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Formulation and Evaluation of Herbal Hydrogel Containing *Psoralea corylifolia* Extract for Skin Applications

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ABSTRACT -

Inflammation is a complex biological response associated with pain, tissue damage, and protein denaturation. The present study aimed to develop and evaluate a herbal hydrogel formulation containing Psoralea corylifolia and Rosmarinus officinalis extracts for topical anti-inflammatory application. The hydrogel was prepared using Carbopol 934 as a gelling agent along with propylene glycol, sodium benzoate, propyl paraben, and triethanolamine. Preformulation and phytochemical screening confirmed the presence of bioactive constituents such as flavonoids, phytosterols, proteins, and fixed oils in the plant extract.

The formulated hydrogel was evaluated for physicochemical parameters including pH, viscosity, spreadability, and drug content. The formulation exhibited a pH of 5.11 and viscosity of 5327 CPS, indicating suitability for dermal application. In vitro drug release studies using Franz diffusion cell demonstrated controlled and sustained release behavior of active constituents. Anti-inflammatory activity was assessed using the protein denaturation assay, with diclofenac sodium as a reference standard. The hydrogel showed a concentration-dependent inhibition of protein denaturation, with activity ranging from 7.79% to 55.84% at concentrations of 20–100 µg/mL, compared to 22.08% to 87.01% for the standard drug. Although lower in potency, the formulation exhibited significant anti-inflammatory activity, likely due to the synergistic effects of phytoconstituents. In conclusion, the developed herbal hydrogel demonstrates promising potential as a biocompatible, controlled-release topical delivery system for managing inflammation, warranting further in vivo and clinical investigations.

Keywords- Herbal Hydrogel, Anti-Inflammatory activity, Topical drug delivery.

INTRODUCTION-

Inflammation is a complex biological response that is frequently associated with pain. It involves several key processes, including increased permeability of blood vessels, enhanced protein denaturation, and alterations in cellular membranes.[1]

Hydrogels are three-dimensional polymeric networks that can absorb and retain large amounts of water while preserving their structural stability. They are highly versatile materials, as their physicochemical properties can be tailored and adjusted during the synthesis process.[2] Hydrogels have attracted considerable attention in the biomedical field because of their excellent biocompatibility and adjustable biodegradability.[3] In this study, the hydrogel formulation incorporates various active ingredients, including herbal extracts from Psoralea Carylifolia and Rosemary. These botanical extract shows anti-inflammatory property. They both are compatible to each other and they show synergistic effect by reduce inflammation. Hydrogels are widely used in the management of skin wounds because they help retain moisture at the wound site while also promoting the absorption of exudates [4].

PHARMACOLOGICAL IMPORTANCE:

BABCHI [*Psoralea corylifolia*]

Family- Fabaceae

Biological Source- It extracted from seeds of Babchi plant.

Flavonoids derived from *Psoralea corylifolia* are considered potentially effective remedies for inflammatory diseases, as they inhibit IL-6–induced activation and phosphorylation of STAT3.Additionally, these compounds have demonstrated anti-inflammatory activity against carrageenan-induced edema in rats [5].

Fig. 1. Babchi Seed

ROSEMARY [Rosmarinus Officinalis]

Family- Lamiaceae

Biological Source- It extracted from rosemary leaf of Rosmarinus officinalis linn.

Rosemary (Rosmarinus officinalis L.) is a perennial shrub that belongs to the Lamiaceae family. In its natural environment, it typically grows to a height of about 1 to 2.5 meter [6]. With this numerous studies have shown that Rosmarinus officinalis exhibits strong anti-inflammatory activity. Further more rosemary extract has been found to suppress other pro-inflammatory mediators, such as nitric oxide, as well as genes associated with inflammation[7].

Fig.2 Rosemary Plant

Table No. 1: Features of *Psoralea corylifolia* and Rosmarinus officinalis L.

