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Comparative investigation of *Moringa oleifera* and *Tagetes erecta* hydrogels for enhancing cutaneous wound healing in rats

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Abstract

Wound healing is a complex and coordinated biological process aimed at restoring tissue integrity following injury. Herbal formulations have gained importance due to their therapeutic potential and minimal side effects. The present study was conducted to evaluate the comparative efficacy of 10% *Moringa oleifera* and 10% *Tagetes erecta* hydrogels in full-thickness cutaneous wound healing in rats. A total of 36 healthy adult Wistar rats were divided into three groups. Anaesthesia was induced using xylazine and ketamine and a standardized 2×2 cm² full-thickness wound was created on the dorsal thoracic region. Group I served as control (normal saline), while groups II and III were treated with *Moringa oleifera* and *Tagetes erecta* hydrogels, respectively. Clinical parameters, including behavioural changes, exudation, and wound contraction, were recorded at regular intervals. Haematological parameters such as haemoglobin and total leucocyte count were also evaluated. Both treatments improved healing compared to control; however, *Moringa oleifera* hydrogel showed relatively faster wound contraction, reduced exudation and better maintenance of haematological values.

Keywords: Wound healing, *Moringa oleifera*, *Tagetes erecta*, hydrogel, rats

Introduction

The skin is the largest organ of the body and serves as a protective barrier against external factors. It is composed of three layers—the epidermis, dermis and hypodermis—each contributing to structural and functional integrity. The epidermis contains specialized cells, while the dermis provides support through connective tissue, blood vessels and nerves (Slatter, 2003; Zomer and Trentin, 2018) ^[18, 21]. A wound is defined as a disruption in the normal continuity of tissues caused by trauma or surgical intervention and may be classified as open or closed. Wound healing is a complex and coordinated process that progresses through overlapping phases—namely inflammation, proliferation and remodeling—facilitating tissue repair through mechanisms such as angiogenesis, collagen deposition, epithelialization and contraction (Slatter, 2003; Williams and Moores, 2017) ^[18, 20].

Ethnomedicinal plants have gained importance in wound management due to their efficacy and minimal side effects. Traditional systems such as Ayurveda emphasize the use of herbal remedies and a large proportion of the population depends on plant-based medicine (Saini *et al.*, 2016; Pan *et al.*, 2014) ^[11, 9]. *Moringa oleifera* is a medicinal plant known for its antimicrobial, antioxidant and anti-inflammatory properties, contributing to its wound healing potential (Ali *et al.*, 2022) ^[2]. Similarly, *Tagetes erecta* (marigold) possesses antibacterial, antifungal and antioxidant activities, making it effective in wound treatment (Dixit *et al.*, 2013) ^[3]. Hydrogels are hydrophilic polymer networks capable of retaining significant amounts of water, thereby maintaining a moist environment that enhances wound healing and supports controlled drug delivery (Ali *et al.*, 2022) ^[2].

Materials and Methods

The present investigation was carried out over a period of approximately six months in the Department of Veterinary Surgery and Radiology and the Department of Veterinary Pathology at the College of Veterinary Science and Animal Husbandry, Rewa, Madhya Pradesh.

Adult Wistar rats of either sex were procured from the College of Veterinary Science and Animal Husbandry, Jabalpur.

A total of 36 clinically healthy adult rats, irrespective of sex, were included in the study. The animals were randomly allocated into three experimental groups, each comprising 12 rats. General anesthesia was induced using a combination of xylazine (5 mg/kg body weight) and ketamine (50 mg/kg body weight), administered intramuscularly.

Each animal was positioned in sternal recumbency and the dorsal thoracic region was clipped and aseptically prepared in accordance with standard surgical protocols (Singh *et al.*, 2017) [17]. A sterile surgical drape was applied over the dorsum. Subsequently, a full-thickness skin incision measuring approximately $2 \times 2 \text{ cm}^2$ was created using a scalpel. The skin was carefully dissected from the underlying subcutaneous tissue and excised, as illustrated in Figures 1.

