RESEARCH PAPER

Investigating the Wound-Healing Efficacy of Brassica Juncea Hydroalcoholic Flower Extract: A Preclinical Study in Cyprinus Rubrofuscus

Prodip Roy[1*], Gourav Pal[1], Dwipannita Mukherjee[1], Soumyadip Sahu[1], Mrityunjoy Majumdar[1], Sourav Roy[1], Pinaki Das[2] and Tamal Basu[1]

[1]*Department of Pharmacology, Netaji Subhas Chandra Bose Institute of Pharmacy, Chakdaha, Nadia 741222, West Bengal, India*
[2]*Veterinary Officer, Dog Squad, Swami Vivekananda State Police Academy, Barrackpore, 700120, West Bengal, India*
[*]***Corresponding Author:*** *Prodip Roy, Department of Pharmacology, Netaji Subhas Chandra Bose Institute of Pharmacy, Roypara, Tatla, Chakdaha, Nadia, West Bengal, India, Pin: 741222*
Email id: prodiproy19951228@gmail.com

Received: 14th June, 2026; Revised: 20th July 2026; Accepted: 20th August, 2026; Available Online: 05th September 2026

ABSTRACT

Background: Wound healing represents a multifaceted biological mechanism encompassing inflammatory responses, tissue proliferation, epithelial regeneration, and structural remodelling. Natural plant-derived compounds are receiving considerable scholarly attention as prospective sources of wound-healing therapeutics. Brassica juncea, commonly known as Indian mustard, contains a wide range of bioactive phytochemical compounds and has been recognized for its historical medicinal uses. However, existing scientific research provides insufficient information regarding the wound-healing potential of its floral components. This investigation sought to assess the wound-healing efficacy of hydroalcoholic flower extract derived from Brassica juncea through an excision wound model and burn wound model utilizing Cyprinus rubrofuscus (Amur carp). Methods: After anaesthesia, standardized excision and burn wounds were created in Cyprinus rubrofuscus between the pectoral and dorsal fins. The animals were divided into four groups: Group I (Control) received no treatment, Group II (Standard) received povidone-iodine, Group III (Test I) received Brassica juncea flower hydroalcoholic extract (25 mg/L), and Group IV (Test II) received the extract (10 mg/L). The flowers were shade-dried, powdered, and macerated in 70% hydroalcoholic solution for 72 h, yielding 8.05% extract, followed by phytochemical screening. Healing was assessed through 50% wound contraction and complete epithelialization, along with dermal irritation assessment for topical safety and tolerability. Results: Phytochemical analysis revealed the presence of carbohydrates, alkaloids, flavonoids, saponins, tannins, phenolic compounds, glycosides, steroids, terpenoids, and proteins. In the excision wound model, complete wound contraction was observed within 16.266±0.542 days at 25 mg/L and 18.555±0.614 days at 10 mg/L, whereas in the burn wound model, complete wound contraction occurred within 19.166±0.654days at 25 mg/L and 18±0.577 days at 10 mg/L. Both treatments showed statistically significant improvement compared to the control group ($p < 0.01$). Dermal assessment revealed no significant or sustained irritation responses. Conclusion: This study indicates that the hydroalcoholic extract from the flowers of Brassica juncea has strong wound-healing potential.

Keywords: Brassica juncea, Hydroalcoholic extract, Phytochemical screening, Cyprinus rubrufusc, Skin irritation study, Excision wound model, Burn wound model, Histopathological assay

How to cite this article: Roy P, Pal G, Mukherjee D, Sahu S, Majumdar M, Roy S, Das P, Basu T, Investigating the Wound-Healing Efficacy of Brassica Juncea Hydroalcoholic Flower Extract: A Preclinical Study in Cyprinus Rubrofuscus. Int J Drug Deliv Technol. 2026;16(8): 180-189; DOI: 10.25258/ijddt.16.8.17
Source of support: Nil.
Conflict of interest: None

1. INTRODUCTION

One of the main causes of physical limitations is wounds. They are caused by microbiological, chemical, or physical factors. Healing is an attempt to preserve normal anatomical structure and function as a survival strategy[1]. The process of mending the skin and other soft tissues following an injury is known as wound healing[2]. Wound healing management is a challenging and costly process. The act of repairing compromised tissue and addressing wounds constitutes a vital function for organism survival[1]. This complex, methodically structured process unfolds across four key phases. They are hemostasis, inflammation or defensive, proliferation, and maturation[3].

Plants produce a wide range of bioactive compounds, making them abundant supplies of several medication types. Natural products offer unparalleled chemical diversity, whether they are pure chemicals or reliable plant extracts. Many plants with volatile oils, polyphenols, and alkaloids as active ingredients are used as popular traditional remedies, while others have become well-known as completed goods known as phytomedicines[4]. Eighty percent of people worldwide rely on traditional

**Author for Correspondence: prodiproy19951228@gmail.com*

medicine, according to the WHO[5]. Compared to synthetic medications, herbal remedies are thought to be more accessible, reasonably priced, safe, and natural, with fewer adverse effects[6].

