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Development of Hydrogel Delivery System for Anti-Inflammatory Action

Suresh Kumar[1], Harish Sharma[1], Thaneshwar Yadav[2], Yogesh Chandra[2], Manish Swarnkar[2], Khushi Sharma[2] , Prerana Sahu[2], Anjali Sahu[1], Gyanesh Kumar Sahu[1], Rajesh Kumar Nema[2]

[1]Rungta Institute of Pharmaceutical Sciences and Research, Bhilai, Chhattisgarh
[2]Rungta Institute of Pharmaceutical Sciences, Bhilai, Chhattisgarh

***Corresponding Author:** Dr. Harish Sharma, Professor & Dean Rungta Institute of Pharmaceutical Sciences & Research, Bhilai, Chhattisgarh, 490024, Email ID. drharishsharma.817@gmail.com

ABSTRACT

Ashwagandha root extract was incorporated into a hydrogel matrix using a suitable gelation method. Various physicochemical and mechanical properties of the resulting hydrogel were characterized, including pH, viscosity, swelling behavior, rheological properties, and drug release kinetics. Ashwagandha (Withaniasomnifera) is an herb widely recognized for its medicinal properties, including its anti-inflammatory, antioxidant, and immunomodulatory effects. In this study, we aimed to develop and characterize a novel Ashwagandha root hydrogel for potential biomedical applications.

Keyword: Hydrogel, Ashwagandha root, wound heeling

INTRODUCTION

Hydrogels are three-dimensional networks of hydrophilic polymers capable of holding large amounts of water. They are similar to natural tissues in terms of their high water content and soft, pliable consistency. Hydrogel wound dressings are formulated to maintain a moist environment around the wound, which is conducive to the healing process. Wounds are managed by the use of traditional dressings such as natural or synthetic bandages, cotton wool, lint and gauzes along with conventional formulation such as creams, ointments and gels. These dressings were mainly used to keep the wound dry, by allowing evaporation of the exudates of the wound, and to obstruct the entrance of bacteria into the wound. Rather than a dry wound, a moist wound environment is optimal for wound healing. This has led to the introduction of modern dressing based on this concept of a moist wound environment but also on the achievement of effective oxygen circulation, to help the regeneration of cells and tissues, and a lower bacterial load. The most important property of the modern dressing includes its ability to remove excessive exudates without the loss of the moisture wound bed [1, 2].

Composition and Types:

Hydrogel dressings can be made from various polymers, including:

1. **Synthetic Polymers**: Such as polyethylene oxide, polyvinyl alcohol, and polyvinyl pyrrolidone.
2. **Natural Polymers**: Such as alginate, collagen, and hyaluronic acid.

These polymers can be combined to create hydrogels with specific properties tailored to different wound types and stages of healing [3].

Properties and Mechanism of Action:

Hydrogel dressings possess several beneficial properties for wound healing:

1. **Moisture Retention**: Hydrogels maintain a moist environment at the wound site, which promotes cell migration, proliferation, and angiogenesis (formation of new blood vessels).
2. **Exudate Absorption**: They can absorb excess exudate from the wound while simultaneously releasing moisture, helping to maintain a balanced moisture level.
3. **Cooling Effect**: Hydrogels often provide a cooling sensation, which can help alleviate pain and discomfort associated with wounds.
4. **Non-Adherent**: Hydrogel dressings are typically non-adherent to the wound bed, minimizing trauma and pain during dressing changes.

5. **Transparency**: Some hydrogel formulations are transparent, allowing for easy wound monitoring without the need for removal [4].

Applications in Wound Healing:

Hydrogel dressings are suitable for various types of wounds, including:

1. **Superficial Wounds**: Such as abrasions, minor burns, and donor sites.
2. **Partial Thickness Wounds**: Including superficial and deep partial thickness burns.
3. **Full Thickness Wounds**: Such as diabetic ulcers, pressure ulcers, and surgical wounds.
4. **Necrotic Wounds**: Hydrogels can help debride necrotic tissue by providing a moist environment conducive to autolytic debridement [5].

Clinical Benefits:

The use of hydrogel dressings in wound care offers several clinical benefits:

1. **Enhanced Healing**: By maintaining a moist environment and facilitating cell proliferation, hydrogels promote faster wound healing.
2. **Reduced Pain**: The cooling effect of hydrogels can help alleviate pain associated with wounds, improving patient comfort.
3. **Minimized Scarring**: Proper wound hydration provided by hydrogel dressings can contribute to reduced scarring and improved cosmetic outcomes.
4. **Ease of Application**: Hydrogel dressings are easy to apply and conform to the contours of the wound bed, making them suitable for irregularly shaped wounds [7].