Feature	Babchi	Rosemary
Main Use	Skin Disorders	General Inflammation
Strength	Strong, Targeted	Moderate Broad
Key Compound	Bakuchiol	Rosemarinic Acid
Use Risk	Higher (Photosensitivity)	Lower (Generally Safe)
Best Form	Topical / Controlled Oral	Tea, Oil, Food

ROLE OF HYDROGELS IN ANTI- INFLAMMATORY

Hydrogels have emerged as a particularly effective class of wound dressings because of their significant anti-inflammatory properties, along with their exceptional ability to retain moisture, their biodegradability, biocompatibility. Structurally, they are three-dimensional, porous, and hydrophilic polymer networks with a high capacity for water absorption. These characteristics have made hydrogels highly valuable in topical wound care, as they closely resemble the natural extracellular matrix (ECM), help sustain a moist environment that promotes healing and help to reduce inflammatory responses at wound site in addition hydrogel can serve

as carrier for anti-inflammatory therapeutic agent and enable the controlled release of therapeutic agents. Depending on their method of synthesis—through physical crosslinking (via reversible ionic or hydrogen bonds) or chemical crosslinking (via covalent bonds)—hydrogels can be engineered to respond to different external stimuli such as pH[8,9] temperature[10,11] light[12]specific chemicals[13]or enzymes[14,15].This responsiveness allows them to dynamically modulate drug release and effectively control inflammation during different stages.

METHODS AND MATERIALS

1. Materials

- Psoralea corylifolia act as a primary active ingredients providing melanocyte stimulating properties, anti-oxidant and anti-inflammatory action which supports skin healing and management of vitiligo.
- Rosemary extract act as a secondary active ingredient providing anti-inflammatory action but less than Psoralea corylifolia.
- Carbopol 934 act as gelling agent. It is responsible for forming the hydrogel structure. And provide consistency for topical application.
- Sodium Benzoate protect formulation from bacterial and fungal growth.
- Propyl Paraben act as preservative by increasing shelf life of the formulation.
- Triethanolamine used as neutralizing agent and pH adjuster which helps in gel formation by neutralizing carbopol with maintaining suitable skin compatible pH.
- Propylene Glycol act as humectant and penetration enhancer which improve the absorption of active constituent.
- Distilled Water used as vehicle which provide the medium for dispersion of all ingredients by forming base for hydrogel.

2.Methods

2.1-PreformulationStudy of Drugs

2.1.1-Organoleptic Properties -

- Color varies from greyish-black to brown.
- Has a characteristic aromatic odor, often likened to coconut oil or an oily smell.
- Taste is bitter and pungent.
- Texture is usually a fine powder, sometimes with oily or resinous components.

2.1.2- Solubility of Babchi -

Psoralea corylifolia is highly lipophilic hence it is poor soluble in aqueous medium and highly soluble in oil and Organic solvents like ethanol, methanol and various oil.

2.2- Preliminary Phytochemical Screening

Phytochemical analysis was performed on the ethanolic extract of *Psoralea corylifolia* seed powder. This was done by using standard procedures describe by harborne (1973) to determine the presence of primary and secondary metabolites.

A. Test for Carbohydrates- Mix a small amount of extract with 2 mL distilled water. Add a few drops of Molisch's reagent (α-naphthol) and mix. Carefully add concentrated sulphuric acid along the side of the test tube to form a separate layer. A purple ring at the interface indicates the presence of carbohydrates.

B. Test for Phytosterols- Dissolve the extract in 2 ml chloroform in a test tube. Carefully add 1 ml concentrated sulphuric acid along the side of the tube and let it stand for 5 minutes. Formation of a reddish-brown color at the interface indicates the presence of phytosterols.

C. Test for Fixed oils- Place a small amount of alcoholic extract between two filter papers and press. The appearance of an oil stain indicates the presence of fixed oil.

