications in 5 fields with a zigzag view. The results of these five fields of view were divided by the average and expressed using a scoring system (Tabel 1).[18,19]

Data analysis

The collected data was tested using a normality test to determine whether the data was normally distributed or not. The data obtained in this study were not normally distributed. Therefore, the data analysis was carried out non-parametrically using the Kruskal-Wallis test. Data analysis was performed in the Statistical Package for the Social Sciences (SPSS) version 29. Data was presented as the mean ± standard deviation. All valuesare considered significant if $p<0.05$.

RESULTS

Changes in wound diameter

Changes in wound diameter are associated with the speed of wound re-epithelialization in the test animals. Figure 1 shows the wound closing as the study progressed. This was observed for the all groups. The results of the average re-epithelialization speed in wound healing were assessed by measuring wound diameter changes on day-0 to -2 and on day-0 to -14 (Table 2). The Kruskal-Wallis test results showed that the wound diameter changes on day-0 to -2 and on day-0 to -14 had p values of 0.360 and 0.989 ($p > 0.05$), indicating that the speed of wound healing was not significantly different between groups.

Figure 1. Development of re-epithelialization on day-0 (A), -2 (B), and -14 (C).

Table 2. Changes in Wistar Rat Acute Wound Diameter with Various Treatments

Group	Diameter change (mm)	
	Day-0 to -2	Day-0 to -14
C	3.5 ± 1.1	1.23 ± 3.0
T1	3.0 ± 1.6	1.33 ± 2.1
T2	4.0 ± 2.2	1.34 ± 1.5

*C is the control group receiving tulle, T1 receiving stingless bee honey and T2 receiving stingless bee propolis

Histological examination

Epithelialization and the presence of fibroblasts, collagen, and neovascularization were clearly visible on histological examination (Figure 2). The results of histological evaluation on the level of epithelialization and the number of fibroblasts, collagen, and neovascularization are shown in Table 3.

The Kruskal-Wallis test results on re-epithelialization speed, fibroblast number, collagen number, and neovascularization number showed p-values of 0.730, 0.779, 0.779, and 0.756 ($p > 0.05$), respectively. This demonstrated that there were no significant differences among all groups on these four parameters.

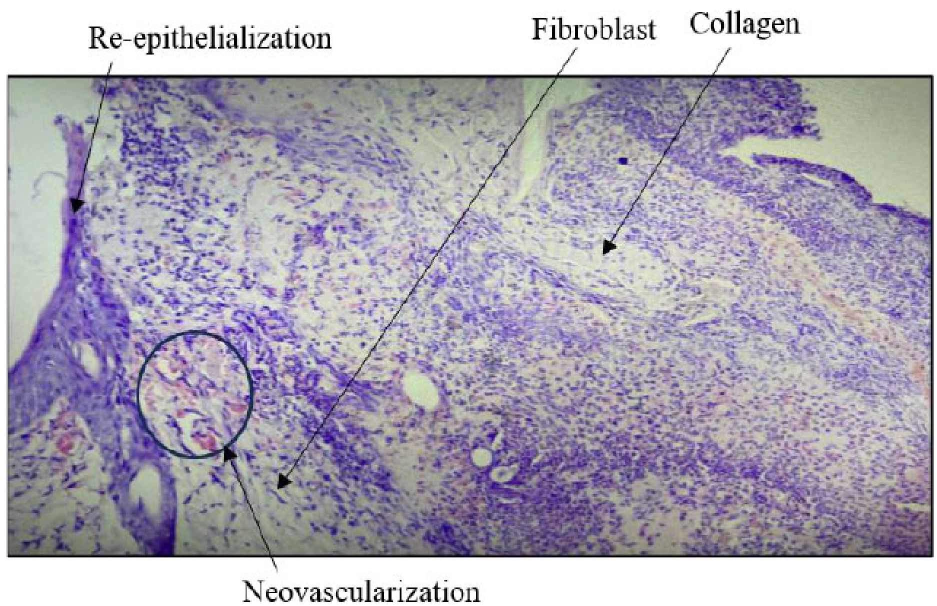

Figure 2. A representative histology image indicating re-epithelialization and the presence of fibroblast, collagen, and neovascularization on 100x magnification.

