

Evaluation of wound healing activity of Agnishikha (*Gloria Superba*)

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Abstract

Wound healing is a coordinated biological process involving inflammation, proliferation, collagen deposition, angiogenesis and tissue remodeling. The present study evaluated the wound-healing activity of an ethanolic extract of *Gloriosa superba* (Agnishikha) using phytochemical investigation and experimental wound models in Wistar albino rats. The extract was prepared by Soxhlet extraction and screened for major phytoconstituents. Wound-healing activity was assessed through excision, incision and dead-space models using wound contraction, epithelization time, wound-size reduction, hydroxyproline, total protein, antioxidant parameters and histopathology as outcome measures. The extract produced improved wound contraction, shorter epithelization time, enhanced collagen-related biochemical indices and improved antioxidant status compared with the control group. Histopathological observations showed improved re-epithelialization, collagen deposition, vascularization and granulation tissue formation. These findings support the wound-healing potential of *Gloriosa superba* and justify further standardization, safety evaluation and mechanistic investigation of its active constituents.

Keywords: *Gloriosa superba*; Agnishikha; wound healing; phytochemicals; excision wound; epithelization; hydroxyproline; antioxidant activity.

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Introduction

Wound healing restores the structural and functional integrity of injured tissue through overlapping phases of hemostasis, inflammation, proliferation and remodeling. Delayed healing may result from infection, oxidative stress, impaired vascular supply and systemic disorders, creating a need for treatments that support tissue repair while limiting inflammation and microbial complications. Medicinal plants are widely investigated because their alkaloids, flavonoids, tannins and phenolic compounds can provide complementary antioxidant, anti-inflammatory and tissue-regenerative actions. *Gloriosa superba* is a traditionally used medicinal plant containing biologically active constituents and was therefore selected in the present study for experimental evaluation of wound-healing activity.

Methods

Collection and Authentication of Plant Material

Plant: *Gloriosa superba*

Site of Collection:

The plant part of *Gloriosa superba* was collected from Pune, Maharashtra, India.

Method for Extraction:

Soxhlet Extraction:

Gloriosa superba powder (100.0 g) was weighed and extracted by ethanol using Soxhlet apparatus. Extraction was performed for 8 cycles and temperature was kept at 65 °C. Solvent was evaporated and extract was further dried at 40 °C for 24 h. Obtained extract was put in glass vials, sealed and stored at -18 °C prior analysis [73].

Percentage extractive yield

After extraction, the filtrate was concentrated and dried to obtain a constant weight of the extract (W₂). The weight of the initial dried plant material (W₁) was noted. The percentage extractive yield was then calculated using the formula [74]:

$$\% \text{ Yield} = (W_2 / W_1) \times 100$$

Preliminary phytochemical screening [75-77]**Table 2: Preliminary phytochemical screening for *Gloriosa superba***

Sr. no	Test name	Procedure
	Carbohydrates Test A) Fehling's test	Boiled together 2 ml of extract solution and 2 ml of Fehling's solution (a mixture of Fehling's solution A and B). brick red precipitate formed.
	B) Barfoed's test	2ml extract + 0.5 ml benedict's reagent + boiled for 2 min. The solution may be green, yellow, or orange
	Alkaloid Test A) Dragendroff's test	2-3 ml of test solution and 0.1 ml of Dragendroff's reagent. production of an orange-brown precipitate shows that alkaloids are present
	B) Wagner's test	2ml extract + 1-2 drops of Wagner's reagent (along the sides of test tube). The presence of alkaloids is shown by the production of a reddish-brown precipitate.
	Glycosides Test A) Keller Killani test	1 ml extract + 1.5 ml glacial acetic acid + 1 drop of 5 % ferric chloride + conc.H ₂ SO ₄ . Blue colour formed when test is present.
	B) Borntrager's test	Add 3 ml of test extract to sulfuric acid, boil, and then filter it. Add the equal quantity of chloroform, shake. The ammonical layer turns

		pink or red when you add ammonia
	Flavonoid Test A) Lead acetate test	A few drops of 10% lead acetate are added to the test extract. Getting yellow colour
	B) Ferric chloride test	Extract solution + few drops 10 % ferric chloride solution. Green ppt may form if test is positive
	Steroids Test Salkowski's test	Extract + few drops of conc. H ₂ SO ₄ . The reddish-brown color may formed
	Tannins & Phenolic compounds	2 ml of extract mixed with 1 ml of a 5% ferric chloride solution. A deep blue-black colour shows that Tannins & Phenolic compound present