Brassica juncea (B. juncea), a member of the Brassicaceae (Mustard family) family, is one of the herbs that is frequently used in herbal therapy. It is sometimes referred to as Indian mustard and is utilized as a source of mustard oil in regional dishes and traditional medicine[7]. It is utilized as spices, edible oil, and oilseed in India. Nearly every portion of this plant is edible and has a specific use, either household or medical. Flowers, stems, seeds, stems, shoots, and roots are among the edible components. Because of its flavor, this plant is used to provide mustard flavor to a variety of foods. It is mostly found in North America, beyond its presence in multiple Canadian provinces and different regions of South America, Asia, and Western and Eastern Siberia[8], *B. juncea* exhibits a complex chemical profile encircling alkanes, alkenes, ketones, alcohols, aldehydes, polyphenols, glucosinolates, sterols, and numerous additional volatile compounds. It has been observed that *B. juncea* contains anti-cancerous substances such as glucosinolates and isothiocyanates. *B. juncea* was used to isolate plant steroids such as castasterone, teasterone, 24-epibrassinolide, and typhasterol[9]. Numerous pharmacological activities, including antioxidant, antibacterial, antifungal, anticancer, anti-inflammatory, antiviral, antidiabetic, anticonvulsant, anti-obesity, antinoceptive, antihyperglycemic, and antidepressant, were demonstrated by the plant[10,11]. Therefore, it is anticipated that the findings of this study will enable the development of novel medications that can be used in conjunction with conventional medication compositions to treat wound healing.

2. MATERIALS AND METHODS

2.1 Plant Materials

Fresh flowers of *Brassica juncea* were collected during January–February from the local market area near Netaji Subhas Chandra Bose Institute of Pharmacy, Chakdaha, Nadia, West Bengal, India. The samples were carefully selected to ensure freshness and authenticity before being used for further experimental analysis.

2.2 Preparation of Extract[12,13]

Fresh flowers of *Brassica juncea* were collected under shade and thoroughly cleansed with distilled water. The cleaned flowers were air-dried for 4–5 days and subsequently hand-crushed into coarse powder. Extraction was carried out using 70% hydroalcoholic solution by maceration procedure for 72 hours. The resulting extract was filtered, packed in aluminium foil, and stored at 4 °C until further use.

2.3 Phytochemical Screening[14]

The crude hydroalcoholic extract of *Brassica juncea* flowers was subjected to qualitative phytochemical analysis to identify the presence of bioactive constituents. Standard procedures were employed to conduct preliminary phytochemical tests, including assays for alkaloids, flavonoids, tannins, saponins, glycosides, phenolic compounds, and steroids. The presence or absence of each class of compounds was recorded based on characteristic colour changes or precipitate formation.

2.4 Drug Solution Preparation[15-17]

2.4.1 Standard drug preparation

Povidone-iodine (Betadine) is a regularly used antibacterial agent that combines iodine, a bactericidal component, with polyvinylpyrrolidone (povidone), a synthetic polymer. The most common commercial form is a 10% solution in water, which produces 1% accessible iodine. That means the final concentration is 0.1%.

2.4.2 Test drug preparation

- 25 mg/L Test Drug: To formulate the test drug, 25 mg of *Brassica juncea* flower extract was dissolved in 1000 ml of water.
- 10 mg/L Test Drug: To formulate the test drug, 10 mg of *Brassica juncea* flower extract was dissolved in 1000 ml of water.

2.5 Animals

Amur Carp (*Cyprinus rubrofuscus*) are among the most important freshwater ornamental fish species[18]. It is appreciated for its brilliant colours, rapid growing rate, and strong market demand. Amur Carp are correctly cultivated as a high-value aquaculture commodity; thus, cultivation procedures must be closely monitored to ensure effective farming practices[19]. Amur Carp are thriving in cold waters. They also react adversely to prolonged, cold winter weather[20]. For this study, Amur Carp were procured from the regional market area which having the average weight of 80-100 gm and they were kept in clean, well-oxygenated water tank with stable pH, suitable temperature and good filtration.

Rabbits weighing 1.5 kg are widely accessible on the native market and are a useful model for performing skin irritation studies. They are housed in spacious, secure, and well-ventilated, with clean bedding and adequate lighting. Each rabbit received a slice of beet or carrot as an alternative of wet food to prevent dehydration during storage.

2.6 Methodology

2.6.1 Excision wound model [21-23]

The excision wound model is a popular experimental strategy for studying wound healing and in the scenario of *Cyprinus rubrofuscus* also known as Amur Carp, it offers a unique aquatic perspective on tissue repair mechanisms. The individuals were divided into 4 groups, such as Control, Standard & Test (25 mg/L) & Test (10 mg/L); each including 6 fish. Fish scales of one side were removed between pectoral fin and dorsal fin and mark the area. Before wound creation and during the clinical intervention, the fishes were anesthetized using clove oil solution, with the concentration standardized at 0.08 ml/L. Then a complete excision wound was carefully generated at the predefined outlines measuring 50 mm2 with the help of a

surgical blade & a forcep. Immediately after wound induction, treatment commenced. The designated drug formulations were applied topically twice daily by gently swabbing the wound surface with a sterile cotton applicator soaked in the respective solution for ≤60 sec.

The experimental subjects were randomly assigned into four treatment sets based on the group following assessment.

Control group: No therapy was administered to the fishes.

Standard treatment group: The fishes were given a topical application of Povidone-iodine solution twice daily.