MATERIAL AND METHOD

Material

All the material was collected from Rungta institute of pharmaceutical sciences and Rungta institute of pharmaceutical science and research KokhaBhilai (C.G)

Extraction method

Extraction of Ashwagandha roots

1. Weighout20gmofashwagandharoots.
2. Thecrudedrugisplacedinathimble-shapedfilterpaperwhichis then kept in a Soxhlet extractor.
3. Add200mlofethanolasasolventintheroundbottomflaskandheatat60°C for 6 hours in the Soxhlet apparatus.
4. Awatercondenserisattachedtothesoxhletatthetop.Thisentireassemblyis fitted into the neck of a round bottom flask containing the solvent.
5. Theflaskisheatedinaheatingmantle.Thesolventvapoursreachthecylinder through the inlet tube and continue to pass upward into the condenser.

Fig 1 Extraction of ashwagandha roots

Table -1 Ingredients tables of hydrogel formulation

S.N.	Ingredients	QuantityTaken(%)
1.	Carbopol-940	5 %
2.	Propyleneglycol	10 %
3.	Methylparaben	0.5 %
4.	Triethanolamine	0.5 %
5.	Distilled water	70 %
6.	Ashwagandha extracts	8 %
7.	Aloe vera gel	6 %

2.3 Method:-

TakeabeakerDissolveCarbopol940in50mlwaterandkeepasidetoswellthe Carbopol for 30 mins. Stir it with the help of a laboratory stirrer.

Add5mlpropyleneglycol8mlashwagandhaextract,and6mlaloeveratothe Carbopol gel. Stir it continuously to mix it uniformly.

Thenaddtherequiredquantityofmethylparabenaspreservativeand triethanolamine to maintain pH up to(6.8-7).

Makethevolumeupto100mlbyaddingtheremainingdistilledwater.

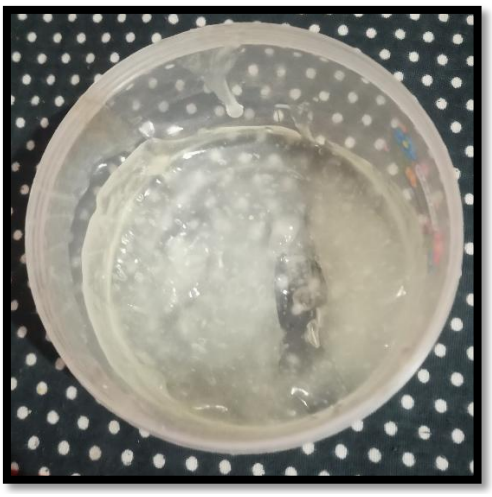

Fig1: Prepared hydrogel formulation

Table 2 Gel formulation

S.N.	Ingredients	F1	F2	F3	F4
1.	Carbopol940	5.0g	5.0g	5.0g	5.0g
2.	Propyleneglycol	10ml	9.5ml	10ml	10ml

3.	Methylparaben	0.5ml	0.5ml	-	0.4ml
4.	Triethanolamine	0.5ml	-	-	-
5.	Distilled water	70ml	65ml	70ml	70ml
6.	Ashwagandha extracts	8ml	-	-	-
7.	Aloe vera gel	6gm	-	-	-

Evaluation Parameters of Ashwagandha root hydrogel-

Organoleptic and pH

An organoleptic test was carried out by observing the odor and color of the gel 48 h after the preparation. The measurement of pH was done using universal pH indicators (pH stick) by putting the stick into the preparations and then comparing the color appearing in the indicator with standard colour

Fig- 2 pH testing

Spreadability test

The dimension of the gel's spreadability was carried out 48 h after medication. For this test, 1 gram of the gel was placed in the center of a round gauged glass plate. On top of the gel, a round glass and a weight with the combined weight of 125 grams were placed. The condition was saved for 1 nanosecond, and also the periphery of the gel's spread was recorded

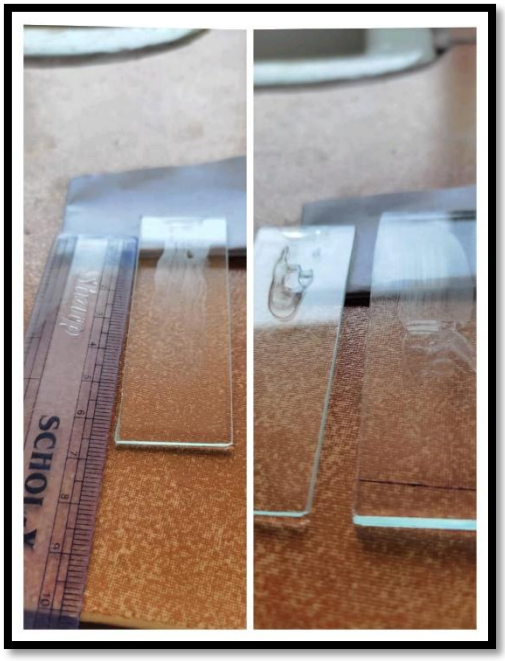

Fig- 3 Spreadability test

3.3 Viscosity test

The viscosity test for anti-inflammatory hydrogel involves loading a homogenized sample into a calibrated viscometer at the specified temperature. Ensure minimal air entrapment. Record stabilization time and measure viscosity. Repeat for accuracy. Analyze data for average viscosity, crucial for formulation optimization.

