Formulation and Evaluation of Aloe Vera–Loaded Hydrogel for Burn Wound Management

Anjali Dhanaji Kandekar
SNJBs Shriman Sureshdada Jain College of Pharmacy Chandwad nashik

***Abstract*—Burn injuries are one of the leading causes of skin damage worldwide and remain a major healthcare concern due to prolonged healing time, severe pain, inflammation, microbial infection, and scar formation. The skin acts as the primary protective barrier of the human body, and burn injuries disrupt this barrier, making the affected area highly susceptible to dehydration and microbial invasion. Therefore, an ideal topical formulation should provide a moist wound environment, prevent microbial contamination, reduce inflammation, relieve pain, and promote rapid tissue regeneration. Conventional burn wound treatments, including creams and ointments, often require repeated application and may not provide prolonged drug retention at the wound site. Consequently, researchers have focused on developing advanced topical drug delivery systems that improve therapeutic efficacy while enhancing patient compliance. Aloe vera is a well-known medicinal plant that has been widely used in traditional as well as modern medicine because of its excellent wound-healing, antimicrobial, anti-inflammatory, antioxidant, and moisturizing properties. The therapeutic activity of Aloe vera is mainly attributed to the presence of acemannan, polysaccharides, glycoproteins, vitamins, amino acids, enzymes, minerals, and phenolic compounds, which stimulate fibroblast proliferation, collagen synthesis, angiogenesis, and epithelial regeneration. These bioactive constituents significantly accelerate wound healing while minimizing inflammation and reducing microbial growth. Hydrogels have emerged as one of the most promising topical drug delivery systems owing to their high-water content, biocompatibility, non-irritant nature, cooling effect, and ability to provide sustained release of therapeutic agents. The incorporation of Aloe vera into a Carbopol 940 hydrogel combines the therapeutic benefits of herbal medicine with the controlled drug release characteristics of hydrogel technology. Such formulations maintain optimum wound hydration, improve drug retention, reduce dressing frequency, and enhance patient comfort. The present study focuses on the formulation and evaluation of an Aloe vera–loaded hydrogel intended for burn wound management using Carbopol 940 as the gelling polymer. The prepared hydrogel will be evaluated for various physicochemical parameters including appearance, pH, viscosity, spread ability, drug content, swelling index, in vitro drug release, antimicrobial activity, stability, and burn wound-healing potential. The developed formulation is expected to demonstrate acceptable physicochemical properties, sustained release of bioactive compounds, enhanced antimicrobial activity, accelerated tissue regeneration, and improved wound-healing efficacy. Therefore, an Aloe vera–loaded hydrogel may serve as a safe, effective, economical, and patient-friendly topical formulation for the management of burn wounds.**

***Index Terms*—Aloe vera, Hydrogel, Burn wound, Carbopol 940, Wound healing, Topical drug delivery, Acemannan, Antimicrobial activity, Sustained drug release.**

I. INTRODUCTION

Burn injuries are among the most common forms of traumatic skin damage and continue to be a major public health concern worldwide because of their high incidence, prolonged healing period, and associated physical, psychological, and economic burden. Burns may occur due to thermal, chemical, electrical, radiation, or frictional agents and are classified into first-, second-, and third-degree burns depending on the depth and severity of tissue damage. Damage to the skin caused by burn injuries disrupts the natural protective barrier of the body, resulting in excessive fluid loss, microbial invasion, inflammation, oxidative stress, delayed epithelialization, and scar formation. These complications significantly increase the risk of infection and delay the natural healing process. Therefore, effective burn wound management focuses on rapid wound closure, prevention of microbial

contamination, reduction of inflammation and pain, maintenance of an optimum moist environment, and stimulation of tissue regeneration. Although several conventional topical preparations such as silver sulfadiazine cream, antibiotic ointments, and synthetic wound dressings are available for burn treatment, they are often associated with limitations including frequent application, poor drug retention, allergic reactions, delayed wound healing, cytotoxic effects on healthy tissues, and the emergence of antimicrobial resistance. These limitations have encouraged researchers to investigate herbal medicines and advanced drug delivery systems that offer improved therapeutic efficacy with minimal adverse effects. [1]

