



Effect of *Typha angustifolia* L. extract Nano formulations on Wound-Healing Potential using Albino Wistar Rats

Ms. Jogeshwari N. Gunjal, Dr. Minal S. Patil*

¹Department of Pharmacognosy, DCS's A. R. A. College of Pharmacy, Mumbai -Agra Highway, Nagaon, Dhule - 424001, Maharashtra, India

Article Information

Received: 27-08-2026

Revised: 04-09-2026

Accepted: 12-09-2026

Published: 29-09-2026

Keywords

T. angustifolia. Linn, wound healing, Nano formulations etc

ABSTRACT:

The present study was aimed an excision and incision wound model was employed to evaluate the wound healing activity of the developed formulation in Wistar albino rats. The animals were randomly divided into different experimental groups, including normal control, disease control, standard treatment, and test treatment groups. The respective formulations were applied topically once daily throughout the experimental period. Wound healing was assessed by measuring wound contraction at predetermined intervals, and representative photographs were recorded on Days 1, 7, 14, and 21 to monitor the progression of healing. The comparative excision wound healing response among the different treatment groups, with progressive wound contraction, scab reduction, and re-epithelialization observed during the study period. The comparative incision wound healing response among the different treatment groups, demonstrating progressive wound closure, improved tissue regeneration, and restoration of skin integrity during the study period.

1. INTRODUCTION:

Medicinal plant materials and herbal remedies derived from them represent a substantial portion of the global medicinal market. Herbal remedies and drugs have played a significant role in curing diseases throughout the history of mankind. Though a large amount of literature is available on their curative properties, standard procedures for quality control of plant materials with respect to their identification (phytochemical, pharmacological, and therapeutic activity) are not available. Standardization of medicinal plants ensures their consistency and therapeutic effectiveness. Herbal products are evaluated for their identity (characterization), quality, and quality of the extracts present, as it is required to evaluate their therapeutic efficacy, i.e., to know their pharmacological action to evidence authenticity (Akshay Sharma et al., 2021).

Wound defined as the cellular and anatomic disruption of a tissue may be caused by chemical, physical, microbial, thermal, or immunological damage to the tissue. Wound healing is restoration of structure and function of an injured tissue in order to approximate prewound characteristics. The effective management of wounds will reduce

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. (<https://creativecommons.org/licenses/by-nc/4.0/>)

the number of complications and allow rapid return to normal function. About 70% to 90% of populations in some industrialized nations and between 70% and 95% of citizens in the majority of developing countries use traditional medicine as primary healthcare to address their healthcare needs and concerns. Several medicinal plants were scientifically proven to be used for the treatment of wounds, and some other medicinal plants are mentioned in the Ethiopian folk medicine for wound management (Wubante Demilew et al., 2018).

Wounds can be classified according to various criteria. Time is an important factor in injury management and wound repair. Thus, wounds can be clinically categorized as acute and chronic according to their time frame of healing (Aleksandra Shedoeva et al., 2019).

Wound healing takes place in all tissues and organs of the body. Many of these repair processes are common to all tissues. Although the process of healing is continuous, it is arbitrarily divided into different phases to aid understanding of the physiological processes that are taking place in the wound and surrounding tissue. Healing is a complex process involving coordinated interactions between diverse immunological and biological systems. It involves a cascade of carefully and precisely regulated steps and events that correlate with the appearance of various cell types in the wound bed during distinct phases of the healing process.

2. MATERIALS AND METHODS

2.1 Preparation of plant extract- The air-dried leaf powders (50g) were successively extracted by Soxhlet extraction by using heating mantle with solvents methanol.