D. Test for Proteins and Free Amino –

a) **Acids Biuret Test**- Dilute the plant extract with water, add Biuret reagent, and observe. Pink or purple color indicates proteins and free amino acids.

b) **Ninhydrin test**- Treat the diluted extract with ninhydrin reagent. Purple color indicates the presence of free amino acids.

E. Test for Flavonoids- Add a few drops of sodium hydroxide to the extract (deep yellow forms), then add dilute HCl. Disappearance of yellow indicates flavonoids.

2.3-Method of Preparation

Extraction of Psoralea corylifolia

For the preparation of babchi-based hydrogel, the babchi powder was first defatted with petroleum ether using a Soxhlet apparatus for 23 extraction cycles to remove the oil content.

Fig.3. Defatting of Babchi Seed Powder

The defatted marc was subsequently extracted with ethanol using a Soxhlet apparatus, and the extraction was continued until the siphon tube solvent became colourless. The resulting ethanolic extract was then used for hydrogel preparation.

Fig. A Before

Fig. B After

After extracting babchi seed powder with ethanol, the excess solvent is removed using distillation apparatus. The crude extract is placed in round bottom flask and heated continuously, causing the ethanol to evaporate. The vapour passes through a condenser they will cooled and collected as a liquid in a receiving flask. This process separate the solvent, leaving behind a concentrated babchi extract in the flask.

Fig.4 Separation of Extract

4. Formulation of Hydrogel

Formulation Table of Selected Batch:

Table No- 2 Formulation Table

Sr. No.	Ingredients	Quantity In Grams	Role of Ingredients
1	Babchi extract	1gm	Anti- inflammatory, Anti- oxidant, Melanocyte stimulating property
2	Rosemary extract	0.5 gm	Anti- inflammatory, Anti- microbial
3	Carbopol 934	1 gm	Gelling Agent
4	Propylene Glycol	1 gm	Humectant
5	Sodium Benzoate	0.1 gm	Anti-microbial Preservative
6	Propyl Paraben	0.01 gm	Preservative
7	Triethanolamine	0.02 gm	Neutralizing Agent
8	Distilled Water	7 gm	Vehicle

Procedure for Preparation of Hydrogel

a. Preparation of Carbopol Gel Base -

Weigh carbopol 934 and then sprinkle slowly into distilled water. Rested swelling for 3-4 hours with gentle stirring to avoid lump formation.

b. Preparation of Preservative Solution -

Dissolve propyl paraben and sodium benzoate in a small quantity of warm distilled water and stir until clear solution form.

c. Preparation of Extract Phase –

Take Babchi seed powder extract and Rosemary extract and add into propylene glycol with slow stirring to avoid air bubbles.

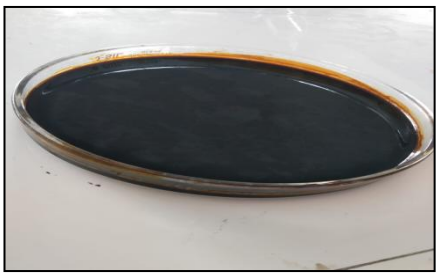

Fig.5 Herbal Extract

d. Incorporation Into Gel Phase -

Add extract phase slowly into swollen carbopol gel. Stirr continuously by using magnetic stirrer. After that add previously prepared preservatives into hydrogel. Mix uniformly.

e. Neutralization and Gel Formation -

Add triethanolamine dropwise into gel with continuous stirring to adjust the pH. At this stage gel become transparent. At this phase dispersion become hydrogel.

f. Makeup The Volume -

Addition of remaining of distilled water to make up the volume (Upto 100%).

g. Final Homogenization –

Homogenize 15-20 minutes to make formulation uniform and stable by removing lumps and aggregates.