Test group (low dose): *Brassica juncea* solution (10 mg/L) was applied topically to the fishes twice daily until complete epithelialization occurred.

Test group (high dose): Fishes were treated with *Brassica juncea* solution at a dosage of 25 mg/L administered topically twice daily until complete epithelialization occurred.

On days 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, and 22 ensuing wound induction, wound contraction was detected at regular intervals systematically. At each designated time point, wound margins were carefully outlined on translucent cellophane sheets utilizing a permanent marker. After transferring the tracings to graph paper, the wound area was measured and documented using a millimetre scale.

The epithelialization time was calculated based on the number of days it took for the eschar to completely detach, leaving the wound surface entirely covered with no exposed or raw tissue.

2.6.2 Burn wound model [24-27]

Fish weighing almost 100 grams, identified as Amur Carp (*Cyprinus rubrofuscus*), were separate into four groups.

During anesthesia, descaled animals were given partial thickness burn wounds by pouring hot, molten wax at 80^0C into a cylinder with an 80 mm^2 circular opening that was put between the animal's dorsal and pectoral fins until the wax solidified. A well-defined, about 80 mm^2 circular burn wound with a severe partial-thickness injury was seen after the wax-adhered cylinder was removed. The experimental animals were randomly divided into four treatment sets as per the group after assessment:

Control group: The fish in this group received no treatment.

Standard group: The fishes in this group received povidone-iodine solution (0.1% PI) administered twice daily.

Test group (low dose): The fishes in this group received treatment with *Brassica juncea* 10mg/L solution administered twice daily until complete epithelialization was achieved.

Test group (high dose): The fishes in this group received treatment with *Brassica juncea* 25mg/L solution administered twice daily until complete epithelialization was achieved.

Wound contraction was measured using the burn wound model. The duration required for complete epithelialization was recorded and documented.

2.7 Skin Irritation Study

Healthy New Zealand white rabbits, aged 10–12 months, were selected for the study. A small dorsal region measuring 6 cm^2 was shaved to prepare the application site for the test topical formulation. Solutions of H. indicus at concentrations of 10 mg/Litre and 25 mg/Litre were administered to the shaved area. The rabbits were monitored continuously over a 3-day period to assess for any manifestations of erythema, edema, or inflammatory responses.[28]

2.8 Statistical Analysis

Data are expressed as mean ± standard error of the mean (S.E.M.). Statistical evaluation was performed using analysis of variance (ANOVA) with subsequent Dunnett's post-hoc test, with statistical significance defined as $P < 0.01$ relative to the control group.[29]

3. RESULT AND DISCUSSION

3.1 Extract Preparation

After maceration with a 70% hydroalcoholic solution for 72 hours, *Brassica juncea* flowers produced a yield of 8.05%.

3.2 Phytochemical Investigation

Various phytochemical studies revealed that the hydroalcoholic extract of Brassica juncea

Flowers contained the following phytochemicals:

Table 1: Phytochemical investigation results of hydroalcoholic extract of flower of *Brassica juncea*

SL No.	Name of the Phytochemical	Name of the Test	Detection	Outcome
1.	Alkaloid	Dragendroff reagent	Reddish-brown precipitate	Present
2.	Carbohydrate	Molish's test	Violet or Purple Ring	Present
3.	Flavonoid	Ferric chloride test	Blackish red colour	Present
4.	Saponin	Foam test	Stable foam	Present
5.	Tannin	Lead acetate test	Yellowish or White	Present

			precipitate	
6.	Glycoside	Kellar Killiani test	Bluish-green at the confluence	Present
7.	Phenol	Ferric Chloride test	Blue or Green colour	Present
8.	Terpenoid	Salkowski test	Reddish-brown colouration	Present
9.	Steroid	Liebermann–Burchard test	Red chloroform layer	Present
10.	Protein	Million's test	Red precipitate	Present

3.3 Impact of *Brassica juncea* Flower Extract on Wound Healing:

3.3.1 Excision Wound Healing

This investigation employed an excision wound model to evaluate the wound healing potential of a hydroalcoholic extract obtained from *Brassica juncea* flower at concentrations of 10 mg/L and 25 mg/L. The primary metrics examined were the timeframe for achieving 50% wound contraction and the timeframe for complete epithelialization. Results were subsequently compared with both a control group and a group receiving standard pharmacological treatment.

Animals administered the hydroalcoholic extract of *Brassica juncea* demonstrated dose-dependent improvements in wound healing performance. The 25 mg/L concentration achieved the shortest epithelialization period (16.266±0.542 days), succeeded by the 10 mg/L concentration (18.555±0.614 days), whereas the control group required the extended duration for complete epithelial coverage (19.54±0.438 days). The reference medication produced the most accelerated epithelialization (15.85±0.634 days); however, the elevated extract concentration (25 mg/L) demonstrated comparable efficacy to the standard treatment.