TLC for Phytoconstituents

A small amount of the plant extract is dissolved in a suitable solvent. A TLC plate coated with silica gel is taken, and a small spot of the sample is applied near the base line using a capillary tube. The plate is then placed in a developing chamber containing an appropriate mobile phase solvent system. After development, the plate is removed, dried, and the spots are visualized under UV light or by using detecting reagents. The **R_f value** of each spot is calculated to identify the components present in the sample [78].

Table 3: TLC for phytoconstituents

Phytoconstituents	Mobile phase
1. Alkaloids	Toluene: methanol 9:1
2. Flavonoids	n-hexane: ethanol 6:4
3. Tannins and phenolic compounds	Butanol:Acetic acid:water 6:3:1

Column Chromatography [79-81]

Column chromatography was performed on silica gel (60-120 mesh) using n-hexane, ethyl acetate and ethanol in sequence. Fractions were collected at a controlled flow rate and screened for phytoconstituents; active fractions were further examined by TLC.

In vivo animal study

The concentrated extract was further dried to obtain a semisolid mass and stored in airtight amber-colored containers at refrigerated temperature until used for pharmacological evaluation.

Chemicals and Drugs Used

The following standard drugs and reagents were used during the study:

Table: Chemicals and Drugs used

Sr. No.	Drug/Chemical	Purpose
1	Povidone-Iodine ointment	Standard wound healing agent
2	Diclofenac	Anti-inflammatory agent
3	Nitrofurazone ointment	Standard antimicrobial healing agent
4	Chlorhexidine	Antiseptic agent
5	Ketamine	Anesthetic agent
6	Xylazine	Muscle relaxant and anesthetic
7	10% Neutral Buffered Formalin	Tissue fixation
8	Ethanol (70%)	Skin sterilization

Experimental Animals [82-85]

Healthy adult Wistar albino rats (150-250 g) were maintained under standard laboratory conditions with food and water ad libitum and acclimatized before experimentation. All procedures were performed in accordance with CPCSEA requirements after approval of the Institutional Animal Ethics Committee.

Experimental Design [86-106]

The animals were randomly divided into the following experimental groups:

Table: Experimental design

Group	Treatment
Group I	Control group (Standard wound care/No treatment)
Group II	Standard treatment group (Povidone-Iodine or Nitrofurazone ointment)

Group III	Test extract/formulation of <i>Gloriosa superba</i>
Group IV	Test extract at different dose/formulation

The treatment was continued daily for 21 days depending upon the wound model employed.

Experimental Models

The wound healing activity of *Gloriosa superba* was evaluated using the following in vivo wound models:

1. Excision wound model
2. Incision wound model
3. Dead space wound model

Excision Wound Model

For the excision model, anesthetized rats received a standardized full-thickness dorsal wound of approximately 500 mm². Test and standard treatments were applied daily, and wound area was recorded on scheduled days to calculate percentage wound contraction and epithelization time.

Incision Wound Model

For the incision model, a standardized paravertebral incision was sutured under aseptic conditions. Treatments were administered during healing, sutures were removed after wound closure, and tensile strength was assessed to estimate collagen maturation and tissue repair.

Dead Space Wound Model

For the dead-space model, sterile implants were placed subcutaneously under anesthesia to induce granulation tissue. After treatment, granulation tissue was collected for wet/dry weight and biochemical estimation of collagen-related and antioxidant parameters.

Parameters for Evaluation

A. Physical Parameters

1. Percentage Wound Contraction

Wound contraction was calculated from the reduction in wound area at predetermined intervals.

$$\text{Percentage Wound Contraction} = \frac{\text{Initial wound area} - \text{Specific day wound area}}{\text{Initial wound area}} \times 100$$

2. Epithelization Time

Epithelization time was recorded as the number of days required for complete closure and separation of the eschar.

3. Wound Size Reduction

Wound size reduction was measured by the graph-paper/tracing method.

4. Scar Formation Assessment

Scar quality was assessed by visual examination of healed tissue.