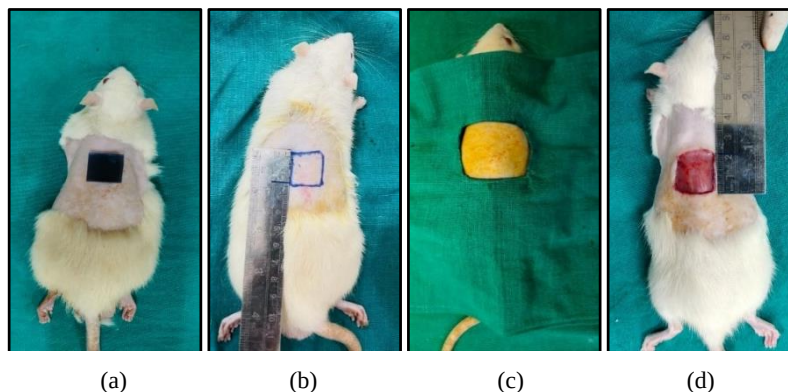


Fig 1: (a) Placement of a template over the dorsum of animal, (b) Marking of the incision site with permanent marker, (c) Prepared the site for wound creation, (d) Full thickness wound ($2 \times 2 \text{ cm}^2$) over the dorsum of animal

Therapy of wounds

All the wounds were washed with sterile normal saline solution followed by the indicated therapy as described in table 1.

Table 1: Treatment protocols in different groups of animals

Groups	Number of animals	Treatment protocols
I	12	Normal saline solution
II	12	10% <i>Moringa oleifera</i> Hydrogel
III	12	10% <i>Tagetes erecta</i> Hydrogel

Preparation of hydrogel

Preparation of plant extracts

Moringa oleifera seeds and *Tagetes erecta* flowers was collected from the local area. Then they were washed, air dried and powdered separately. Ethanolic cold extract was prepared from powdered plant material using standard

protocol as per described by Shafeie *et al.* (2015) [13] with slight modification. The powdered plant material was soaked in ethyl alcohol (90%) in the ratio 1:5 and kept for 3 to 4 days and then was transferred into petri plates for drying. The prepared extract was stored in the refrigerator till further use.

Preparation of hydrogel

Hydrogel was prepared by as per the method described by Ali *et al.* (2022) [12]; Shafeie *et al.* (2015) [13] with slight modification. In this one gram of Carbopol was dissolved in 50 ml of distilled water at $40-50^\circ \text{C}$. After overnight standing, another 50 ml of distilled water was added and stirred to form hydrogel. Triethanolamine (2-3 drops) was added to adjust the pH to 7. To prepare a 10% hydrogel, 10 gram of plant extract was mixed with 90 gram of gel base.

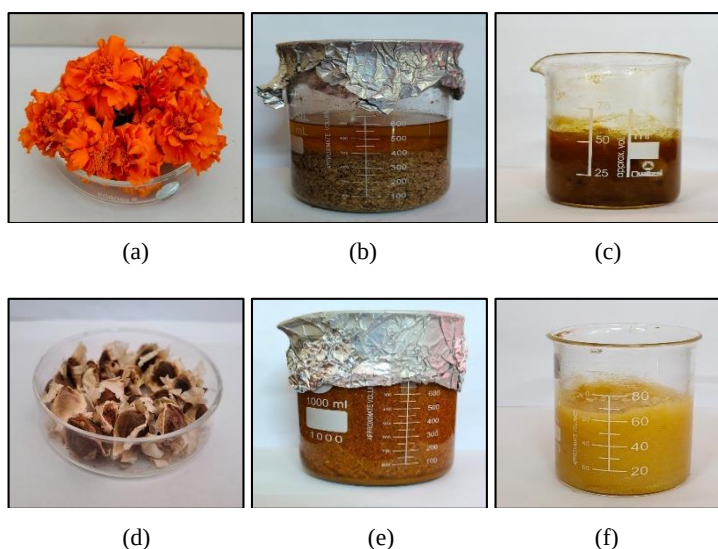


Fig 2: (a) *Tagetes erecta* flower, (b) Grinded powder of *Tagetes erecta* in 90% ethanol, (c) 10% *Tagetes erecta* flower hydrogel, (d) *Moringa oleifera* seeds, (e) Grinded powder of *Moringa oleifera* in 90% ethanol, (f) 10% *Moringa oleifera* seeds hydrogel

Clinical Observations

Feeding behavior and overall behavioral changes of all animals were systematically monitored and recorded on a daily basis throughout the entire study duration.