Table 2: Impact of Brassica juncea Floral Extract on Epithelialization Duration and 50% Wound Contraction Rates Using Excision Wound Methodology

Treatment	Period of epithelialization (days)	50% Wound contraction (days)
Control	19.54±0.438	10.777±0.432
Standard	15.85±0.634***	7.555±0.421***
B. juncea extract (25 mg/L)	16.266±0.542***	8.333±0.645***
B. juncea extract (10 mg/L)	18.555±0.614***	9.333±0.333***

All values are mean ± SEM, n=6, ***p<0.01 vs control

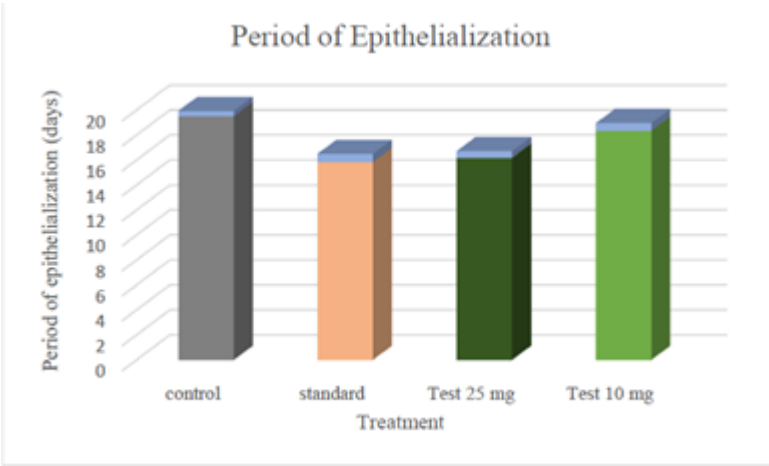


Figure 1: Graphical representation of comparative investigation into epithelialization periods

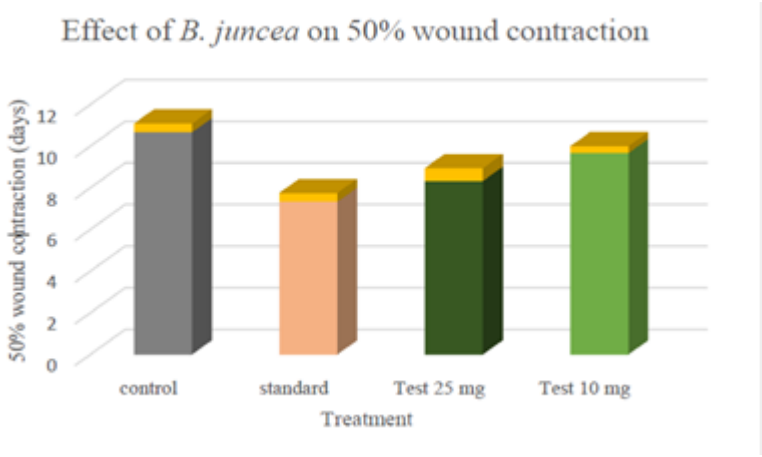


Figure 2: Graphical representation of comparative investigation of Brassica juncea's influence on achieving 50% wound contraction

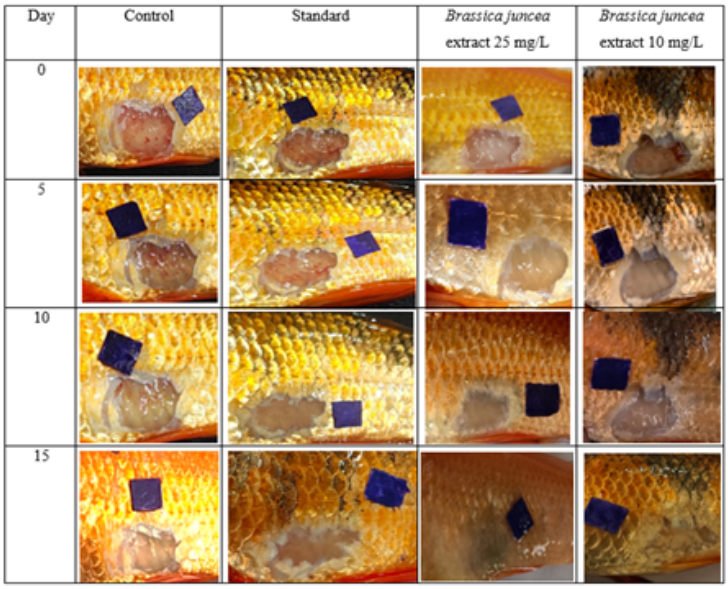


Figure 3: Images of Healing Excision wound Model

3.3.2 Burn wound healing

In the burn wound model, topical administration of *Brassica juncea* at concentrations of 10 mg/L and 25 mg/L, along with the commercially available standard Betadine solution, substantially accelerated the epithelialization process relative to the untreated control group. The standard-treated group achieved complete epithelialization in 15.83±0.654 days. The epithelialization timeframe measured 18.333±0.614 days and 16.166±0.542 days for the 10 mg/L and 25 mg/L treatment groups, respectively, compared to 19.5±0.428 days observed in the control group. Likewise, all treatment groups demonstrated significant improvement in wound contraction kinetics. The 10 mg/L and 25 mg/L groups accomplished 50% contraction in 9.666±0.333 days and 8.333±0.614 days, respectively, whereas the standard-treated group attained this milestone in 15.83±0.654 days, in contrast to 19.5±0.428 days in the control group.