2.2 Preparation of Silver Nanoparticles from extract: For the synthesis of silver nanoparticles (AgNPs), 4 ml of methanolic extracts of *T. angustifolia* were added to 100 ml of 0.01 mM silver nitrate (AgNO₃). After 45 minutes, the formed precipitate was washed three times with distilled water by centrifugation at 13000 rpm for 20 minutes and the sediment was kept at 60°C for 2 hrs. (Parmar S.et.al.,2022)

2.3 Preparation of Nanofibers from extract-

The plant extract and PVA were mixed at ambient conditions using a laboratory magnetic stirrer for 5-6 h to obtain a homogeneous solution. The prepared solution was left overnight at room temperature for degassing. In the electrospinning process, the prepared plant extract and PVA mixture was loaded into a syringe. The electrospun nanofibers were collected on a target drum.

2.4 Procedure:

Preparation of wound healing gel of dry extract, Nanoparticles and Nanofibers

Procedure- Disperse 0.10 g Carbopol 940 in approximately 6–7 mL purified water and allow it to hydrate. Mix 1.0 g dry extract with 1.0 g propylene glycol to make a uniform solution or dispersion. Add 0.50 g glycerin in Carbopol mixture. Add the preservatives in an appropriately compatible phase. Add triethanolamine dropwise until a suitable gel consistency and skin-compatible pH are achieved. Add purified water to make the final weight exactly 10 g. Mix until a smooth, homogeneous gel is obtained.

A. Excision Wound Model

An excision wound model was employed to evaluate the wound healing activity of the developed formulation in Wistar albino rats. Following anesthesia, a full-thickness circular excision wound of 1 cm radius was created aseptically using sterile surgical instruments. The animals were randomly divided into different experimental groups, including normal control, disease control, standard treatment, and test treatment groups. The respective formulations were applied topically once daily throughout the experimental period. Wound healing was assessed by measuring wound contraction at predetermined intervals, and representative photographs were recorded on Days 1, 7, 14, and 21 to monitor the progression of healing.

B. Incision Wound Model

An incision wound model was employed to evaluate the wound healing activity of the developed formulation in Wistar albino rats. Following anesthesia, 2.5 cm long full-thickness paravertebral incision was made aseptically through the skin using a sterile surgical blade. The wound edges were carefully approximated and sutured at approximately 0.5 cm intervals using sterile non-absorbable surgical silk (3-0). The animals were randomly divided into different experimental groups, including normal control, disease control, standard treatment, and test treatment groups. The respective formulations were applied topically once daily throughout the experimental period. The sutures were removed on the 7th post-operative day, and wound healing was evaluated by assessing the rate of wound closure, epithelialization, and tensile strength of the healed skin. Representative photographs were recorded on Days 1, 7, 14, and 21 to monitor the progression of healing.

Experimental Design for Excision and Incision wound model- For the normal control there is not any treatment

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. (<https://creativecommons.org/licenses/by-nc/4.0/>)

is provided. For the disease control group 0.5 g/wound/day plain gel is used. For the standard group 0.5 g/wound/day Povidone-Iodine Ointment is used. For the Dry Extract group 500 mg/kg/day dry extract gel topically used. For the nanoparticles group 500 mg/kg/day nanoparticle gel topically used. For the nanofibers group 500 mg/kg/day nanofiber gel topically used.

Evaluation Parameter-Percentage Wound Healing (% Wound Contraction) The percentage wound healing was determined by measuring the wound area at predetermined intervals (Days 1, 7, 14, and 21). The reduction in wound area was expressed as percentage wound healing using the following formula:

$$\text{Percentage Wound Healing (\%)} = \frac{\text{Initial Wound Area} - \text{Specific Day Wound Area}}{\text{Initial Wound Area}} \times 100$$

Statistical Analysis- Differences among the experimental groups were analyzed using one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison post hoc test. A value of $p < 0.05$ was considered statistically significant.

C. Histopathology: Histology is the study of tissues and their structure. The structure of each tissue is directly related to its function, so histology is related to anatomy and physiology. Similarly, histopathology is the study of tissues affected by disease.