Gross Observations

The wound site was evaluated on postoperative days 0, 3, 7, 14, 21 and 28. Assessments included photographic evaluation along with examination of exudation and the extent of wound contraction. The percentage of wound contraction was determined using a standard formula as described by Singh *et al.* (2010) [16].

$$\text{Percentage of wound contraction} = \frac{a-b}{a} \times 100$$

a = Wound area on day zero

b = Wound area on n^{th} day

Haematological Observations

Approximately 1 ml of blood was collected from the retro-orbital venous plexus on days 0, 7 and 28 using a heparinized capillary tube. Total erythrocyte count (TEC) and total leucocyte count (TLC) were determined using a Neubauer chamber and haemocytometer, respectively, while haemoglobin (Hb) and packed cell volume (PCV) were measured by Sahli's method and the microhaematocrit technique. All values were expressed in standard units.

Statistical analysis

The data was analyzed by employing statistical method as described by Snedecor and Cochran (1968) [19] using SPSS software version 20.

Results and Discussion

Animals in all three groups showed partial feed and water

intake within 24 hours post-surgery, returning to normal feeding by the third or fourth day. Initially, the animals appeared dull, but normal activity resumed within 1-2 days. This transient reduction in activity and appetite may be attributed to postoperative pain and inflammation at the surgical site (Gangwar *et al.*, 2013; Pawar, 2025) [5, 10].

Photographic evaluation

Group I: On 3rd post-operative day, the wound treated with normal saline solution had soft and weak tissue with brownish red colour. The serous exudate was heavily accumulated in the wound area. On the 7th day, a thick crust formed by the granulation and accumulation of serous exudate was observed on the healing surface. The wound size was observed to have been significantly ($p < 0.05$) reduced on the 14th day post treatment. By the 21st day, the size was greatly reduced and was in the form of a small crust. By the 28th day, complete healing along with a scar was noticed.

Group II: The wounds treated with 10% *Moringa oleifera* hydrogel were observed to have a pinkish brown tint on day 3. However, on day 7, there was a noticeable reduction in the size of the wounds, which were brown with less exudates. By day 14, the wounds were almost healed. By day 21, the wounds were fully healed with minimal formation of scar tissue. Wounds were completely healed on day 28.

Group III: On 3rd postoperative day, wounds treated with 10% *Tagetes erecta* hydrogel were dry with a dark brown colour. On day 7, there was slight exudation was present and wounds turned brown with a crust of granulation tissue. Wound size decreased considerably on day 14. The wound was almost healed on day 21. The wound was completely healed on day 28.

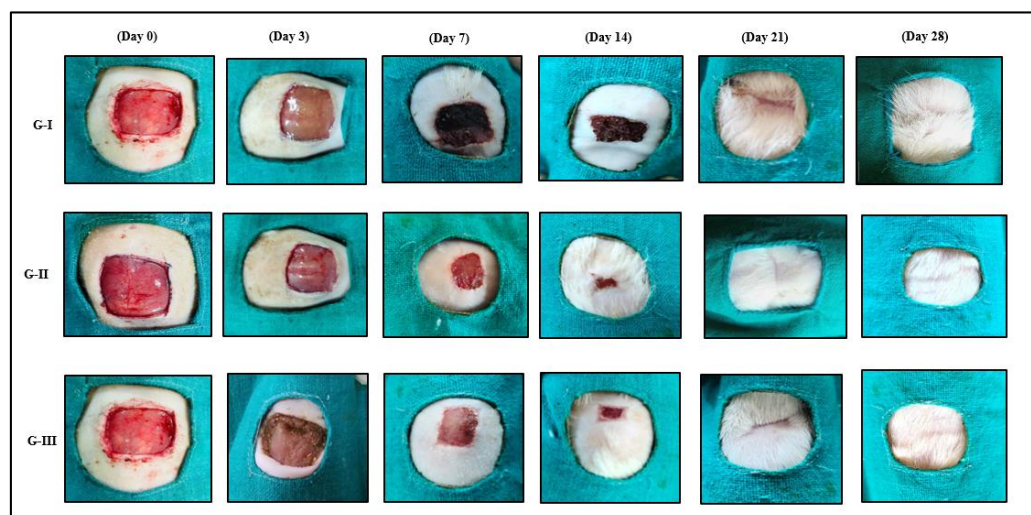


Fig 3: Photographs of wound healing of group I, II and III at different time intervals