Biochemical Parameters

Hydroxyproline Estimation

Hydroxyproline in granulation tissue was used as an indirect indicator of collagen content.

9.2 Total Protein Estimation

Total protein content of granulation tissue was estimated as an index of tissue regeneration.

9.3 Antioxidant Activity

Superoxide dismutase (SOD), catalase and reduced glutathione (GSH) were estimated to assess antioxidant status.

Histopathological Evaluation

Granulation tissue and surrounding skin were collected on predetermined days, fixed in 10% neutral buffered formalin, processed, sectioned and stained with hematoxylin and eosin for microscopic examination.

Results

Collection and Drying of plant

Gloriosa superba plant material collected from Pune, Maharashtra, was shade-dried, powdered and used for extraction and subsequent evaluation.

Percentage extractive yield

Table 6: % extractive yield

Sr. No.	Color	Nature	Percentage Yield (% W/W)
1.	Dark Brown	Semisolid	12.48%

The ethanolic extract was a dark-brown semisolid with an extractive yield of 12.48% w/w.

6.2. Preliminary phytochemical screening

Table 7: Preliminary phytochemical screening for *Gloriosa superba*

Sr. no.	Test name	Observation	Result
	Carbohydrates Test A) Fehling's test:	No brick red precipitate	Carbohydrates absent
	B) Benedict's test	No orange colour	Carbohydrates absent
	Alkaloid Test A) Dragendorff's test	Orange-brown precipitate	Alkaloids present

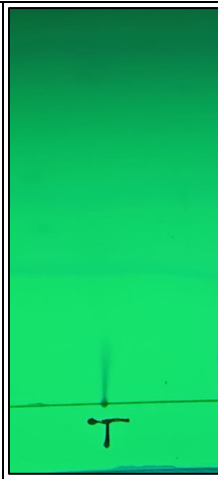
	B) Wagner's test	Reddish brown precipitate	Alkaloids present
	Glycosides Test A) Keller Killani test	No blue colored solution (in the layer)	Cardiac glycosides absent
	B) Borntrager's test	No pink or red colour	Anthraquinone glycosides absent
	Flavonoid Test A) Lead acetate test	Yellow colour	Flavonoid present
	B) Ferric chloride test	Green precipitate	Flavonoid present
	Steroids Test A) Salkowski's test	No red colour (in lower layer)	Steroids absent
	Tannins & Phenolic compounds	Deep blue-black colour	Tannins & Phenolic compounds present

Phytochemical screening indicated alkaloids, flavonoids, tannins and phenolic compounds, whereas carbohydrates, tested glycosides and steroids were not detected.

TLC for Phytoconstituents

Table 8: TLC for phytoconstituents

Phytoconstituents	Rf value	TLC plate image
a) Alkaloids		
b) Flavonoids		

C) Tannins and phenolic compounds	0.244	
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Phytochemical tests for fractions**Table 9: Phytochemical tests for fractions of column chromatography**

Sr. no	Test name	n-Hexane	n-Hexane: Ethyl acetate	Ethyl acetate	Ethyl acetate: Ethanol	Ethanol
1	Carbohydrates Test Fehling's test	-	-	-	-	-
	Benedict's test	-	-	-	-	-
2	Alkaloid Test Dragendorff's test	-	+	+	+	+
	Wagner's test	+	+	+	+	+
3	Glycosides Test Keller Killani test	-	-	-	-	-
	Borntrager's test	-	-	-	-	-
4	Flavonoid	-	-	-	+	-

	Ferric chloride test					
	Lead acetate test	-	-	-	-	-
5	Steroids Test Salkowski's test	-	-	-	-	-
6	Tannins & Phenolic compounds	-	-	-	-	-

Fraction screening showed prominent alkaloidal constituents across several solvent fractions, while flavonoids were detected in the ethyl acetate:ethanol fraction.