Fig.6 Hydrogel

Formulation Table of Three Different Batches Shows as Below:

Table 3: Formulation Table

Ingredients	F1	F2	F3	Role of Ingredients
Babchi extract	1 gm	1 gm	1 gm	Anti- inflammatory, Anti- oxidant, Melanocyte stimulating property
Rosemary extract	0.5 gm	0.5 gm	0.5 gm	Anti- inflammatory, Anti- microbial
Carbopol 934	0.25 gm	0.50gm	1 gm	Gelling Agent
Propylene Glycol	1 ml	1 ml	1 ml	Humectant
Sodium Benzoate	0.05 gm	0.05 gm	0.05 gm	Anti-microbial Preservative
Propyl Paraben	0.005 gm	0.005 gm	0.005 gm	Preservative
Triethanolamine	0.5 gm	0.5 gm	0.2 gm	Neutralizing Agent
Distilled Water	7 ml	7 ml	7 ml	Vehicle

5. Evaluation tests of Topical Babchi Based Hydrogel

Physical Appearance-

Table No. 4 Physical Appearance

Parameters	F1	F2	F3
Appearance	Slightly gel like	Slightly gel like	Smooth transparent gel
Colour	Dark Coloured	Faint Green	Faint Green
Texture	Not Even	Not Even	Easily Applied
Homogenicity	Slightly Lumps	Slightly Lumps	Uniform

5.1 pH Measurement

To determine the pH of a hydrogel using a pH meter, first switch on and allow to stabilize it. Calibrate it using a standard buffer solution (usually pH 7). Wash the electrodes with distilled water and dry it after that deep the electrode into the hydrogel and weight until reading become stable note the pH which is displayed on the pH meter. Mostly normal pH range of the hydrogel is in between 4.5 – 6.5.

5.2 Viscosity

To determine viscosity of hydrogel by using a Brookfield viscometer. First select the suitable spindle which is suitable spindle no 64. Immerse the spindle into hydrogel upto marked level and set the required speed which is 10rpm at room temperature for viscosity. Allow the spindle rotate at 10 rp min that beaker which is filled with 30 gm of hydrogel and weight until reading become stable. At last note the viscosity and wash the spindle after use. And this viscosity was measured by Brook Field Viscometer.

5.3 Spreadability

Spreadability of hydrogel was measured by the parallel plate method. Standard-sized glass slides were prepared in two sets for the spreadability test. In that parallel plate method, 0.5 gram of the herbal hydrogel formulation was placed between the slides, forming a thin layer. Any excess gel adhering to the slide surfaces was carefully removed, and the setup was fixed onto a stand. A 100 g weight was then applied to the upper slide, and the time required for the slide to move across the hydrogel was recorded. This procedure was performed three times to obtain an average value, and spreadability was calculated using the appropriate formula[16].

$$\text{Spreadability} = \text{Weight} \times \text{Length} / \text{Time}$$

5.4 Washability

For the washability test, the hydrogel formulation was applied and then rinsed with water. Its ease of removal was assessed manually.

5.5 Drug Content By UV

Drug content of hydrogel mostly checked by UV Spectrophotometer. Hydrogel equivalent to 10 mg of babchi seed powder extract was taken in a 10 ml of volumetric flask containing 10 ml of ethanol to gel 100 µg/ml. The resultant solution was filtered by using Whatman filter paper and then absorbance was measured at 254 nm by using a UV Spectrophotometer.

5.6 In vitro Testing Drug Release Study Using Egg Membrane (Frans Diffusion)

Hydrogel formulations can be effectively evaluated for their drug release and permeation behavior using a **Franz Diffusion Cell**. In this method, the hydrogel containing the drug is placed in the donor compartment, while a suitable membrane such as a dialysis membrane or excised skin separates it from the receptor compartment filled with a buffer solution maintained at physiological temperature (around 37°C) and continuously stirred. At predetermined time intervals, samples are withdrawn from the receptor compartment and analyzed using **UV–Visible Spectroscopy** to determine the amount of drug released. The obtained data are used to calculate parameters such as cumulative drug release, flux, permeability coefficient, and lag time, which are interpreted based on **Fick's Laws of Diffusion**. In the results, a plot of cumulative drug release versus time is typically presented, while in the discussion, the release mechanism (such as diffusion-controlled or swelling-controlled) is explained along with the influence of formulation factors like polymer concentration and crosslinking density. This method provides valuable insight into the efficiency and suitability of the hydrogel as a drug delivery system.