Procedure- The animal tissue sample was isolated and put in a 10% neutral buffer formalin solution. Specimens were cut into sections of 3-5- μm thickness and embedded in paraffin. Serial sections (3 μm) were cut using a microtome and stained with hematoxylin-eosin (H&E) stain. The prepared slides were examined under a microscope (Nikon ECLISE E100 Microscopes)

3 RESULT AND DISCUSSION:

A. Excision Wound Healing-

Group	Day 1	Day 7	Day 14	Day 21
Normal Control				
Disease Control				

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. <https://creativecommons.org/licenses/by-nc/4.0/>

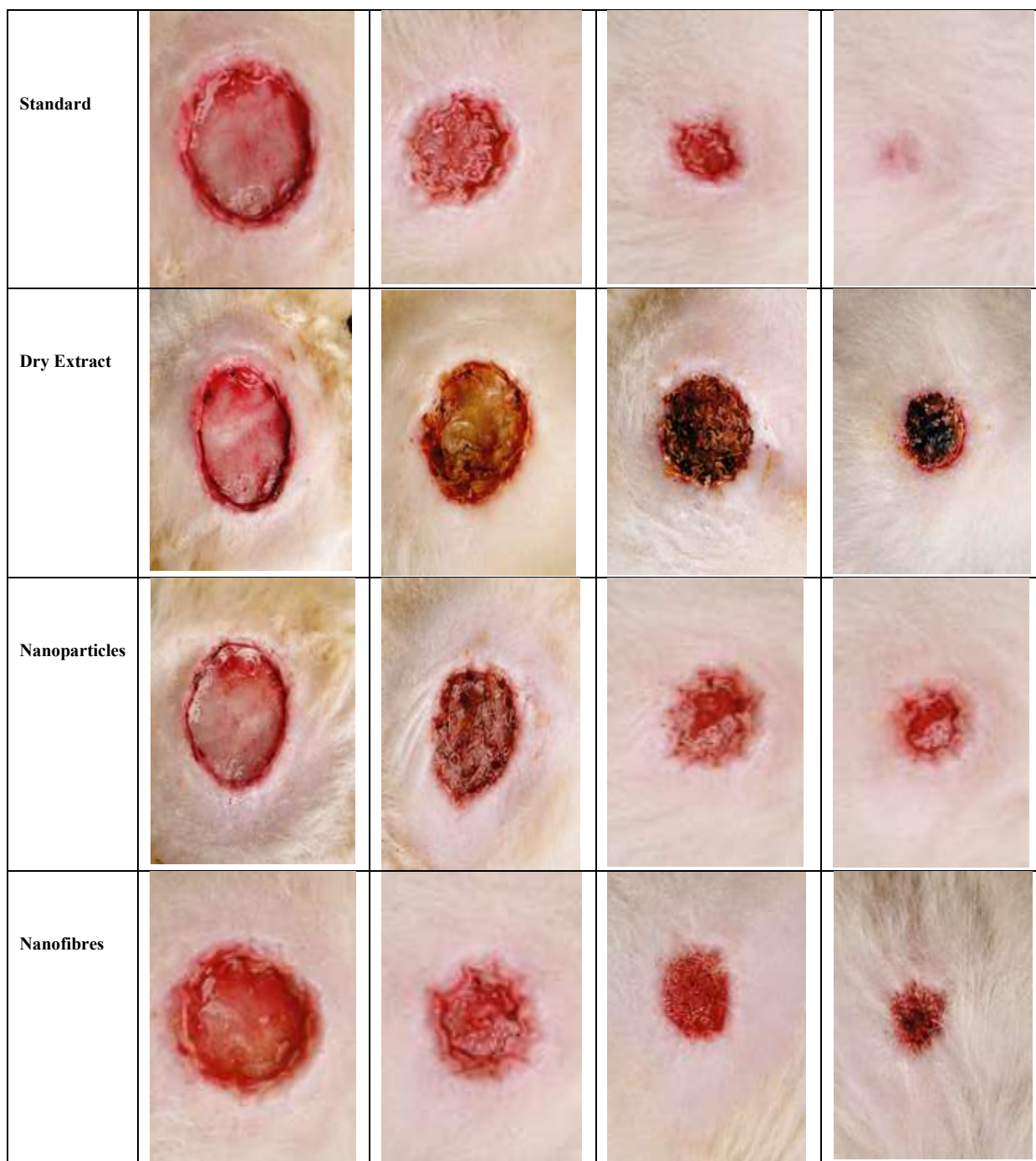


Fig. 1 Excision Wound Healing

Table 1: Percentage Wound Healing in Excision Wound Model

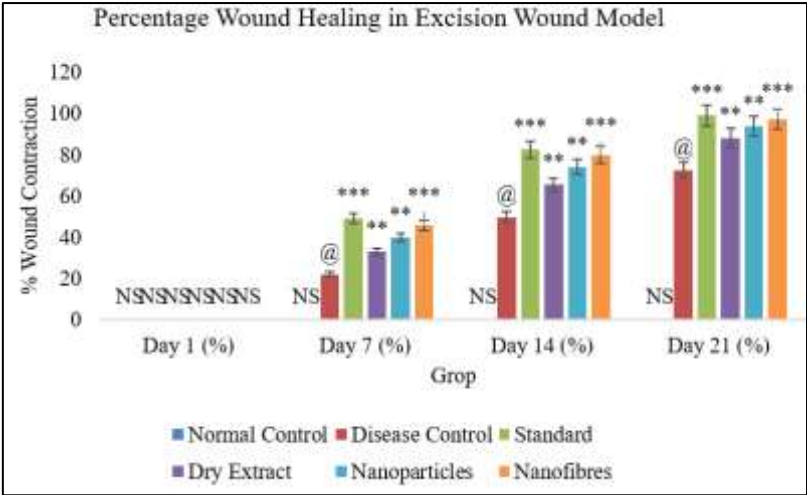
Group	Day 1 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)
Normal Control	0.00 ± 0.00	NA	NA	NA
Disease Control	0.00 ± 0.00	21.84 ± 2.16 @	49.67 ± 2.41 @	72.58 ± 2.28 @
Standard	0.00 ± 0.00	48.92 ± 2.05***	82.46 ± 1.84***	98.94 ± 0.68***
Dry Extract	0.00 ± 0.00	32.71 ± 1.96*	65.38 ± 2.12**	88.17 ± 1.34**
Nanoparticles	0.00 ± 0.00	39.86 ± 2.08**	73.95 ± 1.87**	93.84 ± 0.92**
Nanofibres	0.00 ± 0.00	45.63 ± 1.74***	79.84 ± 1.56***	97.26 ± 0.54***

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

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. <https://creativecommons.org/licenses/by-nc/4.0/>



Graph 1: Percentage Wound Healing in Excision Wound Model

B. Incision Wound Healing:

Group	Day 1	Day 7	Day 14	Day 21
Normal Control				
Disease Control				
Standard				

©2026 The authors
This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers.<https://creativecommons.org/licenses/by-nc/4.0/>