TLC for active fractions**Table 10: TLC for active fractions**

Phytoconstituents	Rf value	TLC plate image
A) n-Hexane 1. Alkaloids		
B) n-Hexane: Ethyl acetate 1. Alkaloids		

C) Ethyl acetate 1. Alkaloids		
D) Ethyl acetate: Ethanol 1. Alkaloids 2. Flavonoids		
E) Ethanol 1. Alkaloids		

Table: Effect of *Gloriosa superba* Extract on Epithelization Time

In vivo animal study		Sr . No.	Experimental Group	Day 0 (mm ²)	Day 7 (mm ²)	Day 14 (mm ²)	Day 21 (mm ²)
Evaluation of Physical Parameters Table: Effect of <i>Gloriosa superba</i> Extract on Percentage Wound Contraction in Excision Wound Model		1	Control Group	500.00 ± 0.00	342.18 ± 8.24	186.47 ± 6.82	84.25 ± 4.18
		2	Standard Group	500.00 ± 0.00	208.34 ± 6.42**	68.14 ± 4.26**	4.28 ± 0.84**
		3	Test Extract Group	500.00 ± 0.00	246.52 ± 7.18*	92.48 ± 5.14**	18.54 ± 1.28**

Sr . No.	Experimental Group	Day 3 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)	Sr. No.	Experimental Group	Epithelization Time (Days)
1	Control Group	18.42 ± 1.25	36.81 ± 1.84	61.47 ± 2.22	82.18 ± 2.04	1	Control Group	22.48 ± 0.64
2	Standard Group	32.68 ± 1.48*	58.74 ± 2.11**	86.35 ± 2.38**	99.14 ± 1.06**	2	Standard Group	14.22 ± 0.48***
3	Test Extract Group	27.45 ± 1.36*	51.26 ± 1.94*	79.42 ± 2.17**	95.72 ± 1.48**	3	Test Extract Group	16.37 ± 0.52**

Values are expressed as Mean ± SEM (n = 6)
p < 0.01, *p < 0.001 compared with control group.

Percentage Wound Contraction (Day 21)**Figure: Percentage wound contraction**

Values are expressed as Mean ± SEM (n = 6).

Significance: ***p < 0.001 compared with control group.

Values are expressed as Mean ± SEM (n = 6)
p < 0.01, *p < 0.001 compared with control group.

Table: Effect of *Gloriosa superba* Extract on Wound Size Reduction

Values are expressed as Mean ± SEM (n = 6)
p < 0.01, *p < 0.001 compared with control group.

Table: Scar Formation Assessment

Sr. No.	Experimental Group	Observation
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1	Control Group	Thick scar formation with delayed healing
2	Standard Group	Minimal scar formation with complete healing
3	Test Extract Group	Mild scar formation with satisfactory healing

Evaluation of Biochemical Parameters

Table: Effect of *Gloriosa superba* Extract on Hydroxyproline Content

Sr. No.	Experimental Group	Hydroxyproline Content (mg/g tissue)
1	Control Group	38.42 ± 1.48
2	Standard Group	72.68 ± 2.14***
3	Test Extract Group	65.24 ± 1.86***

Values are expressed as Mean ± SEM (n = 6)

***p < 0.001 compared with control group.

Table: Effect of *Gloriosa superba* Extract on Total Protein Content

Sr. No.	Experimental Group	Total Protein Content (mg/g tissue)
1	Control Group	42.18 ± 1.24
2	Standard Group	78.42 ± 2.18***
3	Test Extract Group	70.36 ± 1.92***

Values are expressed as Mean ± SEM (n = 6)

***p < 0.001 compared with control group.

Table: Effect of *Gloriosa superba* Extract on Antioxidant Parameters

Sr. No.	Parameters	Control Group	Standard Group	Test Extract Group
1	SOD (U/mg protein)	8.24 ± 0.42	16.82 ± 0.74***	14.68 ± 0.66** *

2	Catalase (μmol/min/mg protein)	18.42 ± 0.84	34.28 ± 1.12***	30.46 ± 1.08** *
3	GSH (μg/mg tissue)	12.38 ± 0.56	25.42 ± 0.94***	22.68 ± 0.88** *

Values are expressed as Mean ± SEM (n = 6)

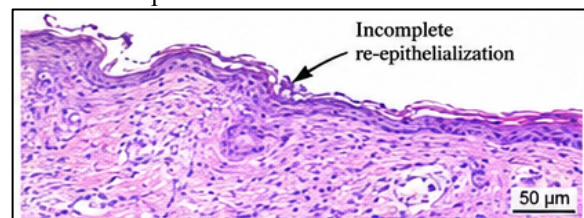
***p < 0.001 compared with control group.