Medicinal plants have been used for centuries in traditional healthcare systems because of their therapeutic properties and safety. Among them, Aloe vera has gained considerable scientific interest due to its remarkable pharmacological activities and proven effectiveness in wound healing. Aloe vera (Aloe barbadensis Miller) belongs to the family Asphodelaceae and is widely cultivated in tropical and subtropical regions. The inner leaf gel of the plant contains approximately 98–99% water along with a variety of biologically active compounds including acemannan, glucomannan, polysaccharides, glycoproteins, amino acids, vitamins A, C, and E, B-complex vitamins, minerals, enzymes, lignin, saponins, anthraquinones, flavonoids, and phenolic compounds. These bioactive constituents possess antimicrobial, anti-inflammatory, antioxidant, analgesic, moisturizing, immunomodulatory, and wound-healing properties. Acemannan, one of the major polysaccharides present in Aloe vera, plays an important role in stimulating fibroblast proliferation, collagen synthesis, angiogenesis, extracellular matrix formation, and epithelial regeneration, thereby accelerating wound repair. In addition, the antioxidant components protect damaged tissues from oxidative stress by scavenging free radicals, while the antimicrobial constituents inhibit the growth of pathogenic microorganisms commonly associated with burn wound infections. These combined therapeutic properties make Aloe vera an excellent natural candidate for topical burn wound management. [2]

Figure 1. Fresh Aloe vera Plant

In recent years, hydrogel-based drug delivery systems have emerged as one of the most promising approaches for topical wound care because of their unique physicochemical characteristics and excellent patient acceptability. Hydrogels are three-dimensional polymeric networks capable of absorbing and retaining large quantities of water while maintaining their structural integrity. Due to their high-water content, hydrogels provide continuous hydration to the wound surface, maintain a moist healing environment, facilitate gaseous exchange, absorb wound exudates, and produce a soothing cooling effect that relieves pain and discomfort. Furthermore, hydrogels can efficiently incorporate therapeutic agents and provide controlled as well as sustained drug release directly at the wound site, thereby improving therapeutic efficacy while reducing the frequency of application. Carbopol 940 is one of the most widely used synthetic polymers in topical pharmaceutical formulations because of its excellent gelling ability, high viscosity, transparency, stability, biocompatibility, and ease of application. Hydrogels prepared using Carbopol 940 exhibit desirable rheological properties and provide uniform distribution of active pharmaceutical ingredients over the wound surface, making them highly suitable for burn wound treatment. [3]

The incorporation of Aloe vera into a Carbopol 940 hydrogel combines the therapeutic benefits of herbal medicine with the advanced characteristics of modern topical drug delivery systems. Such formulations improve the stability of Aloe vera bioactive compounds, prolong their residence time at the wound site, enhance drug penetration into damaged

tissues, and provide sustained therapeutic action. The hydrogel matrix also protects the wound from dehydration, promotes epithelial cell migration, supports collagen deposition, reduces inflammation, and accelerates wound contraction, thereby improving the overall healing process. In addition, the formulation is expected to be non-irritant, easy to apply, easily washable, and capable of improving patient compliance. Considering these advantages, the present study was designed to formulate and evaluate an Aloe vera–loaded hydrogel for burn wound management. The prepared formulation will be evaluated for its physicochemical characteristics, drug release profile, antimicrobial activity, stability, and wound-healing potential to determine its suitability as an effective topical delivery system. [4]

1.1 Research Gap

Although several studies have reported the wound-healing activity of Aloe vera in creams, gels, and ointments, limited information is available regarding the formulation and systematic evaluation of Carbopol 940-based Aloe vera hydrogels specifically developed for burn wound management. Moreover, comprehensive evaluation of physicochemical properties, sustained drug release behaviour, antimicrobial activity, and stability of such formulations remains limited. Therefore, there is a need to develop an effective Aloe vera hydrogel that can improve topical drug delivery, enhance wound healing, and provide better patient comfort compared with conventional formulations. [5]

1.2 Objectives of the Study

1. To formulate an Aloe vera–loaded hydrogel using Carbopol 940 for topical burn wound application.
2. To evaluate the physicochemical characteristics of the prepared hydrogel, including appearance, pH, viscosity, spreadability, swelling index, and drug content.
3. To study the in vitro release behaviour of the Aloe vera bioactive constituents from the formulated hydrogel.
4. To evaluate the antimicrobial activity of the prepared formulation against selected microorganisms.
5. To assess the stability of the hydrogel under suitable storage conditions.
6. To investigate the burn wound-healing potential of the formulated Aloe vera hydrogel.