Tabel 3: Effect of *Brassica juncea* on period of epithelization and wound contraction in burn wound model

Treatment Group	Epithelialization Period (Days)	Wound Contraction (50%) (Days)
Control (No treatment)	20.833±0.6	10±0.516
Standard (1%v/v)	17.666±0.714***	8.666±0.421***
Brassica juncea (10 mg/l)	18±0.577***	9±0.447***
Brassica juncea (25 mg/l)	19.166±0.654***	9.333±0.614***

All values are mean ± SEM, n=6, ***p<0.01 vs control

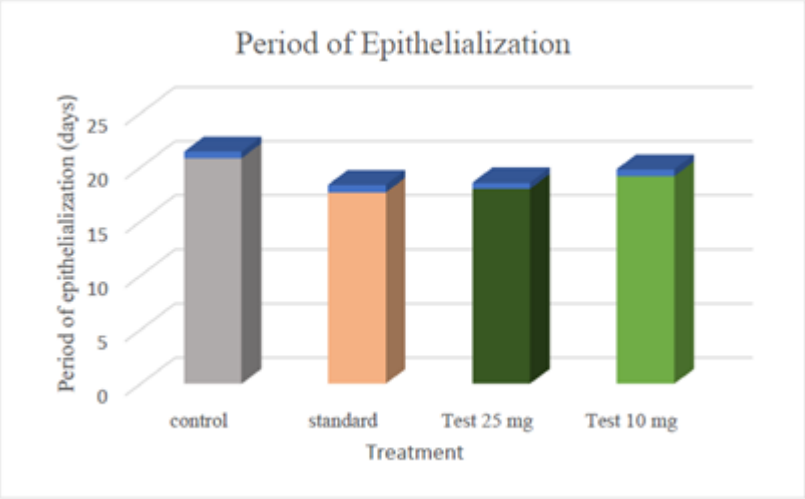


Figure 4: Graphical representation of comparative study of Period of Epithelialization

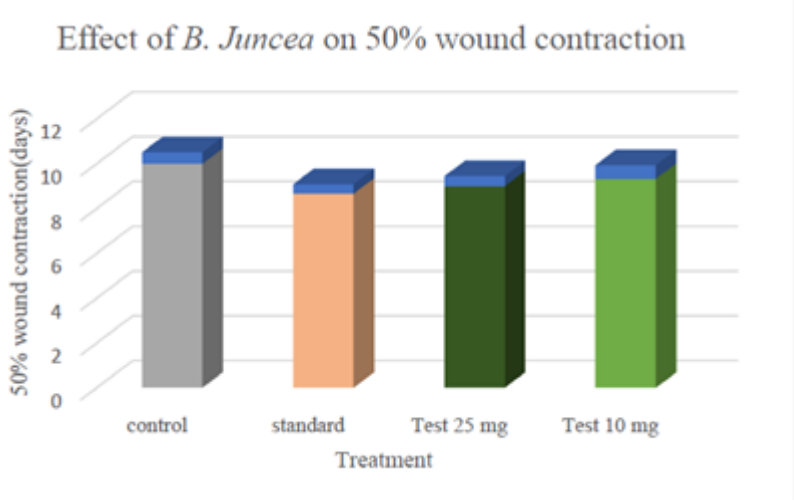


Figure 5: Graphical representation of comparative study of Effect of *B. juncea* on 50% wound contraction

The research findings revealed a pronounced dose-dependent relationship, wherein the elevated concentration (25 mg/L) yielded superior outcomes relative to the reduced concentration (10 mg/L) across both measured parameters—specifically the epithelialization duration and the 50% wound contraction timeframe—when compared against the control group.

3.4 Skin Irritation Test

The acute dermal irritation investigation was performed by examining rabbit skin regions one hour following the administration of the pharmaceutical solution. During the 24-hour assessment, two of the treated skin regions demonstrated normal appearance, whereas the final treated area exhibited normal characteristics at the 72-hour assessment.