Histopathological Evaluation

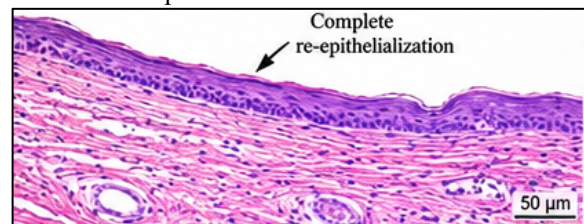
Separated Histopathological Images

Day 7

Control Group



Standard Group



Test Extract Group

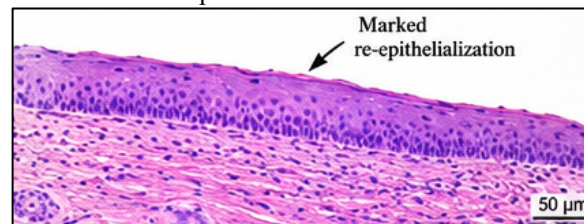


Table: Histopathological Observations of Wound Healing Activity

Sr. No.	Histopathological Parameter	Control Group	Standard Group	Test Extract Group
1	Re-epithelialization	Poor	Complete	Markedly improved
2	Collagen Fiber Deposition	Mild	Dense collagen fibers	Moderate to dense

3	Fibroblast Proliferation	Low	Extensive	Moderate to high
4	Angiogenesis	Poor vascularization	Extensive neovascularization	Improved vascularization
5	Inflammatory Cell Infiltration	Severe	Minimal	Mild
6	Granulation Tissue Formation	Delayed	Well organized	Improved
7	Keratinization	Incomplete	Complete	Nearly complete

Statistical Analysis

All experimental values were expressed as Mean $\pm$ Standard Error of Mean (SEM) for six animals in each group (n = 6). Statistical analysis was performed using one-way Analysis of Variance (ANOVA) followed by Dunnett's multiple comparison test. Values were considered statistically significant at $p < 0.05$, highly significant at $p < 0.01$, and very highly significant at $p < 0.001$ when compared with the control group.

Discussion

Gloriosa superba extract improved wound contraction and reduced epithelization time compared with the control group, indicating faster restoration of skin integrity. The biochemical findings, including increased hydroxyproline and total protein, support enhanced collagen formation and tissue regeneration, while increased SOD, catalase and GSH suggest improved antioxidant defense during healing.

The histopathological findings were consistent with the quantitative observations, showing improved re-epithelialization, collagen deposition, vascularization and granulation tissue organization in extract-treated tissue. The combined phytochemical, biochemical and histological findings indicate that the observed activity may reflect the contribution of alkaloids, flavonoids and other phenolic constituents present in the extract.

Conclusion

The study demonstrates significant wound-healing activity of Gloriosa superba extract in experimental models. Improvement in wound contraction,

epithelization, collagen-related indices, antioxidant parameters and tissue architecture supports its potential as a source of wound-healing phytoconstituents.

Further work should focus on isolation and standardization of active constituents, dose optimization, detailed toxicity assessment and confirmation in well-controlled clinical studies before therapeutic application.

7. References

1. Tanaka M, Fernández-del Castillo C, Adsay V, Chari S, Falconi M, Jang JY, Kimura W, Levy P, Pitman MB, Schmidt CM, Shimizu M. International consensus guidelines 2012 for the management of IPMN and MCN of the pancreas. *Pancreatology*. 2012 May 1;12(3):183-97.
2. Mone NS, Bhagwat SA, Sharma D, Chaskar M, Patil RH, Zamboni P, Nawani NN, Satpute SK. Naphthoquinones and their derivatives: emerging trends in combating microbial pathogens. *Coatings*. 2021 Apr 9;11(4):434.
3. Hua F, Bruijnzeel LA, Meli P, Martin PA, Zhang J, Nakagawa S, Miao X, Wang W, McEvoy C, Peña-Arancibia JL, Brancalion PH. The biodiversity and ecosystem service contributions and trade-offs of forest restoration approaches. *Science*. 2022 May 20;376(6595):839-44.
4. Ahn JK, Chebotaryov S, Choi JH, Choi S, Choi W, Choi Y, Jang HI, Jang JS, Jeon EJ, Jeong IS, Joo KK. Observation of reactor electron antineutrinos disappearance in the RENO experiment. *Physical Review Letters*. 2012 May 11;108(19):191802.
5. Kumar B, Vijayakumar M, Govindarajan R, Pushpangadan P. Ethnopharmacological approaches to wound healing—exploring medicinal plants of India. *Journal of ethnopharmacology*. 2007 Nov 1;114(2):103-13.
6. Roberts PR, LATG KW, Santamauro JT, Zaloga GP. Dietary peptides improve wound healing following surgery. *Nutrition*. 1998 Mar 1;14(3):266-9.
7. Aulton ME, Taylor K, editors. *Aulton's pharmaceuticals: the design and manufacture of medicines*. Elsevier Health Sciences; 2013.
8. Li J, Chen J, Kirsner R. Pathophysiology of acute wound healing. *Clinics in dermatology*. 2007 Jan 1;25(1):9-18.
9. Ghosh D, Antony B, editors. *Ashwagandha: Potential Drug Candidate from Ancient Ayurvedic Remedy*. CRC Press; 2025 Sep 5.