DISCUSSIONS

This research is an experimental study with a post-test-only control group design, which aims to analyze the potential of honey and propolis from stingless bees in healing acute wounds during the proliferation phase, as assessed from the speed of re-epithelialization and the number of fibroblasts, collagen, and neovascularization.

Wound healing is the body's natural and normal response to injury. Wound healing is a complex and dynamic process for the rapid recovery of damaged tissue, enabling it to return to its normal function. This process consists of 4 highly interconnected and overlapping phases, which are hemostasis, inflammation, proliferation, and remodeling.[2]

In this study, tulle was used as a control. Tulle dressings are paraffin dressings that are one of the earliest modern dressings. The dressings are permeable to bacteria and form a waterproof paraffin covering over the wound. However, these dressings can cause maceration because water vapor and exudates cannot escape and are trapped in the wound. Additionally, it can stick to the wound and, in some cases, can cause trauma upon removal and require a secondary dressing. The uses of these dressings are also limited to simple, clean, shallow wounds, minor burns, and are used as the primary dressing over skin grafts.[20,21] The drawbacks of tulle dressings underscore the need for better dressing development.

Based on the results of measuring the wound diameter, re-epithelialization in each group showed an improvement in the wound contraction area, where the speed of re-epithelialization of groups treated with topical administration of honey and propolis from stingless bees was comparable to that of the control (tulle). This indicates that honey and propolis from stingless bees can meet the criteria for use as alternative dressings whereas honey and propolis from stingless bees have the ability to act as anti-

Table 3. Histological Evaluation Results of Acute Wounds Healing on Day-14

Group	Speed of Re-epithelialization	Fibroblast Number	Collagen Number	Neovascularization Number
C	1.00 ± 1.00	1.40 ± 0.54	1.40 ± 0.54	1.40 ± 0.54
T1	1.00 ± 1.00	1.60 ± 0.54	1.40 ± 0.54	1.40 ± 0.54
T2	1.40 ± 0.89	1.60 ± 0.54	1.40 ± 0.54	1.20 ± 0.44

*C is the control group receiving tulle, T1 receiving stingless bee honey and T2 receiving stingless bee propolis

inflammatory, antioxidants, antibacterials, and moisturizers.[10,20,21] These results also align with the histopathological assessment of the re-epithelialization speed. Re-epithelialization of wounds following the application of honey and propolis from stingless bees can occur due to the migration of keratinocytes from the surrounding tissue of the epithelium, covering the wound surface. This re-epithelialization process is directly proportional and interconnected with other research variables, namely the number of fibroblasts, collagen, and neovascularization.[2,3] To corroborate the findings on re-epithelialization, we also found that the number of fibroblasts, collagen, and neovascularization demonstrated improvements that occurred with the topical administration of honey and propolis from stingless bees, which were equivalent to the control group. As reported earlier, acute wound repair is characterized by an increase in the number of fibroblasts, collagen, and neovascularization.[10]

Fibroblasts produce extracellular matrix, which is the main component of scar tissue formation and causes the movement of keratinocytes through the wound filling. Macrophages produce growth factors that stimulate proliferation, migration, and extracellular matrix formation and synthesize collagen that holds wound edges together.[2,3]

Fibroblasts synthesize collagen, and thus, an increase in the number of fibroblasts is often accompanied by an increase in the amount of collagen.[10] Collagen causes primary and secondary hemostasis, which occur through two pathways that are interconnected simultaneously and mechanically. Primary hemostasis involves platelet aggregation and platelet blockage brought about by exposure to collagen in the subendothelial matrix. Secondary hemostasis refers to the activation of the coagulation cascade in which soluble fibrinogen is converted into insoluble strands that form a fibrin meshwork. The platelet plug and fibrin network combine to create a thrombus which stops bleeding, releases complements and growth factors, and provides infiltrating cells needed for wound healing.[2,3]

Increased re-epithelialization, fibroblasts, and collagen can stimulate angiogenesis.[10,22] The neovascularization growth begins in the granulation tissue, forming vascular tissue to supply the wound area, and, in the 2-3rd week, the vascularization undergoes regression and maturation.[23] Neovascularization occurs after the wound gap is closed in the re-epithelialization process. Next, granulation tissue is formed due to fibrin clots which have been replaced by fibroblasts and then produce collagen that later blocks the platelets and fibrin network. This blockage triggers thrombus formation which stops bleeding, leading to complements and growth factors release, further providing infiltrating cells required for wound healing. Lastly, the blood vessels regress, and myofibroblasts cause overall wound contraction.[1-3]