Degree of exudation

Degree of exudation was subjected to chi square-analysis and data revealed that the exudation score showed significant association ($p < 0.05$) on day 3, 7 and 14 among group I, II and III and the values were 25.340, 25.477 and 14.303 respectively. Non-significant association ($p > 0.05$) was detected on day 21 while, no association was noted on day 0 and day 28.

Exudation scores remained higher in the control group on days 3, 7 and 14 compared to groups II and III treated with 10% *Moringa oleifera* and 10% *Tagetes erecta* hydrogels. This reduction in treated groups may be due to the hydrogels' ability to absorb excess fluid and maintain a moist wound environment, supporting healing. Exudate formation is a normal response to surgical injury, resulting from increased vascular permeability during inflammation

and gradually decreases as healing progresses (Pawar, 2025) [10].

Wound contracture

Significant increase ($p<0.05$) in the percentage wound contraction was noted within groups at different days interval in all the three treatment groups till day 21. Non-significant difference ($P>0.05$) was observed between day 21 and 28 in three groups. Group II revealed highest wound contraction followed by group III and group I at different time interval throughout the study period. These findings align with earlier reports indicating enhanced wound healing and contraction in animals treated with *Moringa oleifera* hydrogel (Ali *et al.*, 2022) [2]. Similar observations have also been documented in rabbits and rats by various researchers (Sharma, 2025; Singh *et al.*, 2016a; Firdous and Sautya, 2018; Natarajan *et al.*, 2018; Selvam *et al.*, 2021; Ahmed *et al.*, 2024) [14, 15, 4, 7, 12, 1]. The improved wound contraction observed in the *Moringa oleifera*-treated group in the present study may be attributed to its bioactive constituents, such as flavonoids, tannins, phenolics and saponins. These compounds possess antioxidant, anti-inflammatory and antimicrobial properties, which help reduce oxidative stress, limit infection and promote faster progression of wound healing.

Table 2: Mean $\pm$ SE values of wound contracture (%) at different time intervals in three different treatment groups

Time interval (Days)	Group		
	I	II	III
Day 0	0.00 ^a $\pm$ 0.00	0.00 ^a $\pm$ 0.00	0.00 ^a $\pm$ 0.00
Day 3	11.67 ^{Ab} $\pm$ 3.68	43.33 ^{Cb} $\pm$ 2.05	34.48 ^{Bb} $\pm$ 1.99
Day 7	60.63 ^{Ac} $\pm$ 2.34	80.42 ^{Bc} $\pm$ 3.04	74.58 ^{Bc} $\pm$ 1.67
Day 14	82.35 ^{Ad} $\pm$ 2.58	93.33 ^{Bd} $\pm$ 0.86	88.85 ^{Bd} $\pm$ 1.72
Day 21	97.92 ^{Ae} $\pm$ 0.66	99.35 ^{Ae} $\pm$ 0.25	98.50 ^{Ae} $\pm$ 0.65
Day 28	100.00 ^{Ae} $\pm$ 0.00	100.00 ^{Ae} $\pm$ 0.00	100.00 ^{Ae} $\pm$ 0.00

-Values with different superscript (capital letters) differ significantly ($p<0.05$) among the groups at particular time intervals.
-Values with different superscript (small letters) differ significantly ($p<0.05$) within the groups at different time intervals.

Haematological Observations
Haemoglobin

A significant decline in haemoglobin levels was observed in all groups on day 7, followed by a progressive increase by day 28. Comparison among the groups I, II and III revealed a non-significant association on day 0, 7 and 28. The lowest haemoglobin value was noted in group I on day 7 (14.00 $\pm$ 0.04 g/dl), whereas the highest value was observed in group II on day 28 (14.98 $\pm$ 0.04 g/dl).