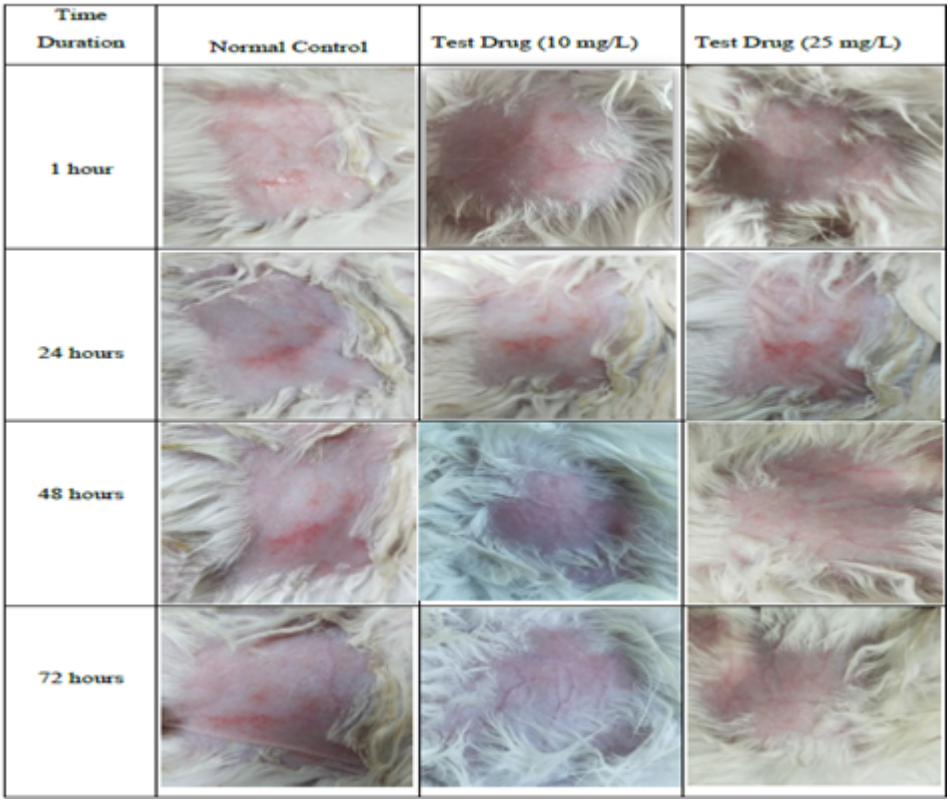


Figure 4: Observation of dermal irritation response after topical application of hydroalcoholic flower extract of *B. juncea*

3.5 Histopathology

Histopathological analysis of the skin tissues from the burn wound and excision models revealed that the treated groups had significantly improved when compared to the untreated control. The control group showed persistent inflammatory cell infiltration, insufficient collagen deposition, and incomplete epithelialization. Poor collagen deposition, persistent inflammatory cell infiltration, and insufficient epithelialization were all present in the control. *Brassica juncea* treatment at 25 mg/L demonstrated almost the same histoarchitectural repair as the conventional 0.1% povidone-iodine treatment group. Dense collagen fibers, a well-formed epidermis, fewer inflammatory cells, and more fibroblast proliferation were traits of this group. The 10 mg/L dose also showed a notable improvement, though not as much as the 25 mg/L group.