10. Novak ML, Koh TJ. Phenotypic transitions of macrophages orchestrate tissue repair. *The American journal of pathology*. 2013 Nov 1;183(5):1352-63.
11. Rocha Júnior AM, Vieira BJ, Andrade LC, Aarestrup FM. Effects of low-level laser therapy on the progress of wound healing in humans: the contribution of in vitro and in vivo experimental studies. *Jornal Vascular Brasileiro*. 2007;6:257-65.
12. Holt DR, Kirk SJ, Regan MC, Hurson M, Lindblad WJ, Barbul A. Effect of age on wound healing in healthy human beings. *Surgery*. 1992 Aug 1;112(2):293-8.
13. Guo SA, DiPietro LA. Factors affecting wound healing. *Journal of dental research*. 2010 Mar;89(3):219-29.
14. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities and medicinal properties of neem (*Azadirachta indica*). *Current science*. 2002 Jun 10;1336-45.
15. Sidhu GS, Singh AK, Thaloor D, Banaudha KK, Patnaik GK, Srimal RC, Maheshwari RK. Enhancement of wound healing by curcumin in animals. *Wound Repair and Regeneration*. 1998 Mar;6(2):167-77.
16. Amar Surjushe AS, Resham Vasani RV, Saple DG. Aloe vera: a short review.
17. Surjushe A, Vasani R, Saple D. Aloe vera: a short review. *Indian journal of dermatology*. 2008 Oct 1;53(4):163-6.
18. Parente LM, Lino Junior RD, Tresvenzol LM, Vinaud MC, de Paula JR, Paulo NM. Wound healing and anti-inflammatory effect in animal models of *Calendula officinalis* L. growing in Brazil. *Evidence-Based Complementary and Alternative Medicine*. 2012;2012(1):375671.
19. Heena D, Sunil T. Carica papaya: Potential implications in human health. *Current Traditional Medicine*. 2019 Dec 1;5(4):321-36.
20. Oliveira YR, de Sousa WG, da Silva PH, Pacheco AC, Ferreira PM, de Abreu MC. Ethnopharmacology of Anacardiaceae R. Br. from Northeast Brazil. *Scientia Naturalis*. 2023 Jul 31;5(1).
21. Sawatdee S, Choochuay K, Chanthorn W, Srichana T. Evaluation of the topical spray containing *Centella asiatica* extract and efficacy on excision wounds in rats. *Acta Pharmaceutica*. 2016 Jun 30;66(2):233-44.
22. Rozani M, Susanto D, Fauzi M, Sali A. Wound treatment using aloe vera in the process of accelerating wound healing for post-op patients at the lompe ntodea community health center. *STRADA: Jurnal Ilmiah Kesehatan*. 2024 May 30;13(1):38-44.
23. Cauich-Kumul R, Campos MR. Bee propolis: Properties, chemical composition, applications, and potential health effects. In *Bioactive compounds 2019 Jan 1* (pp. 227-243). Woodhead Publishing.
24. Henshaw FR, Bolton T, Nube V, Hood A, Veldhoen D, Pfrunder L, McKew GL, Macleod C, McLennan SV, Twigg SM. Topical application of the bee hive protectant propolis is well tolerated and improves human diabetic foot ulcer healing in a prospective feasibility study. *Journal of Diabetes and its Complications*. 2014 Nov 1;28(6):850-7.
25. Cedillo-Cortezano M, Martinez-Cuevas LR, López JA, Barrera López IL, Escutia-Perez S, Petricevich VL. Use of medicinal plants in the process of wound healing: a literature review. *Pharmaceuticals*. 2024 Feb 27;17(3):303.
26. Arribas-López E, Zand N, Ojo O, Snowden MJ, Kochhar T. A systematic review of the effect of *Centella asiatica* on wound healing. *International journal of environmental research and public health*. 2022 Mar 10;19(6):3266.
27. Middleton Jr E, Kandaswami C, Theoharides TC. The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease, and cancer. *Pharmacological reviews*. 2000 Dec 1;52(4):673-751.
28. Xu Y, Bian S, Shang L, Wang X, Bai X, Zhang W. Phytochemistry, pharmacological effects and mechanism of action of volatile oil from *Panax ginseng* CA Mey: a review. *Frontiers in Pharmacology*. 2024 Aug 13;15:1436624.
29. Pradhan J, Nayak S, Bindhani BK. EVALUATION OF THE USAGE OF ETHNOBOTANICAL MEDICINAL PLANTS IN THE TREATMENT OF SKIN DISEASES IN INDIA. *World*. 2026;5(2).
30. Lei X. Mechanisms and therapeutic roles of medicinal plants in skin Photoaging. *Clinical, Cosmetic and Investigational Dermatology*. 2025 Dec 31;1709-26.
31. Thakur R, Jain N, Pathak R, Sandhu SS. Practices in wound healing studies of plants. *Evidence-Based Complementary and Alternative Medicine*. 2011;2011(1):438056.
32. Madhavi K, Reddy KJ. Review on Chromatographic Fingerprint Analysis of Herbal Medicines.
33. Agrawal R, Jurel P, Deshmukh R, Harwansh RK, Garg A, Kumar A, Singh S, Guru A, Kumar A, Kumarasamy V. Emerging trends in the treatment