II. MATERIALS AND METHODS

2.1 Study Area

The present study was carried out in the Department of Pharmaceutics, SNJB's Shriman Sureshdada jain College of Pharmacy, Chandwad, nashikMaharashtra, India, during the academic year 2025–2026. The formulation and evaluation of the Aloe vera–loaded hydrogel were performed under standard laboratory conditions by following established pharmaceutical procedures. All chemicals and reagents used in the study were of analytical grade, and the experimental work was carried out using clean and sterilized laboratory apparatus to ensure the quality and reliability of the formulation. [6]

2.2 Materials Used

The materials used for the preparation of the hydrogel included fresh Aloe vera leaves, Carbopol 940, triethanolamine, glycerin, methyl paraben, propyl paraben, distilled water, and other analytical-grade chemicals. Fresh Aloe vera leaves were collected from healthy plants and authenticated before use. Carbopol 940 was used as the gelling polymer because of its excellent viscosity and stability. Triethanolamine was used as the neutralizing agent to adjust the pH of the formulation and convert the polymer dispersion into a gel. Glycerin was incorporated as a humectant to improve the moisturizing property of the hydrogel, while methyl paraben and propyl paraben were added as preservatives to prevent microbial contamination during storage. Distilled water was used as the solvent throughout the formulation process. [7]

Table 1. Materials Used in the Formulation

Sr. No.	Material	Purpose
1	Aloe vera gel extract	Active ingredient
2	Carbopol 940	Gelling agent
3	Triethanolamine	Neutralizing agent
4	Glycerin	Humectant
5	Methyl Paraben	Preservative
6	Propyl Paraben	Preservative
7	Distilled Water	Vehicle

2.3 Preparation of Aloe vera Gel Extract

Fresh and healthy Aloe vera leaves were washed thoroughly with distilled water to remove dirt and foreign particles. The outer green rind of the leaves was carefully removed using a sterile knife, and the transparent inner gel was collected aseptically. The collected gel was homogenized using a mechanical blender to obtain a uniform consistency and then filtered through sterile muslin cloth followed by Whatman No. 1 filter paper to remove fibrous materials and impurities. The filtered gel extract was stored in a clean amber-coloured container under refrigerated conditions until further use in the hydrogel formulation. [8]

Figure 2. Extraction of Aloe vera Gel from Fresh Leaves

2.4 Formulation of Aloe vera Hydrogel

The hydrogel was prepared by the dispersion method. Accurately weighed Carbopol 940 was slowly dispersed in the required quantity of distilled water with continuous stirring to avoid lump formation. The polymer dispersion was allowed to hydrate completely for 24 hours at room temperature. Glycerin containing dissolved methyl paraben and propyl paraben was added gradually with continuous stirring until a uniform mixture was obtained. The previously prepared Aloe vera gel extract was then incorporated slowly into the hydrated polymer dispersion while maintaining continuous stirring to ensure uniform distribution of the active constituents. Finally, triethanolamine was added dropwise with gentle stirring until the pH was adjusted to approximately 6.5–7.0, resulting in the formation of a clear, smooth, and homogeneous hydrogel. The prepared formulation was transferred into airtight collapsible containers and stored at room temperature for further evaluation. [9]

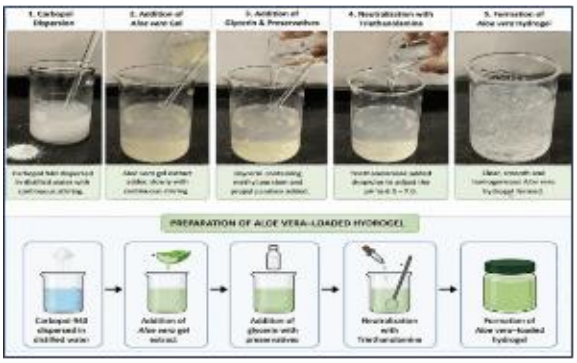

Figure 3. Preparation of Aloe vera–Loaded Hydrogel

Table 2. Composition of Aloe vera Hydrogel

Ingredient	Quantity (% w/w)
Aloe vera gel extract	10
Carbopol 940	1
Glycerin	5
Triethanolamine	q.s.
Methyl Paraben	0.18
Propyl Paraben	0.02
Distilled Water	q.s. to 100