Table 3: Mean $\pm$ SE values of haemoglobin (gm/dl) at different time intervals in three different treatment groups

Time interval (Days)	Group		
	I	II	III
Day 0	14.67 ^{Ab} $\pm$ 0.05	14.73 ^{Ab} $\pm$ 0.04	14.69 ^{Ab} $\pm$ 0.05
Day 7	14.00 ^{Aa} $\pm$ 0.04	14.02 ^{Aa} $\pm$ 0.09	13.96 ^{Aa} $\pm$ 0.08
Day 28	14.83 ^{Ac} $\pm$ 0.06	14.98 ^{Ac} $\pm$ 0.04	14.86 ^{Ab} $\pm$ 0.05

-Values with different superscript (capital letters) differ significantly ($p<0.05$) among the groups at particular time intervals.
-Values with different superscript (small letters) differ significantly ($p<0.05$) within the groups at different time intervals.

Total leucocyte count

All the mean TLC value of group I, II and III on day 7 revealed significant rise followed by a significant drop on day 28 but the values were within the normal physiological range. Comparison among the groups revealed a non-significant variation in group I, II and III on day 0. On day 7, group I exhibited a significantly higher mean value compared to both group II and group III, whereas group II and III did not differ statistically with respect to each other. At day 28, group I values was significantly higher than groups II and III, while groups II and III were statistically similar to each other.

Table 4: Mean $\pm$ SE values of total leucocyte (thousand/mm³) at different time intervals in three different groups

Time interval (Days)	Group		
	I	II	III
Day 0	7.30 ^{Aa} $\pm$ 0.03	7.23 ^{Aa} $\pm$ 0.04	7.27 ^{Aa} $\pm$ 0.03
Day 7	9.08 ^{Bc} $\pm$ 0.10	8.27 ^{Ab} $\pm$ 0.04	8.38 ^{Ab} $\pm$ 0.04
Day 28	7.69 ^{Bb} $\pm$ 0.05	7.17 ^{Aa} $\pm$ 0.04	7.22 ^{Aa} $\pm$ 0.04

-Values with different superscript (capital letters) differ significantly ($p<0.05$) among the groups at particular time intervals.
-Values with different superscript (small letters) differ significantly ($p<0.05$) within the groups at different time intervals.

The observed changes in haemoglobin (Hb) and total leucocyte count (TLC) are consistent with previous findings (Pawar, 2025) [10]. Hb levels showed a decline on day 7, followed by recovery toward baseline by day 28, which may be attributed to surgical blood loss and the inflammatory response. In contrast, TLC exhibited a temporary increase during the early postoperative period, indicating an acute inflammatory reaction and gradually returned to normal levels by day 28. Similar trends have been reported by Sharma (2025) [14], where Hb decreased initially and later improved, while TLC increased on day 7 and declined thereafter. The transient rise in TLC reflects a short-term inflammatory response and subsequent adaptation, suggesting good biocompatibility of the treatment. These findings are in agreement with earlier studies (Onah *et al.*, 2025; Lakshmi, 2022) [8, 6].

Conclusion

The present study demonstrated that both 10% *Moringa oleifera* and *Tagetes erecta* hydrogels significantly enhanced wound healing in rats compared to the untreated control group. However, the *Moringa oleifera* hydrogel exhibited comparatively superior efficacy, as indicated by a marked reduction in exudation, inflammation, edema and associated discomfort, reflecting a more effective and rapid healing response. In addition, haematological parameters in the *Moringa oleifera*-treated group remained closer to normal physiological values, suggesting better systemic tolerance and minimal adverse effects. Overall, these findings highlight the greater therapeutic potential of *Moringa oleifera* hydrogel, while also indicating that both hydrogels are economical and readily available options for wound management in veterinary practice.