Fig.7 In vitro testing by using Frans Diffusion

5.7 In Vitro Anti-Inflammatory Activity By Protein Denaturation.

The reaction mixture (10ml) consisted of 0.4ml of egg albumin, 5.6 ml of phosphate buffered saline (pH 6.4) and 100 ml of different concentrated sample. Similar volume of double distilled water served as control. Then the mixture was incubated at (37°c) in a incubator for 15 minutes and then heated at 70°c for 5 minutes. After cooling, their absorbance was measured at 660nm. By using vehicle as a blank. Diclofenac sodium at the concentration was used as a reference drug and treated similarly for determination of absorbance. The percentage inhibition of protein denaturation was calculated using the following formula [17,18,19].

$$\% \text{ Inhibition} = C\text{-}T / C$$

Where,

T= Absorbance of test sample

C= Absorbance of control

RESULT AND DISCUSSION:

1. Phytochemical Screening of Seed Extracts of Psoralea corylifolia

Table No. 5 Phytochemical Screening of Extract

Sr. No.	TEST	RESULT
1	Carbohydrates	Present
2	Phytosterols	Present
3	Fixed Oils	Present
4	Proteins And Free Amino 1) Acids Biuret Test 2) Ninhydrin Test	Present
5	Flavonoids	Present

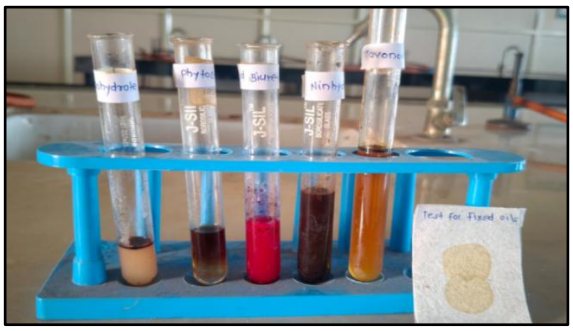

Fig.8 Phytochemical Screening Babchi Extract

2. pH Meter:

The standard pH range for hydrogel is in between 4.5 -6.5. The pH of hydrogel was measured by using pH meter. The pH of herbal hydrogel of batch 3 was found to be 5.11.

Fig.9 pH Measurement

Table No. 6 pH Measurement

BATCH	OBSERVED pH	RESULT
F1	8.08	Not within acceptable it's alkaline leads skin irritation.
F2	8.01	Not within acceptable range due to alkaline nature.
F3	5.11	Within acceptable range for topical application, good skin compatibility.

3. Viscosity:

Viscosity of hydrogel by using Brook Field Viscometer of batch 3 was found to be 5327 CPS at 10 rpm. That show hydrogel's spreadability and its application properties.

Table No.7 Viscosity Measurement

BATCH	VISCOSITY	RESULT
F1	Below 1000 cP	Not acceptable, very low gel consistency.
F2	Below 1000 cP	Not acceptable due to poor gel consistency leads poor retention on skin.
F3	5327 cP	Acceptable, Good gel consistency, thickness and spreadability.

Fig.10 Brookfield Viscometer

4. Spreadability-

The spreadability of the prepared herbal hydrogel was found to be 7.33 g.cm/sec. Indicating that good spreadability and suitability for topical application. It ensures ease of application on skin surface, distribution of gel and better compliance.