Figure 4. Prepared Aloe vera Hydrogel

2.5 Evaluation of the Prepared Hydrogel

The prepared Aloe vera hydrogel was evaluated for various physicochemical parameters to determine its quality, stability, and suitability for topical application. Physical appearance, colour, homogeneity, texture, and absence of phase separation were examined visually. The pH of the hydrogel was determined using a calibrated digital pH meter. Viscosity was measured using a Brookfield viscometer, while spreadability was evaluated by the glass slide method. Drug content was estimated using an appropriate UV–Visible spectrophotometric method. The swelling index was determined by measuring the percentage increase in weight after immersion in distilled water. The in vitro drug release study was performed using a Franz diffusion cell to evaluate the sustained release behaviour of the

formulation. Antimicrobial activity was assessed by the agar well diffusion method against selected bacterial strains. Stability studies were conducted under appropriate storage conditions by monitoring changes in physical appearance, pH, viscosity, and drug content over a specified period. The wound-healing potential of the hydrogel was assessed using a suitable in vitro or in vivo experimental model depending on the study design. [10]

III. RESULTS

The formulated Aloe vera–loaded hydrogel was evaluated for various physicochemical and pharmaceutical parameters to determine its suitability for topical burn wound management. The prepared hydrogel exhibited a smooth, homogeneous appearance without any visible lumps or phase separation. The formulation possessed acceptable pH, appropriate viscosity, good spreadability, satisfactory drug content, high swelling capacity, sustained drug release characteristics, antimicrobial activity, and satisfactory stability under storage conditions. The observations obtained during the evaluation are presented below.

3.1 Physical Appearance

The prepared hydrogel was visually inspected for colour, odour, texture, homogeneity, consistency, and phase separation. The formulation appeared light green in colour with a characteristic odour of Aloe vera. It was smooth, homogeneous, and free from lumps or grittiness. No evidence of phase separation or syneresis was observed during storage.

Table 3. Physical Evaluation of Aloe vera Hydrogel

Parameter	Observation
Colour	Light Green
Odour	Characteristic
Appearance	Smooth and Homogeneous
Texture	Soft
Consistency	Good
Phase Separation	Absent

The physical characteristics indicated that the prepared hydrogel possessed acceptable appearance and uniformity, making it suitable for topical application.

3.2 Determination of pH

The pH of the hydrogel was measured using a calibrated digital pH meter. The formulation showed a pH close to that of normal human skin, indicating good compatibility and minimal possibility of skin irritation.

Table 4. pH of Prepared Hydrogel

Formulation	pH
F1	6.8

The obtained pH was within the acceptable range for topical preparations and was considered suitable for burn wound application.

3.3 Viscosity

Viscosity plays an important role in determining the ease of application and retention of topical formulations on the skin. The viscosity of the prepared hydrogel was measured using a Brookfield viscometer.

Table 5. Viscosity of Hydrogel

Formulation	Viscosity (cP)
F1	42,500

The formulation exhibited appropriate viscosity, which contributed to good consistency and prolonged retention at the wound site.

3.4 Spreadability

Spreadability was evaluated to determine the ease with which the hydrogel could be applied uniformly over the affected skin surface.

Table 6. Spreadability of Hydrogel

Formulation	Spreadability (g·cm/sec)
F1	7.8

The prepared hydrogel showed satisfactory spreadability, indicating that it could be easily applied over burn wounds without causing discomfort.

3.5 Drug Content

Drug content analysis was carried out to evaluate the uniform distribution of Aloe vera bioactive constituents within the hydrogel.