The wound-healing properties of honey and propolis from stingless bees are attributed to their antioxidant, antibacterial, anti-inflammatory, and moisturizing activities. The antioxidant properties of honey and propolis from stingless bees stem from phenolic and flavonoid content which act as electron transporters to neutralize, reduce, and eliminate free radicals. Hence, they protect cell structures from reactive oxygen species (ROS).[10] Various phenolics and flavonoids have been successfully detected on both products, including catechin, apigenin, kaempferol, rutin, myricetin, and quercetin.[9] The antibacterial activity of stingless bee honey and propolis prevents the growth of pathogenic bacteria in wounds, preventing damage to wound tissues.[21] The antibacterial properties have been tested against Gram-positive (*Bacillus subtilis, Micrococcus luteus, Bacillus megaterium, Staphylococcus aureus,* and *Bacillus brevis*) and Gram-negative (*Escherichia coli*, *Pseudomonas syringae*, *Klebsiella pneumoniae,* and *Salmonella typhimurium*) bacteria.[24] The anti-inflammatory effect of honey and propolis from stingless bees functions to prevent a prolonged inflammatory process, thereby preventing fibrosis in wound tissue, which has the potential to become a chronic wound.[10] The moisturizing effect of the honey and propolis maintains moisture in wounds, enabling the transport of enzymes, growth factors, and hormones, which in turn promote cell growth.[20] The abilities of the two products as antioxidants, antibacterials, anti-inflammatory, and moisturizers form a good wound bed, thereby increasing the potential for re-epithelialization and the number of fibroblasts, collagen, and neovascularization in acute wounds.[10,20,21]

The appropriate dressing selection can be chosen based on availability, quantity, and cost. The use of honey and propolis from stingless bees can be an alternative dressing option to modern types of dressings that function to protect wounds from dehydration and increase the wound healing speed, for instance, tulle, which is used as a control in this study. These dressings are superior compared to the classic dressings, such as gauze, fiber, plaster, and bandages, which can only cover the wound.[4] The availability of honey and propolis from stingless bees can now be obtained at affordable prices in liquid form. They are also kept in packaging that is easy to carry, so that it can be an alternative for people living in rural areas who are far from health facilities needing to treat their wounds. Additionally, the development of these two products as wound dressings can increase the productivity of honey and propolis farmers of stingless bees, especially in the East Kalimantan area.[22-27]

Although this study has been carefully

designed, it still has a caveat regarding histological staining. Histological staining using H & E can only illustrate the general tissues and cells and cannot identify fibroblasts and collagen in much detail. However, it is still possible to observe fibroblasts and collagen using H & E staining. To overcome this weakness, further investigation using more specific stainings, such as Masson's trichrome staining for collagen or immunohistochemistry, should be explored. Apart from that, additional research regarding wound healing activity can be carried out for chronic wounds, thereby further strengthening the foundation of the commercialization of stingless bee honey and propolis dressings.[28,29]

Overall, the results of this study are in accordance with previous studies, which have reported the wound healing properties of honey and propolis from stingless bees owing to their antioxidant, antibacterial, anti-inflammatory, and moisturizing properties. These biological activities are attributed to the phenolics and flavonoids contained in the honey and propolis.[10,26,27] To the best of our knowledge, this is the first research that reported wound healing properties of honey and propolis of Indonesia's stingless bee.

CONCLUSION

Based on the assessment of speed of re-epithelialization and the number of fibroblasts, collagen, and neovascularization, honey and propolis from stingless bees have the potential to treat acute wounds in the proliferation phase where their wound healing properties are equivalent to tulle. These primary dressings are commonly used in health care facilities. Therefore, honey and propolis from stingless bees can be considered as alternative dressings for acute wounds.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

ACKNOWLEDGMENT

The authors would like to thank the Medical Faculty, Universitas Mulawarman, for the support.

ETHICAL CONSIDERATION

All animal protocols were approved by the Health Research Ethics Commission, Faculty of Medicine, Mulawarman University (no. 212/KEPK-FK/XI/2023).

FUNDING

None.

AUTHOR CONTRIBUTION

All authors had contributed to the manuscript writing and agreed on the final version of mthe anuscript for publication.