- of skin disorders by herbal drugs: traditional and nanotechnological approach. *Pharmaceutics*. 2024 Jun 28;16(7):869.
34. Breijyeh Z, Karaman R. Antibacterial activity of medicinal plants and their role in wound healing. *Future Journal of Pharmaceutical Sciences*. 2024 May 13;10(1):68.
 35. Elhewehy AA, El-Fishawy AM, Aly RM, Mohsen E, Fayed MA. Isolation and quantification of polyphenolics, exploration of antioxidant, cytotoxicity, and wound healing activities of *Pithecellobium dulce* (Roxb.) Benth. *Scientific Reports*. 2026 Jan 11;16(1):1338.
 36. Jadhav PS, Shinde PH, Mulla JA. Formulation and evaluation of a *Tridax procumbens*-loaded phospholipid complex (phytosome) gel for wound healing and antimicrobial activities. *RSC Pharmaceutics*. 2026;3(1):237-46.
 37. Bayode MA, Ogunlakin AD, Gyebe GA, Ojo OA. Evaluation of the ethanolic extract of *Mondai whitei* (Hook. f.) Skeels for their antioxidant, anti-inflammatory and antidiabetic properties. *Edelweiss Applied Science and Technology*. 2026;10(1):102-27.
 38. Preradović N, Nakarada Đ, Gašić U, Simonović Radosavljević J, Mojović M. Green Extraction and Liposomal Encapsulation of *Inonotus obliquus* (Chaga) Extracts: Comparative Phytochemical and Antioxidant Analysis. *Molecules*. 2026 Jan 1;31(1):146.
 39. Umeh VN, Ilodigwe EE, Ajaghaku DL, Erhirhie EO, Moke GE, Akah PA. Wound-healing activity of the aqueous leaf extract and fractions of *Ficus exasperata* (Moraceae) and its safety evaluation on albino rats. *Journal of Traditional and Complementary Medicine*. 2014 Oct 1;4(4):246-52.
 40. Papazidou V, Makrygiannis I, Mantiniotou M, Athanasiadis V, Bozinou E, Lalas SI. Isolation of bioactive compounds and antioxidant activity evaluation of *Crataegus monogyna* leaves via pulsed electric field-assisted extraction. *Plants*. 2025 Jul 22;14(15):2262.