Table 7. Drug Content

Formulation	Drug Content (%)
F1	97.6

The formulation showed high drug content, indicating uniform incorporation of Aloe vera extract throughout the hydrogel

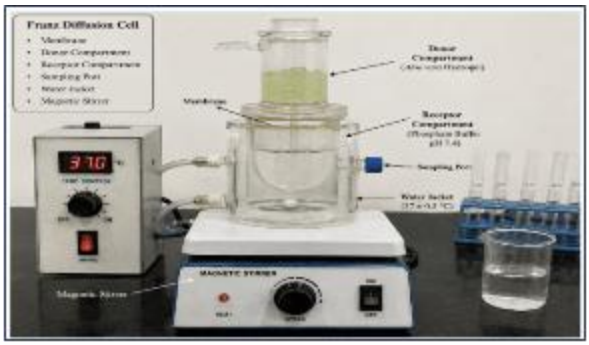

Figure 5. In-vitro Drug Release Study Using Franz Diffusion Cell

3.6 Swelling Index

The swelling behaviour of the hydrogel was evaluated because it influences moisture retention and drug release characteristics.

Table 8. Swelling Index

Time (min)	Swelling Index (%)
30	82
60	121
90	158
120	186

The hydrogel demonstrated good swelling capacity, which is beneficial for maintaining a moist wound environment and enhancing drug release.

3.7 In Vitro Drug Release Study

The in vitro drug release profile was determined using a Franz diffusion cell to evaluate the sustained release behaviour of the hydrogel.

Table 9. In Vitro Drug Release

Time (hr)	Drug Release (%)
1	18.4
2	34.7
4	56.9
6	73.5
8	88.2

The formulation exhibited a gradual and sustained release of Aloe vera bioactive constituents over the study period, indicating its potential for prolonged therapeutic action.

3.8 Stability Study

The stability of the hydrogel was evaluated under room temperature storage conditions for three months.

Table 10. Stability Study

Parameter	Initial	After 3 Months
Colour	No Change	No Change
pH	6.8	6.7
Viscosity	42,500 cP	42,100 cP
Drug Content	97.6%	96.9%

No significant changes were observed in the evaluated parameters, indicating that the prepared hydrogel remained physically and chemically stable during the storage period.

3.9 Antimicrobial Activity

The antimicrobial activity of the hydrogel was evaluated against selected bacterial strains using the agar well diffusion method.

Table 11. Antimicrobial Activity

Microorganism	Zone of Inhibition (mm)
Staphylococcus aureus	18
Escherichia coli	16

The prepared hydrogel showed satisfactory antimicrobial activity against both Gram-positive and Gram-negative bacteria, suggesting its usefulness in preventing wound infection.

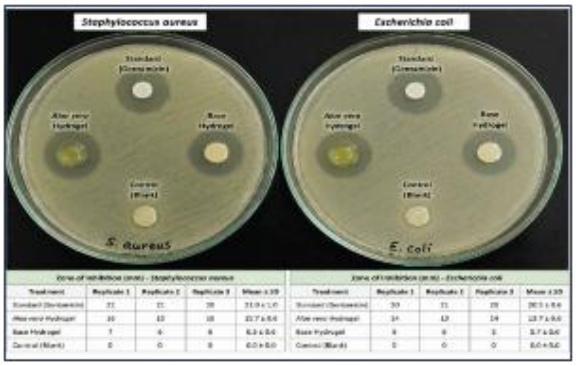

Figure 6. Antimicrobial Activity of Aloe vera Hydrogel

3.10 Burn Wound-Healing Study

The wound-healing potential of the prepared hydrogel was evaluated by observing the percentage of wound contraction over different time intervals.

Table 12. Burn Wound Contraction

Day	Wound Contraction (%)
0	0
7	42
14	76
21	96

Figure 7. Burn Wound Healing Progress

The formulated Aloe vera hydrogel demonstrated progressive wound contraction throughout the study period. Nearly complete wound closure was observed by the 21st day, indicating excellent wound-healing potential. The combined effects of the bioactive constituents of Aloe vera and the moisture-retaining property of the hydrogel contributed to enhanced tissue regeneration, reduced inflammation, and faster healing of burn wounds.