References

1. Ahmed KA, Jabbar AA, Galali Y, Al-Qaane AM, Akçakavak G, Salehen NA, *et al.* Cumin (*Cuminum cyminum* L.) seeds accelerates wound healing in rats:

- possible molecular mechanisms. *Skin Res Technol.* 2024;30(5):e13727.
2. Ali A, Garg P, Goyal R, Khan A, Negi P, Li X, *et al.* An efficient wound healing hydrogel based on a hydroalcoholic extract of *Moringa oleifera* seeds. *S Afr J Bot.* 2022;145:192-198.
 3. Dixit P, Tripathi S, Verma KN. A brief study on marigold (*Tagetes* species): A review. *Int Res J Pharm.* 2013;4(1):43-48.
 4. Firdous SM, Sautya D. Medicinal plants with wound healing potential. *Bangladesh J Pharmacol.* 2018;13(1):41-52.
 5. Gangwar AK, Kumar N, Sharma AK, Devi S, Negi M, Shrivastava S, *et al.* Bioengineered acellular dermal matrix for the repair of full thickness skin wounds in rats. *Trends Biomater Artif Organs.* 2013;27(2):67-80.
 6. Lakshmi KB. Evaluation of nanohydroxyapatite chitosan and ceftiofur biocomposite films on cutaneous wound healing in rats [M.V.Sc. & A.H. thesis]. Tirupati: Sri Venkateswara Veterinary University; 2022.
 7. Natarajan SB, Das SK, Chandran SP, Oo AM, Kanneppady SS, Entezarian M, *et al.* *Moringa oleifera* leaf extract loaded hydrogel for diabetic wound healing. *Malays J Med Res.* 2018;2(2):35-41.
 8. Onah JA, Fadason ST, Abidoeye EO, Kadima KB, Aba PE, Onah DC, *et al.* Haematological and serum biochemical responses following surgically created open skin wound healing in alloxan-induced diabetic rabbits. *Comp Clin Pathol.* 2025;34(1):109-118.
 9. Pan SY, Litscher G, Gao SH, Zhou SF, Yu ZL, Chen HQ, *et al.* Historical perspective of traditional indigenous medical practices: the current renaissance and conservation of herbal resources. *Evid Based Complement Alternat Med.* 2014;2014:525340.
 10. Pawar T. Studies on the effect of poultry derived collagen on the healing of full thickness skin wound in rats [M.V.Sc. & A.H. thesis]. Jabalpur: Nanaji Deshmukh Veterinary Science University; 2025.
 11. Saini S, Dhiman A, Nanda S. Traditional Indian medicinal plants with potential wound healing activity: a review. *Int J Pharm Sci Res.* 2016;7(5):1809-1819.
 12. Selvam SI, Joicesky SM, Dashli AA, Vinothini A, Premkumar K. Assessment of antibacterial, anti-inflammatory and wound healing activity in Wistar albino rats using green silver nanoparticles synthesized from *Tagetes erecta* leaves. *J Appl Nat Sci.* 2021;13(1):343-350.
 13. Shafeie N, Naini AT, Jahromi HK. Comparison of different concentrations of *Calendula officinalis* gel on cutaneous wound healing. *Biomed Pharmacol J.* 2015;8(2):979-992.
 14. Sharma Y. Comparative evaluation of amorphous hydrogel with colloidal silver and purified recombinant human epidermal growth factor for wound healing activity in rabbits [M.V.Sc. & A.H. thesis]. Jabalpur: Nanaji Deshmukh Veterinary Science University; 2025.
 15. Singh CP, Mishra PK, Gupta SP. Design and formulation of *Tridax procumbens* based polyherbal cream for wound healing potential. *Pharm Lett.* 2016;8:15-21.
 16. Singh MP, Bharghava S, Bhaduarua RS, Sharma CS. Wound healing potential of alcoholic extract of *Mimosa pudica* Linn. leaves. *Pharmacologyonline.* 2010;2:32-38.
 17. Singh P, Sharma AK, Kumar N, Tamil Mahan P, Singh R, Saxena S. Bubaline omasal derived extracellular matrix for reconstruction of full thickness skin wounds in rats. *BAOJ Surg.* 2017;3(2):021.
 18. Slatter DH. Textbook of small animal surgery. 3rd ed. Philadelphia: Saunders; 2003. p. 259-261.
 19. Snedecor GM, Cochran WC. Statistical methods. 6th ed. Kolkata: Oxford & IBH Publishing Co.; 1968.
 20. Williams J, Moores A. BSAVA manual of canine and feline wound management and reconstruction. 2nd ed. Gloucester: British Small Animal Veterinary Association; 2017. p. 15.
 21. Zomer HD, Trentin AG. Skin wound healing in humans and mice: Challenges in translational research. *J Dermatol Sci.* 2018;90(1):3-12.