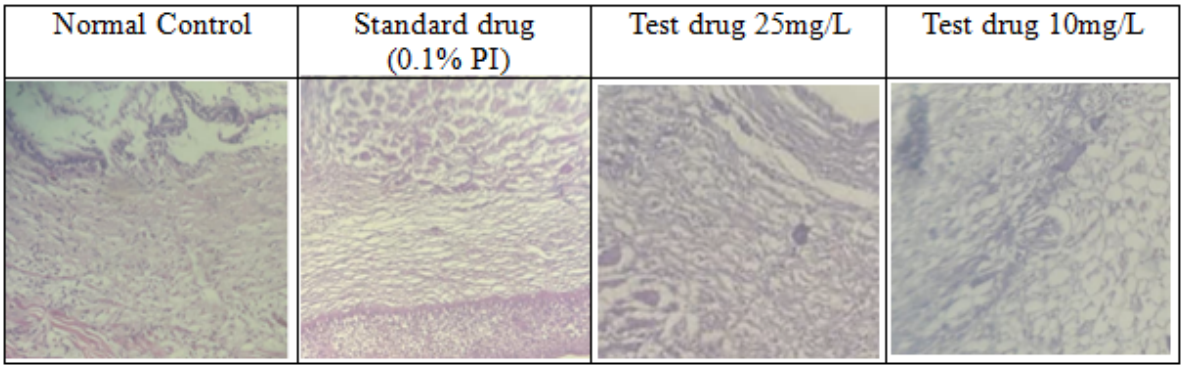


Figure 5: Histopathological assessment of skin in the excision wound model

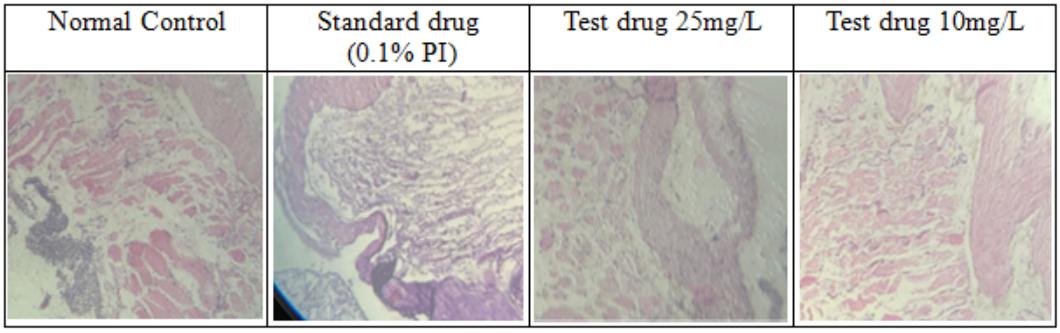


Figure 6: Histopathological assessment of skin in the burn wound model

Wound healing represents a complex biological process encompassing multiple coordinated phases: inflammation, proliferation, collagen synthesis, angiogenesis, and tissue remodeling. This investigation assessed the wound-healing efficacy of a hydroalcoholic flower extract from *Brassica juncea* in *Cyprinus rubrofuscus* fish utilizing both excision and burn wound models. Povidone-iodine (Betadine) served as the known standard treatment. The extract demonstrated statistically significant, dose-dependent enhancement in wound tissue remodeling contraction and epithelialization rates, with the 25 mg/L concentration exhibited superior healing property compared to the 10 mg/L concentration and achieved outcomes equivalent to those of the standard treatment group. Histopathological analysis revealed enhanced re-epithelialization, well-organized collagen deposition, augmented angiogenesis, and diminished inflammatory cell infiltration. No dermal irritation was detected. Phytochemical analysis identified the presence of alkaloids, steroids, flavonoids, tannins, saponins, polyphenols, glycosides, and carbohydrates. The capacity of *Brassica juncea* to facilitate wound healing can be attributed to its wide bioactive phytochemical constituents[30]. Steroids function through anti-inflammatory mechanisms, whereas alkaloids demonstrate antioxidant, antimicrobial, and anti-inflammatory capabilities[31]. Tannins act primarily through antioxidant mechanisms and facilitate tissue regeneration, while proteins and amino acids stimulate cellular proliferation and promote wound maturation. Flavonoids support antioxidant process and moderate inflammatory processes[32]. Consequently, the synergistic antioxidant, anti-inflammatory, and antimicrobial properties of tannins, alkaloids, steroids, flavonoids, and proteins collectively produce the wound-healing efficacy of *Brassica juncea*.. The collective findings indicate that *Brassica juncea* flower extract demonstrates considerable therapeutic potential for topical wound-healing applications.

4. CONCLUSION

This investigation was performed to assess the wound-healing efficacy of a hydroalcoholic flower extract of *Brassica juncea* in Amur carp (*Cyprinus rubrofuscus*), employing both experimentally induced excision wound and burn wound models. Phytochemical analysis of the hydroalcoholic flower extract identified the presence of therapeutically significant constituents, including carbohydrates, flavonoids, tannins, alkaloids, steroids, phenolic compounds, saponins, and proteins, which are recognized for their contributions to tissue repair and regenerative processes. Two distinct concentrations (25 mg/L and 10 mg/L) were employed to assess the wound-healing efficacy. In comparison with the control group, both treatment concentrations demonstrated substantial enhancements in wound contraction and the healing process. Notably, the wound-healing activity exhibited by the *Brassica juncea* flower extract at 25 mg/L concentration was equivalent to that of the reference standard, povidone-iodine diluted solution.

These results indicate that the hydroalcoholic extract of *Brassica juncea* flower demonstrates considerable promise as a wound-healing agent and may represent a viable natural therapeutic option for the management of external wounds. Consequently, these positive outcomes support the need for continued research to clarify the underlying mechanisms of action and expand its potential clinical applications.

5. ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Dr. Arnab Samanta, Principal of Netaji Subhas Chandra Bose Institute of Pharmacy. The authors also acknowledge the valuable collaboration and support provided by all members of the teaching and non-teaching staff at Netaji Subhas Chandra Bose Institute of Pharmacy.

6. CONFLICTS OF INTEREST

The authors have no conflicts of interest in this study

7. REFERENCES

1. Purohit SK, Solanki R, Mathur V, Mathur M. Evaluation of wound healing activity of ethanolic extract of Curcuma longa rhizomes in male albino rats. Asian Journal of Pharmaceutical Research. 2013;3(2):79-81.
2. Garg VK, Paliwal SK. Wound-healing activity of ethanolic and aqueous extracts of Ficus benghalensis. The Journal of Advanced Pharmaceutical Technology & Research .2011;2: 110-4.
3. Bura AR. Effect of wound healing potential of Plumeria obtusa (Champa) Spray. Asian Journal of Pharmaceutical Research. 2018 Nov 27;8(4):231-5

4. Raja RR, Haribabu Y, Sajeeth CI. Medicinal herbs in the management of Common Skin disease–Ethno Botanical Approach.

5. Thombre N, Thete M, Shimpi P. Review on Role of Herbs in Management of Oral diseases. Asian Journal of Pharmaceutical Research. 2020;10(4):321-6.

6. Wagh S, Bhoite V. Common Herbs used as Preventives against Covid-19 in India. Research Journal of Pharmacognosy and Phytochemistry. 2025 Mar 11;17(1):65-8

7. Aziz SS, El-Zayat MM, El-Khateeb AY. Phytochemical characterization, antioxidant and antimicrobial activities of Brassica juncea (L.) mustard seeds aqueous and ethanolic extracts. Journal of Plant Production. 2020 Feb 1;11(2):85-8.

8. Kumar V, Kaur N, Wadhwa P. A review over the effect of heavy metal in metabolism of Brassica juncea (L.) and Myristica fragrans. Asian Journal of Pharmaceutical Research. 2021;11(2):97-103.

9. Sharma A, Kumar V, Kaur P, Thukral AK, Bhardwaj R. Phytochemical and elemental analysis of Brassica juncea L. leaves using GC-MS and SEM-EDX. Research Journal of pharmacy and technology. 2015;8(12):1662-4.

10. Bae WY, Kim HY, Choi KS, Chang KH, Hong YH, Eun J, Lee NK, Paik HD. Investigation of Brassica juncea, Forsythia suspensa, and Inula britannica: phytochemical properties, antiviral effects, and safety. BMC complementary and alternative medicine. 2019 Sep 11;19(1):253.

11. Mahmudah RA, Hasanuddin S, Saleh A, Yuliastri WO, Isrul M. Antidepressant activity and identification of chemical compounds extract mustard leaves (Brassica juncea L.). Research Journal of Pharmacy and Technology. 2019;12(7):3223-7.