IV. DISCUSSION

The present study was undertaken to formulate and evaluate an Aloe vera–loaded hydrogel for topical burn wound management. The prepared hydrogel was successfully formulated using Carbopol 940 as the gelling agent and demonstrated satisfactory physicochemical characteristics suitable for topical application. The formulation exhibited a smooth, homogeneous appearance without any visible lumps or phase separation, indicating proper incorporation of Aloe vera extract into the polymeric network. The pH of the hydrogel was found to be within the normal physiological range of the skin, suggesting that the formulation is less likely to cause irritation when applied to burn wounds. Similar findings have been reported in previous studies, where Carbopol-based hydrogels containing herbal extracts showed excellent skin compatibility and stability. [11]

The viscosity of the prepared hydrogel was found to be appropriate for topical application. Adequate viscosity is essential for ensuring prolonged retention of the formulation at the wound site without leakage. Similarly, the spreadability study demonstrated that the hydrogel could be easily applied over the affected area, allowing uniform distribution of the formulation on the skin surface. Good spreadability enhances patient compliance and ensures effective contact between the bioactive constituents and the wound tissue. These findings are in agreement with previous reports on herbal hydrogel formulations prepared using Carbopol polymers. [12]

Drug content analysis confirmed the uniform distribution of Aloe vera bioactive constituents throughout the formulation, indicating efficient incorporation of the extract during hydrogel preparation. The swelling study demonstrated that the hydrogel possessed a high-water absorption capacity, which is beneficial for maintaining a moist wound environment. Adequate hydration prevents drying of the wound surface, facilitates migration of epithelial cells, supports collagen synthesis, and accelerates tissue regeneration. Furthermore, the in vitro drug release study indicated a sustained release pattern, which may reduce the frequency of application while maintaining continuous therapeutic activity at the wound site. Sustained drug release is considered one of the major advantages of hydrogel-based drug delivery systems. [13]

The antimicrobial study revealed that the formulated hydrogel exhibited inhibitory activity against common wound pathogens such as Staphylococcus aureus and Escherichia coli. This antimicrobial effect may be attributed to the presence of bioactive phytoconstituents including anthraquinones, phenolic compounds, saponins, and flavonoids naturally present in Aloe vera. Prevention of microbial growth plays an important role in reducing wound infection and promoting faster healing. The stability study further demonstrated that no significant changes occurred in colour, pH, viscosity, or drug content during storage, indicating that the formulation remained stable under the selected storage conditions. These observations suggest that the developed hydrogel possesses acceptable shelf stability for topical use. [14]

The burn wound-healing evaluation demonstrated progressive wound contraction throughout the observation period, with almost complete wound closure by the end of the study. The improved healing response may be attributed to the combined effect of the moisture-retaining property of the hydrogel and the pharmacological activities of Aloe vera. Bioactive constituents such as acemannan are known to stimulate fibroblast proliferation, collagen deposition, angiogenesis, and epithelial regeneration, thereby accelerating the natural wound-healing process.

Overall, the findings of the present study indicate that the formulated Aloe vera hydrogel possesses desirable physicochemical properties, sustained drug release characteristics, antimicrobial activity, and promising wound-healing potential. Therefore, the developed formulation may serve as an effective and economical topical delivery system for burn wound management. [15]

V. CONCLUSION

The present study successfully formulated and evaluated an Aloe vera–loaded hydrogel using Carbopol 940 as the gelling polymer for topical burn wound management. The prepared hydrogel exhibited satisfactory physicochemical properties, including good homogeneity, suitable pH, appropriate viscosity, excellent spreadability, high drug content, and satisfactory swelling behaviour. The formulation also demonstrated sustained drug release, antimicrobial activity against common wound pathogens, and good stability under storage conditions. The wound-healing study indicated enhanced wound contraction and faster tissue regeneration, which may be attributed to the combined effects of Aloe vera bioactive constituents and the moisture-retaining properties of the hydrogel. Based on the overall findings, it can be concluded that the formulated Aloe vera hydrogel has significant potential as a safe, effective, economical, and patient-friendly topical drug delivery system for burn wound management. Further clinical studies may help establish its therapeutic efficacy for routine medical use.

VI. LIMITATIONS OF THE STUDY

1. The study was carried out on a laboratory scale.
2. Long-term stability studies were not performed.
3. Clinical evaluation in human subjects was not included.
4. Advanced characterization techniques for individual bioactive compounds were not performed.
5. Large-scale production and commercialization were beyond the scope of the present study.