3.4 Sterility test

The sterility test was carried out using the spread plate fashion. A small amount of the gel was taken and placed in the Nutrient Agar (NA) medium, which was put on a petri dish and smoothed with the help of ansterile spreader rod. The petri dish was incubated for ± 24 h. After that, it was observed to indicate whether colonies of bacteria in the medium were present

RESULTS AND DISCUSSION

Formulation consideration

The selection of each material and excipient used in the formula should be precisely considered to insure that all of them can produce feasible efficacity of the medicine. In this exploration, ethanol and distilled water are used as the diluents in the birth process. The election is taken with the consideration of the solubility of the active ingredients having crack mending exertion was in Ashwagandha roots. Crack mending is a complex process, and along that process, it's important to keep the crack area sterile, free from impurity and bacteria that can beget infection, and do used. The recent development in crack operation set up that a wettish terrain would accelerate the crack mending process, especially in the reepithelization process. Carbopol, when dispersed into water and alkalized, will form a rigid three- dimensional network that has the capability to absorb water and to retain the water content absorbed in its network. Propylene glycol is a humectant that has a vital part in topical medications by maintaining skin humidity and adding water immersion from the epidermis to the deeper corridor of the skin(the dermis). As water vastly grease microbial growth, in order to help this passing in the expression of the hydrogel that contains further than 80 of water, methylparaben as a preservative is added in the formula. There for the crack won't be defiled or infected, and the infection won't inhibit the crack mending process.

Physical properties and physical stability test of gel

Organoleptic and pH

Human skin is known to have a normal pH between 4.0 and 6.0 organoleptic properties refer to the sensory characteristics of a substance, especially its taste, smell, appearance, and texture. When it comes to hydrogels, which are water-based materials capable of holding large amounts of water within their three-dimensional networks, organoleptic properties become particularly relevant. pH is another crucial factor to consider when formulating hydrogels. pH affects the stability, swelling behavior, and compatibility of hydrogels with biological systems. Some considerations for pH in hydrogelthis acidic environment will inhibit the growth of bacteria, so infection does not occur. This is one of the activities in wound healing

Spreadability and viscosity test

The other important aspects affecting the quality of topical medications are spreadability and density. These two factors affect the retention time of the medication and its ease of operation over the skin face, which will eventually have an impact on the effectiveness of the remedy lower spreadability means advanced density, which will make the medication more delicate to apply on the skin. Too high spreadability, which means too low density, is also undesirable because it'll dock the retention time on the skin face. Therefore, it's necessary to have the ideal dispersibility and density values. The results of the spreadability and density tests for the four crack mending gel formulas from after 48 h of storehouse, are presented in table 2. The spreadability ranges from3.783 –4.650 cm and the density from2433.333 – 3000 cps. The test results show that the gel has good dispersibility and density parcels and is in agreement with the original target, i.e., the spreadability of 3 – 5 cm and a density of 2000 – 3000 cps.

A density shift test was performed to estimate the gel's physical stability in a storehouse terrain. The density of the gel that had been stored for 1 mo was compared with the density of the gel after 48 h of storehouse. The lower the chance shift in density, the better the physical stability of the gel.

Table 3 Test result of spreadability and viscosity

Formula	Spreadability(cm)	Viscosity after 48 h of storage (cps)
1	4.650±0.265	2433.333±57.735
2	3.983±0.416	3000.000±0.000
3	4.100±0.350	2466.667±57.735
4	3.783±0.029	2750.000±0.000

Sterility test

Topical medications used for crack mending must meet certain sterility conditions. It's related to product safety toward the exposed skin towel because the crack is susceptible to infection by bacteria and other microorganisms. thus, it's necessary to ensure the product sterility in order not to harm the cases further. From table 3, it can be seen that, in general, the medications meet the sterility conditions, indeed thoughnon-sterile gels also live, i.e., Formula 1 replication 3 and Formula 4 replication 3.

Wound healing activity

This test was conducted to determine the extract Ashwagandha root gel's ability to heal wounds in male Wistar rats. The test was carried out by applying the Ashwagandha root extract gel on the backs of the rats that had been injured. The rats were divided into six treatment groups, one rat each for Formula 1–4, one treatment group for the negative control (rats were injured without treatment), and one treatment group for the positive control.

CONCLUSION

The formulation of extract Ashwagandha root in a gel preparation for wound healing has been proven to produce preparations that meet various quality requirements of pharmaceutical products, including pH, viscosity, sterility, and wound healing activity. The gelling agent (Carbopol) and humectant (propylene glycol) used in this work have a significant role in the formulation; they can improve the humidity of the formula and maintain it. The moist environment can improve the wound healing process. Formula with the greatest amount of gelling agent and humectant, has the best wound healing activity, even better than the positive control, while it's physical and stability test results meet the requirements. Therefore, it can be concluded that Formula 4 is the best formula.

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