12. Ganesan S, Parasuraman S, Maheswaran SU, Gnanasekar N. Wound healing activity of Hemidesmus indicus formulation. Journal of Pharmacology and Pharmacotherapeutics.2012;3(1):66-67. https://10.4103/0976-500X.92516

13. Vandana Aneja VA, Ashish Suthar AS, Sonika Verma SV, Kalkunte S. Phyto-pharmacology of Hemidesmus indicus. Pharmacognosy Reviews.2008;2(3): 143-151

14. 14.Kokate CK, Purohit AP, Gokhale SB. Text book of Pharmacognosy. Pune: Nirali Prakashan.2012.

15. Noga EJ. Fish Disease: Diagnosis and Treatment. Iowa, USA: Blackwell Publishing Ltd.2010. https://doi.org/10.1002/9781118786758.

16. Plumb JA, Hanson LA. Health maintenance and principal microbial diseases of cultured fishes. Iowa, USA: Blackwell Publishing Ltd.2011. https://doi.org/10.1002/9780470958407

17. Hassan M, Melad AA, Yusoff NA, Tosin OV, Norhan NA, Hamdan NA. Melaleuca cajuputi leaf extract accelerates wound healing in African catfish, Clarias gariepinus. Aquaculture Reports. 2023;31:101682. https://doi.org/10.1016/j.aqrep.2023.101682

18. 18. Galib SM, Naser SA, Mohsin AB, Chaki N, Fahad MF. Fish diversity of the River Choto Jamuna, Bangladesh: Present status and conservation needs. International journal of biodiversity and conservation. 2013 Jun;5(6):389-95.

19. 19. Baidun A, Kurnia A, Nofriza F. The Role of Work Competence and Compensation on Increasing Organizational Commitment. Journal of Management. 2024 Sep 20;3(2):577-89.

20. 20. Ahmad W, Ishtiaq A, Khan NA, Abbas M, Abbas Z. Effects of dietary protein on growth and nutrient utilization in ornamental koi fish Cyprinus rubrofuscus (Lacepede, 1803). Journal of Fisheries. 2026;14(1):141203.

21. 21.Majumdar M, Samanta A, Roy A. Study of wound healing activity of different formulations of Nigella sativa seed extract. Research Journal of Pharmacy and Technology. 2016;9(12):2097-105. https://doi.org/10.5958/0974-360X.2016.00427.3

22. Roy P, Majumdar M, Roy S, Pramanick K, Das A, Manna R, Chanda A, Saha P, Biswas D. Preclinical evaluation of Marsilea quadrifolia leaves for its wound healing activity. International Journal of Biology, Pharmacy and Allied Sciences.2024;13(2):983-995. https://doi.org/10.31032/IJBPAS/2024/13.2.7827

23. Grush J, Noakes DL, Moccia RD. The efficacy of clove oil as an anesthetic for the zebrafish, Danio rerio (Hamilton). Zebrafish. 2004;1(1):46-53. https://doi.org/10.1089/154585404774101671.

24. Shivhare Y, Singh P, Patil UK. Healing potential of Trichosanthes dioica Roxb on burn wounds. Research Journal of Pharmacology and Pharmacodynamics. 2010;2(2):168-71.

25. Rachmasari A, Kartini RA, Alviani G, Solihah I. Healing effect of Spray gel collagen extract from Channa striata bone on burn in rats. Research Journal of Pharmaceutical Dosage Forms and Technology. 2019;11(4):275-9. https://doi.org/10.5958/0975-4377.2019.00046.6

26. Patil SA, Joshi VG, Sambrekar SN. Wound healing effects of Mussaenda frondosa extracts on second degree superficial burned rat. Research Journal of Pharmacology and Pharmacodynamics. 2012;4(3):163-8.

27. Roy S, Ghosh S, Pramanick K, Roy P, Majumdar M, Roy S. Preclinical evaluation of Paederia foetida leaves for burn wound healing activity. Research Journal of Pharmacy and Technology.

2024;17(4):1727-30. https://doi.org/10.52711/0974-360X.2024.00274

28. Khalid M, Siddiqui HH, Freed S. In-vitro assessment of antioxidant activity of Dalbergia latifolia barks extract against free radicals. American-Eurasian Journal of Scientific Research. 2011; 6(3): 172-177.
29. Majumdar M, Roy P, Roy S, Sarkar N S, Dutta S, Samanta A, Manna R, Das S, Chanda A. Evaluation of Hydroalcoholic Extract of Roots of Thysanolaena latifolia for its Abortifacient Activity on Poecilia sphenops. Toxicology International. 2025;32(4):805–811. https://doi.org/10.18311/ti/2025/v32i4/50889
30. Ericson-Neilsen W, Kaye A. Steroids: Pharmacology, Complications, and Practice Delivery Issues. Ochsner Journal. 2014;14(2):203-207. https://doi.org/10.1043/TOJ-13-0013.1
31. Rajput A, Sharma R, Bharti R. Pharmacological activities and toxicities of alkaloids on human health. Materials Today: Proceedings. 2022;48(5):1407-1415. https://doi.org/10.1016/j.matpr.2021.09.189
32. Varma SB, Giri SP. Study of wound healing activity of Tectona grandis Linn. leaf extract on rats. Ancient Science of Life. 2013; 32(4):241-244. https://10.4103/0257-7941.131984