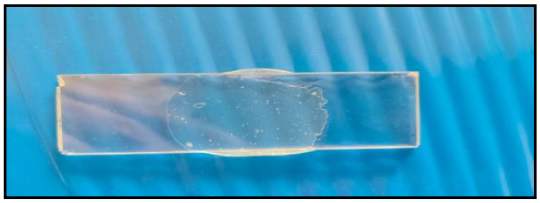

Fig. 11 Spreadability Test

5. UV Spectroscopy

UV Spectroscopy Characterization of Pure Extract of *Psoralea corylifolia*:

The determination of λ max for the pure extract of *Psoralea corylifolia* involves preparing and analyzing solutions with concentration 10 µg/ml. In this process, the solution goes through analysis in UV spectrometer (Shimadzu UV-1900 i) across the wavelength range from 200-400nm, with ethanol serving as the blank solution for reference. The λ max of *Psoralea corylifolia* solution is identified and visualized in a corresponding figure during the analysis. This crucial parameter, which indicates the wavelength at which the solution exhibits maximum absorbance, plays a pivotal role in understanding the spectroscopic charecteristics of the extract. The absorption profile, represented by the of λ max, offers valuable insights into the specific wavelengths at which the constituents of *Psoralea corylifolia* effectively absorb light. It's worth nothing that the of λ max of *Psoralea corylifolia* is also determined in the same experimental setup, with its maximum absorbance identified at 254 nm. The of λ max values, illustrated in the figure, contribute to a comprehensive understanding of the UV absorption behavior of *Psoralea corylifolia* extract.

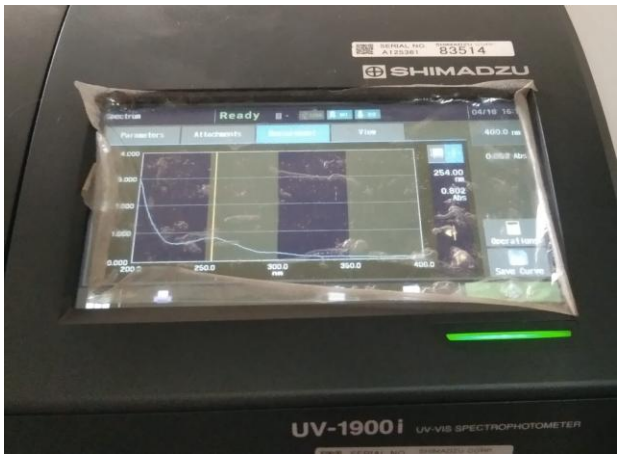

Fig.12 UV Spectroscopy Characterization of Pure Extract of *Psoralea corylifolia*

6. Invitro Anti-Inflammatory Activity by Protein Denaturation Method:

Observation Table-

Table No.8 Anti-inflammatory Test by Protein Denaturation Assay

			Protein Denaturation Assay					
Sr. No.	Sample code	Concentration (µg/ml)	Absorbance at 660 nm					
			Test 1	Test 2	Test 3	Mean	% of Inhibition	IC_{50} (µg/ml)
1	Control		1.54	1.54	1.54	**1.54**	-	
2	Standard (Diclofenac Sodium)	20	1.20	1.20	1.22	**1.20**	**22.08%**	
		40	0.91	0.89	0.93	**0.91**	**40.91%**	**52.21**
		60	0.67	0.65	0.63	**0.65**	**57.79%**	
		80	0.40	0.37	0.44	**0.40**	**74.03%**	
		100	0.21	0.18	0.23	**0.20**	**87.01%**	
3	Hydrogel	20	1.42	1.45	1.40	**1.42**	**7.79%**	
		40	1.27	1.33	1.34	**1.31**	**14.94%**	
		60	1.12	1.19	1.17	**1.16**	**24.68%**	**94.16**
		80	0.91	0.95	0.99	**0.95**	**38.31%**	
		100	0.68	0.72	0.63	**0.68**	**55.84%**	