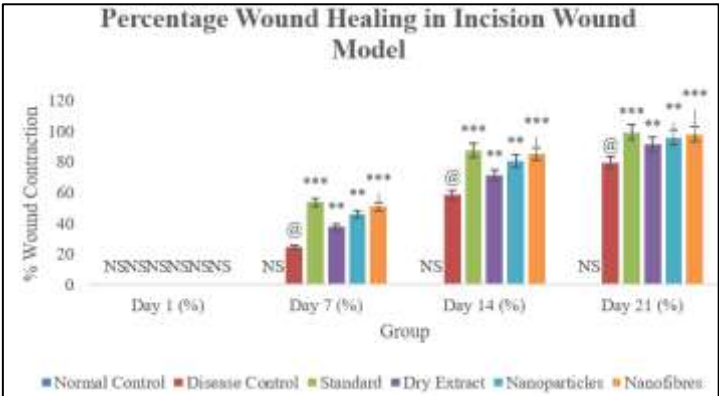


Fig. 2 Incision Wound Healing

Table 2: Percentage Wound Healing in Incision Wound Model

Group	Day 1 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)
Normal Control	0.00 ± 0.00	NA	NA	NA
Disease Control	0.00 ± 0.00	24.35 ± 2.08	58.42 ± 2.31	79.16 ± 2.05
Standard	0.00 ± 0.00	53.74 ± 1.82***	87.36 ± 1.45***	99.12 ± 0.42***
Dry Extract	0.00 ± 0.00	37.48 ± 2.14*	71.28 ± 1.96**	91.24 ± 1.08**
Nanoparticles	0.00 ± 0.00	45.96 ± 1.78**	80.35 ± 1.62**	95.68 ± 0.76**
Nanofibres	0.00 ± 0.00	50.82 ± 1.54***	85.14 ± 1.38***	98.06 ± 0.51***

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



Graph 2: Percentage Wound Healing in Incision Wound Model

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers.<https://creativecommons.org/licenses/by-nc/4.0/>

C. Histopathology-

- **Normal Control:** Showing the normal histological structure of skin, thin epidermal layers with dermal layer and the absence of the normal hair follicle and evidence of inflammatory infiltration, edema, or degenerative changes. No abnormality detected.

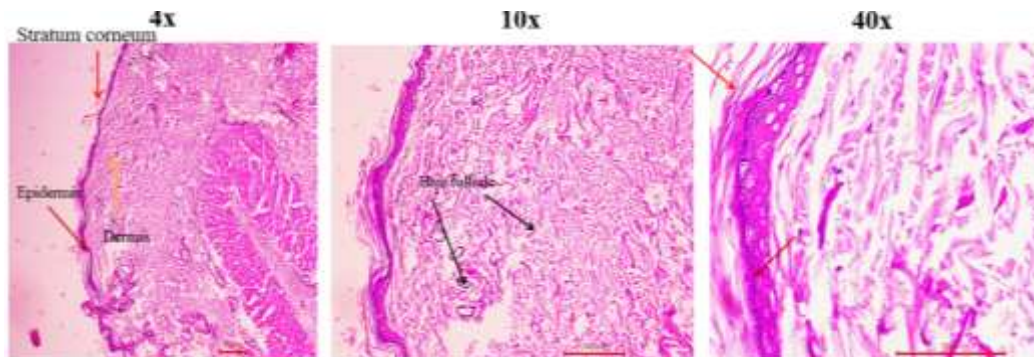


Fig. No. 3: Normal Control Histological Structure of Skin

- **Disease Control:** Showing the disease control histological structure of skin, breakdown of epidermal layers with dermal and the presence of the normal hair follicle and, no evidence of inflammatory infiltration, edema, or degenerative changes. Mild abnormality detected.