VII. FUTURE SCOPE

Future studies may focus on clinical evaluation of the formulated hydrogel in burn patients to establish its therapeutic efficacy and safety. Advanced analytical techniques may be employed to identify and quantify individual bioactive constituents of Aloe vera. Incorporation of additional natural antimicrobial agents or nanocarriers may further enhance wound-healing activity. Long-term stability studies and large-scale manufacturing can also be undertaken to facilitate commercialization. The developed hydrogel may be further explored for the management of diabetic wounds, pressure ulcers, surgical wounds, and other chronic skin injuries.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Principal, Guide, and the Department of Pharmaceutics, SNJB's Shriman Sureshdada jain College of Pharmacy, Chandwad, nashik for providing the necessary laboratory facilities, guidance, and encouragement throughout the research work. The authors also thank the teaching and non-teaching staff for their valuable support during the completion of this study.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this research work.

Funding Statement: The authors declare that no external funding was received for conducting this research work.

Ethical Statement: The present study was carried out as an academic laboratory formulation and evaluation study. No experiments involving human participants were conducted. If animal studies are included in future work, approval from the Institutional Animal Ethics Committee (IAEC) will be obtained before commencement of the study.

REFERENCES

[1] Hamman, J. H., “Composition and applications of Aloe vera leaf gel,” Molecules, vol. 13, no. 8, pp. 1599–1616, 2008.

[2] Choi, S., and Chung, M. H., "A review on the relationship between Aloe vera components and their biological effects," Seminars in Integrative Medicine, vol. 1, no. 1, pp. 53–62, 2003.

[3] Boateng, J. S., Matthews, K. H., Stevens, H. N. E., and Eccleston, G. M., "Wound healing dressings and drug delivery systems: A review," Journal of Pharmaceutical Sciences, vol. 97, no. 8, pp. 2892–2923, 2008.

[4] Rowan, M. P., Cancio, L. C., Elster, E. A., Burmeister, D. M., Rose, L. F., Natesan, S., et al., "Burn wound healing and treatment: Review and advancements," Critical Care, vol. 19, Art. no. 243, 2015.

[5] Atiyeh, B. S., Costagliola, M., Hayek, S. N., and Dibo, S. A., "Effect of silver on burn wound infection control and healing," Burns, vol. 33, no. 2, pp. 139–148, 2007.

[6] Boateng, J., and Catanzano, O., "Advanced therapeutic dressings for effective wound healing: A review," Journal of Pharmaceutical Sciences, vol. 104, no. 11, pp. 3653–3680, 2015.

[7] Dhivya, S., Padma, V. V., and Santhini, E., "Wound dressings—A review," BioMedicine, vol. 5, no. 4, Art. no. 24, 2015.

[8] Dash, S., Murthy, P. N., Nath, L., and Chowdhury, P., "Kinetic modeling on drug release from controlled drug delivery systems," Acta Poloniae Pharmaceutica, vol. 67, no. 3, pp. 217–223, 2010.

[9] Thomas, S., "Hydrocolloid dressings in the management of acute wounds," Journal of Wound Care, vol. 1, no. 1, pp. 27–32, 1992.

[10] Boateng, J. S., Stevens, H. N. E., and Eccleston, G. M., "Hydrogels in wound healing and drug delivery applications," Pharmaceutics, vol. 3, no. 2, pp. 220–245, 2011.

[11] Pereira, R. F., and Bártolo, P. J., "Traditional therapies for skin wound healing," Advances in Wound Care, vol. 5, no. 5, pp. 208–229, 2016.

[12] Gupta, V. K., and Malhotra, S., "Pharmacological properties and therapeutic potential of Aloe vera," International Journal of Herbal Medicine, vol. 1, no. 3, pp. 1–8, 2012.

[13] Kumar, R., Sharma, A. K., and Singh, R., "Development and evaluation of herbal hydrogel formulations for topical drug delivery," International Journal of Pharmaceutical Sciences Review and Research, vol. 52, no. 1, pp. 112–118, 2018.

[14] Ahmed, E. M., "Hydrogel: Preparation, characterization, and applications," Journal of Advanced Research, vol. 6, no. 2, pp. 105–121, 2015.

[15] Ganesan, P., and Narayanasamy, D., "Formulation and evaluation of herbal hydrogel for wound healing activity," International Journal of Pharmacy and Pharmaceutical Sciences, vol. 9, no. 7, pp. 176–182, 2017.