REFERENCES

1. Wilkinson HN, Hardman MJ. Wound healing: cellular mechanisms and pathological outcomes. Open Biol. 2020/09/30. 2020;10(9):200223. Available from: https://pubmed.ncbi.nlm.nih.gov/32993416
2. Rodrigues M, Kosaric N, Bonham CA, Gurtner GC. Wound Healing: A Cellular Perspective. Physiol Rev. 2019;99(1):665–706. Available from: https://pubmed.ncbi.nlm.nih.gov/30475656
3. Tottoli EM, Dorati R, Genta I, Chiesa E, Pisani S, Conti B. Skin Wound Healing Process and New Emerging Technologies for Skin Wound Care and Regeneration. Pharmaceutics. 2020;12(8):735. Available from: https://pubmed.ncbi.nlm.nih.gov/32764269
4. Dhivya S, Padma VV, Santhini E. Wound dressings - a review. BioMedicine. 2015/11/28. 2015;5(4):22. Available from: https://pubmed.ncbi.nlm.nih.gov/26615539
5. Long I. Insight of the Pathophysiology of Diabetic Foot Ulcer [Internet]. Diabetic Foot - Recent Advances. IntechOpen; 2023. Available from: http://dx.doi.org/10.5772/intechopen.108190
6. Jayalakshmi MS, Thenmozhi P, Vijayaraghavan R. Plant Leaves Extract Irrigation on Wound Healing in Diabetic Foot Ulcers. Evid Based Complement Alternat Med. 2021;2021:9924725. Available from: https://pubmed.ncbi.nlm.nih.gov/34055026
7. Thomas A, Bankar N, Nagore D, Kothapalli L, Chitlange S. Herbal Oils for Treatment of Chronic and Diabetic Wounds: A Systematic Review. Curr Diabetes Rev. 2022;18(2). Available from: http://dx.doi.org/10.2174/1573399817666210322151700
8. Ramli NZ, Chin K-Y, Zarkasi KA, Ahmad F. The Beneficial Effects of Stingless Bee Honey from Heterotrigona itama against Metabolic Changes in Rats Fed with High-Carbohydrate and High-Fat Diet. Int J Environ Res Public Health. 2019;16(24):4987. Available from: https://pubmed.ncbi.nlm.nih.gov/31817937
9. Hakim SS, Wahyuningtyas RS, Siswadi S, Rahmanto B, Halwany W, Lestari F. Physicochemical Properties and Micronutrient Content of Kelulut Honey (Heterotrigona Itama) with Different Colors. Journal of Social and Economic Forestry Research. 2021;39(1):1–12.
10. Esa NEF, Ansari MNM, Razak SIA, Ismail NI, Jusoh N, Zawawi NA, et al. A Review on Recent Progress of Stingless Bee Honey and Its Hydrogel-Based Compound for Wound Care Management. Molecules. 2022;27(10):3080. Available from: https://pubmed.ncbi.nlm.nih.gov/35630557
11. Nordin A, Omar N, Sainik NQAV, Chowdhury SR, Omar E, Bin Saim A, et al. Low dose stingless bee honey increases viability of human dermal fibroblasts that could potentially promote wound healing. Wound Med. 2018;23:22–7. Available from: http://dx.doi.org/10.1016/j.wndm.2018.09.005
12. Suriawanto N, Setyawati E, Narwan. Pengaruh Pemberian Ekstrak Propolis Lebah Tanpa Sengat Pada Penyembuhan Luka Bakar Tikus Putih (Rattus norvegicus). J Bioteknol & Biosains Indones. 2021;8(1):68–76. Available from: http://dx.doi.org/10.29122/jbbi.v8i1.4585
13. Huanbutta K, Sittikijyothin W, Sangnim T. Development of topical natural based film forming system loaded propolis from stingless bees for wound healing application. J Pharm Investig. 2020;50(6):625–34. Available from: http://dx.doi.org/10.1007/s40005-020-00493-w
14. Shamsudin S, Selamat J, Sanny M, Abd. Razak S-B, Jambari NN, Mian Z, et al. Influence of origins and bee species on physicochemical, antioxidant properties and botanical discrimination of stingless bee honey. Int J Food Prop. 2019;22(1):239–64. Available from: http://dx.doi.org/10.1080/10942912.2019.1576730
15. Leonhardt SD, Rasmussen C, Schmitt T. Genes versus environment: geography and phylogenetic relationships shape the chemical profiles of stingless bees on a global scale. Proceedings Biol Sci. 2013;280(1762):20130680. Available from: https://pubmed.ncbi.nlm.nih.gov/23658202
16. Sahlan M, Rahmawati O, Pratami DK, Raffiudin R, Mukti RR, Hermasyah H. The Effects of stingless bee (Tetragonula biroi) honey on streptozotocin-induced diabetes mellitus in rats. Saudi J Biol Sci. 2019/12/02. 2020;27(8):2025–30. Available from: https://pubmed.ncbi.nlm.nih.gov/32714027
17. Masson-Meyers DS, Andrade TAM, Caetano GF, Guimaraes FR, Leite MN, Leite SN, et al. Experimental models and methods for cutaneous wound healing assessment. Int J Exp Pathol. 2020/03/30. 2020;101(1–2):21–37. Available from: https://pubmed.ncbi.nlm.nih.gov/32227524
18. Mehrabani M, Najafi M, Kamarul T, Mansouri K, Iranpour M, Nematollahi MH, et al. Deferoxamine preconditioning to restore impaired HIF-1α-mediated angiogenic