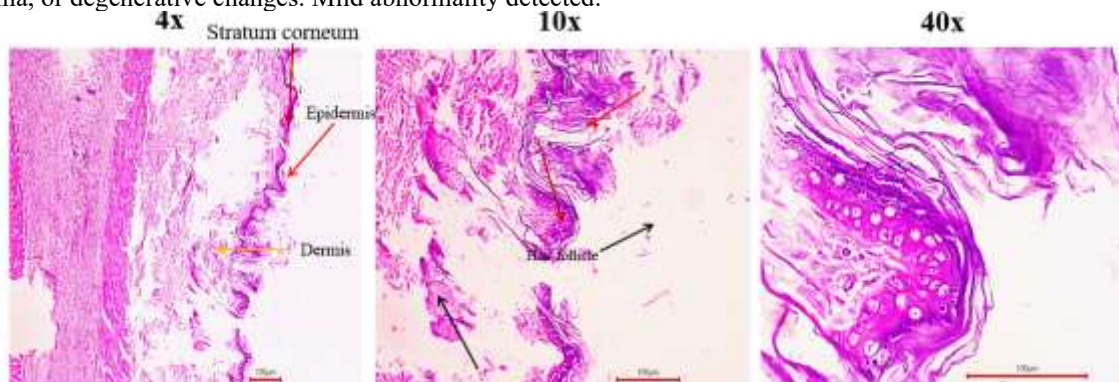


Fig. No. 4: Disease Control Histological Structure of Skin

- **Standard:** Showing the normal histological structure of skin, Stratum corneum epidermal layers with dermal and the presence of the hair follicle and, no evidence of inflammatory infiltration, edema, or degenerative changes. No abnormality detected.

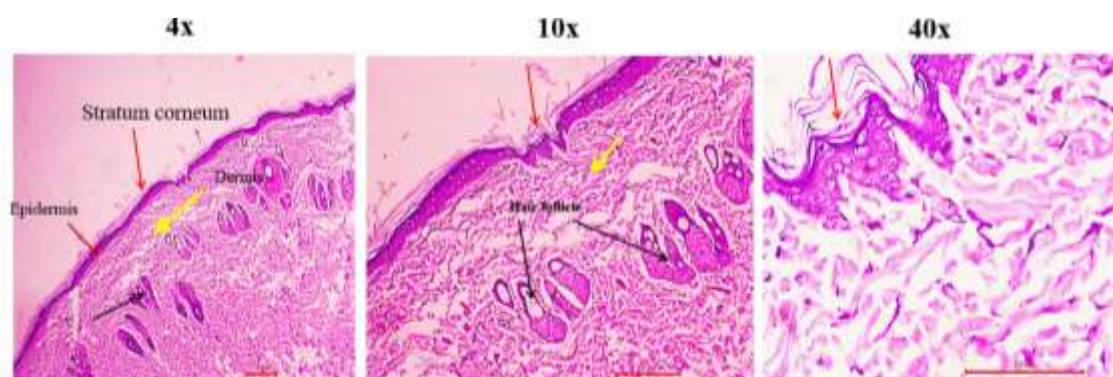


Fig. No. 5: Standard Control Histological Structure of Skin

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. <https://creativecommons.org/licenses/by-nc/4.0/>

- **Dry extract:** Showing the normal histological structure of skin, Stratum corneum epidermal layers with dermal and the presence of the hair follicle and, evidence of inflammatory infiltration of cell, edema, or degenerative changes. No abnormality detected.

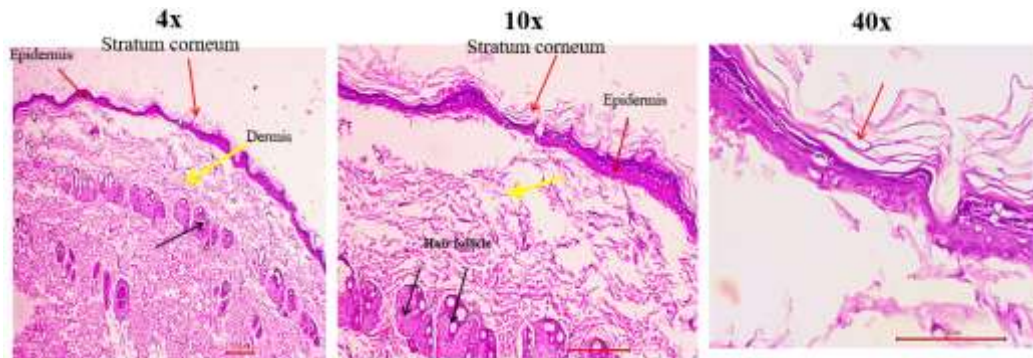


Fig. No. 6: Dry extract Control Histological Structure of Skin

- **Nanoparticle:** Showing the normal histological structure of skin, Stratum corneum epidermal layers with dermal and the presence of the hair follicle and, no evidence of inflammatory infiltration, edema, or degenerative changes. No abnormality detected.

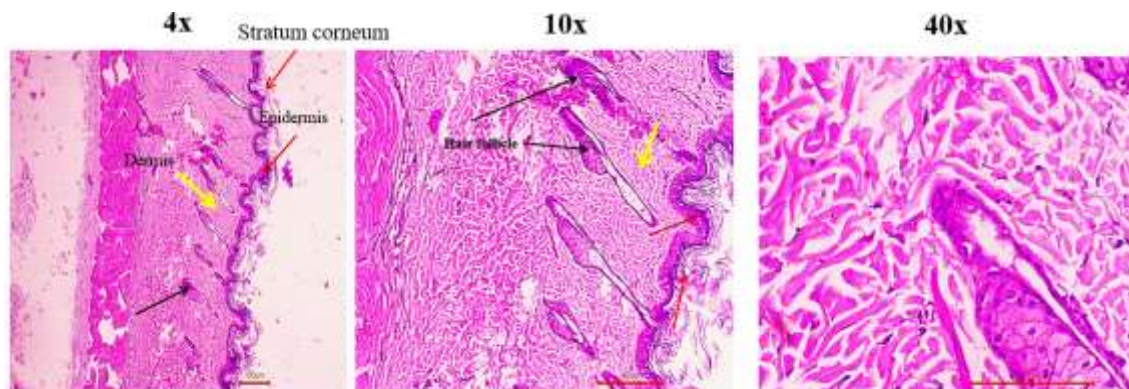


Fig.

No. 7: Nanoparticles Control Histological Structure of Skin

- **Nanofibres:** Showing the normal histological structure of skin, Stratum corneum epidermal layers with dermal and the presence of the hair follicle and, no evidence of inflammatory infiltration, edema, or degenerative changes. No abnormality detected. This group shows better activity.

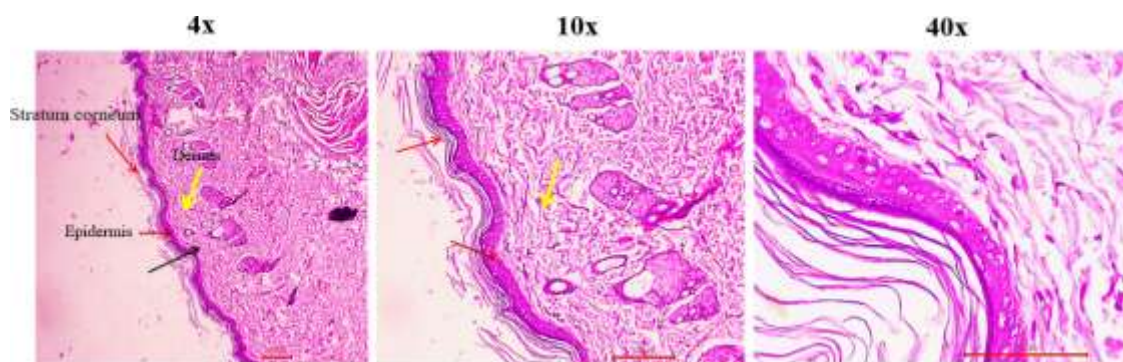


Fig. No. 8: Nanofibers Control Histological Structure of Skin

Observation: The percentage wound healing increased progressively in all treatment groups throughout the experimental period. The disease control group exhibited the slowest wound healing on Days 7, 14, and 21,

©2026 The authors

This is an Open Access article

distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. <https://creativecommons.org/licenses/by-nc/4.0/>

respectively. In contrast, the standard treatment group demonstrated the highest percentage wound healing on the respective observation days. Among the test formulations, the nanofibre group showed the greatest improvement which was comparable to the standard treatment. The nanoparticle formulation also exhibited significant wound healing while the dry extract showed moderate wound healing over the same period.