mechanisms in adipose-derived stem cells from STZ-induced type 1 diabetic rats. Cell Prolif. 2015;48(5):532–49. Available from: https://pubmed.ncbi.nlm.nih.gov/26332145
19. Yudhika I, Jailani M, Dasrul. Histopathological overview of wound healing process in white rats (Rattus norvegicus) using Chromolaena odorata leaf jelly extract. J Int Surg Clin Med. 2021;1(2):21–8. Available from: http://dx.doi.org/10.51559/jiscm.v1i2.16
20. Ilenghoven DIA Review of Wound Dressing Practices. Clin Dermatology Open Access J. 2017;2(6). Available from: http://dx.doi.org/10.23880/cdoaj-16000133
21. Mama M, Teshome T, Detamo J. Antibacterial Activity of Honey against Methicillin-Resistant Staphylococcus aureus: A Laboratory-Based Experimental Study. Int J Microbiol. 2019;2019:7686130. Available from: https://pubmed.ncbi.nlm.nih.gov/31073310
22. Sarheed O, Ahmed A, Shouqair D, Boateng J. Antimicrobial Dressings for Improving Wound Healing [Internet]. Wound Healing - New insights into Ancient Challenges. InTech; 2016. Available from: http://dx.doi.org/10.5772/63961
23. Han G, Ceilley R. Chronic Wound Healing: A Review of Current Management and Treatments. Adv Ther. 2017/01/21. 2017;34(3):599–610. Available from: https://pubmed.ncbi.nlm.nih.gov/28108895
24. Al-Hatamleh MAI, Boer JC, Wilson KL, Plebanski M, Mohamud R, Mustafa MZ. Antioxidant-Based Medicinal Properties of Stingless Bee Products: Recent Progress and Future Directions. Biomolecules. 2020;10(6):923. Available from: https://pubmed.ncbi.nlm.nih.gov/32570769
25. Tashkandi H. Honey in wound healing: An updated review. Open life Sci. 2021;16(1):1091–100. Available from: https://pubmed.ncbi.nlm.nih.gov/34708153
26. Syafrizal, Ramadhan R, Wijaya Kusuma I, Egra S, Shimizu K, Kanzaki M, et al. Diversity and honey properties of stingless bees from meliponiculture in East and North Kalimantan, Indonesia. Biodiversitas J Biol Divers. 2020;21(10). Available from: http://dx.doi.org/10.13057/biodiv/d211021
27. Yanti EN, Kustiawan PM. Study of Indonesian Stingless Bee Propolis Potential As Antioxidant: A Review. J Farm Sains dan Prakt. 2023;261–9. Available from: http://dx.doi.org/10.31603/pharmacy.v9i3.7105
28. Suvik A, Effendy AWM. The use of modified Masson's trichrome staining in collagen evaluation in wound healing study. Mal J Vet Res. 2012;3(1):39–47.
29. Darby IA, Hewitson TD. Fibroblast Differentiation in Wound Healing and Fibrosis [Internet]. International Review of Cytology. Elsevier; 2007. p. 143–79. Available from: http://dx.doi.org/10.1016/s0074-7696(07)57004-x