4 CONCLUSION:

The present study demonstrated that all treatment groups promoted excision and incision wound healing when compared with the disease control group. Among the tested formulations, the standard treatment exhibited the highest percentage wound healing throughout the study wound closure by Day 21. Among the test formulations, the nanofibre dressing showed the greatest therapeutic efficacy which was comparable to the standard treatment. The nanoparticle formulation also produced significant wound healing while the dry extract exhibited moderate wound healing. The findings indicate that incorporation of the active constituents into a nanofibre-based delivery system significantly enhanced the wound healing process by accelerating wound closure and tissue regeneration. Overall, the wound healing efficacy followed the order: Standard > Nanofibres > Nanoparticles > Dry Extract > Disease Control, suggesting that the developed nanofibre formulation is a promising topical wound dressing for improving excision and incision wound healing.

5 REFERENCES:

1. T. Velnar, T. Bailey and V. Smrkol (2009) The Wound Healing Process: an Overview of the Cellular and Molecular Mechanisms, The Journal of International Medical Research, 37, 1528– 1542.
2. Akshay Sharma, Suryamani Khanna, (2021) Medicinal plants and their components for wound healing applications, Future Journal of Pharmaceutical Sciences, 1-13.
3. Wubante Demilew , Getnet Mequanint Adinew and Seyfe Asrade (2018) Evaluation of the Wound Healing Activity of the Crude Extract of Leaves of *Acanthus polystachyus* Delile (Acanthaceae), Hindawi Evidence-Based Complementary and Alternative Medicine, 1-9.
4. Mohammad Reza Farahpour (2019) Medicinal Plants in Wound Healing, Intech Open, 34-47.
5. Mohd Abdul Majeed Khan, Sushil Kumar, Maqsood Ahmed (2011) Structural and thermal studies of silver nanoparticles and electrical transport study of their thin films, . Nanoscale Research Letters, 6, 1-8.
6. Rashid Forouzande , Ali Akbar Gharehaghaji, Dina Mohammadi (2025) Advances in electrospinning techniques for synthesis of nanofibers loaded with herbal extracts and natural ingredients: A comprehensive review, Synthesis and Sintering 5, 1–40.
7. Shareef, Ali Aboud; Farhan, Fadhil Jabbar (2024) Green Synthesis of Silver Nanoparticles Using Aqueous Extract of *Typha domingensis* Pers. Pollen (qurraid) and Evaluate its Antibacterial Activity, Baghdad Science Journal, Vol. 21(1),28-40.
8. Waheed H., Kredy H.(2026) Ecofriendly Synthesis and Characterization of Silver Nanoparticles Using *Typha Domingensis* with Different pH Values and Multiple Temperature: An Experimental Study, Journal of Nanostructure,16(1),89-98.
9. A. Mandal, V. Meda(2011) Synthesis, characterization and comparison of antimicrobial activity of PEG/TritonX-100 capped silver nanoparticles on collagen scaffold, Colloids Surf. B: Biointerfaces,1-6.
10. Willems F Wolkers et. al., (1997) Heat Stability of Proteins in Desiccation-Tolerant Cattail (*Typha latifolia* L.) Pollen: a fourier transform infrared spectroscopic study, Comparative Biochemistry and Physiology part A, 117(3), 349-355.
11. Rezig Sana, Jaouadi Mounir (2014) Study of Structure and Properties of Tunisian Typha Leaf Fibers, International Journal of Engineering Research & Technology,3, 539-546.
12. Morton JJ.(1972) Evaluation of vulnerary activity by open wound procedure in rats. Arch. International Pharmacodynamics Journal,196,117-120.
13. Nayak BS, Sandiford S, Maxwell A.(2009) Evaluation of the wound-healing activity of ethanolic extract of *Morinda citrifolia* L. leaf. Evidence-Based Complementary and Alternative Medicine,6(3),351-356.
14. Stitzel KA, Spielmann H, Griffin G.(2002) The international symposium on regulatory testing and animal welfare: recommendations on best scientific practices for acute systemic toxicity testing. ILAR journal,43,108-111.