Graphical Data-

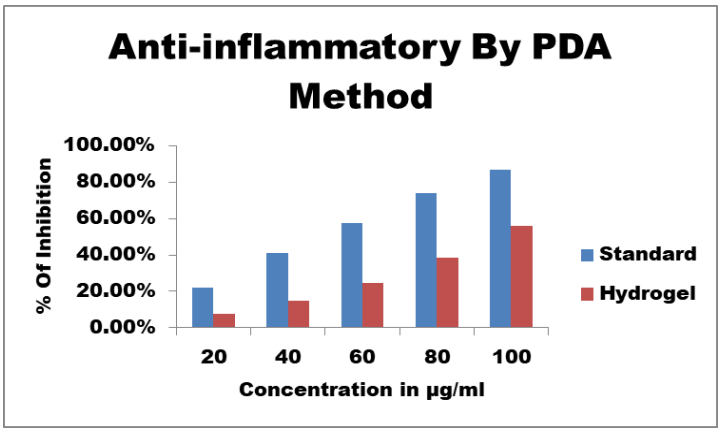

Fig.13 Graphical representation of anti-inflammatory activity of standard and test

Images of The Activity -

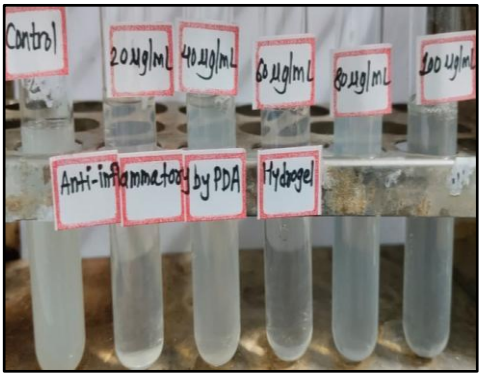

Fig.14 Anti-inflammatory assay by PDA method

Conclusion of Anti-Inflammatory Activity-

The presented data for the anti-inflammatory activity assessed by the protein denaturation assay (PDA method) shows a clear concentration-dependent inhibition of protein denaturation for both the standard drug and the hydrogel formulation. As the concentration increases from 20 to 100 µg/ml, the percentage inhibition steadily rises in both cases, indicating enhanced anti-inflammatory potential at higher doses. The standard exhibits stronger activity across all concentrations, with inhibition increasing from around 20% at 20 µg/ml to approximately 85–90% at 100 µg/ml. In comparison, the hydrogel shows a gradual increase from about 8–10% to nearly 55–60% inhibition over the same concentration range. Although the hydrogel demonstrates comparatively lower activity than the standard, it still exhibits significant inhibitory effects, confirming its moderate anti-inflammatory potential. Overall, the results suggest that the hydrogel formulation possesses dose-dependent anti-inflammatory activity, likely due to its ability to stabilize proteins and prevent denaturation, though its efficacy is less potent than the standard reference compound.

CONCLUSION-

The present study successfully formulated and evaluated a herbal hydrogel containing *Psoralea corylifolia* and *Rosmarinus officinalis* extracts for topical anti-inflammatory application. The formulation was prepared using Carbopol 934 and evaluated for various physicochemical and biological parameters. Among the three prepared batches, F3 was found to be the optimized formulation, exhibiting suitable pH (5.11), acceptable viscosity (5327cP), good spreadability, and uniform consistency, making it appropriate for dermal application. In contrast, batches F1 and F2 were not selected due to their low viscosity and non-acceptable pH, which may lead to poor skin retention and potential irritation. The in vitro drug release study demonstrated controlled and sustained release behavior, indicating the effectiveness of the hydrogel as a drug delivery system. Furthermore, the anti-inflammatory activity assessed by the protein denaturation method showed concentration-dependent inhibition. Although the activity was lower compared to the standard drug (diclofenac sodium), the formulation exhibited significant anti-inflammatory potential, likely due to the synergistic action of phytoconstituent. In conclusion, the developed herbal hydrogel represents a promising, biocompatible, and effective topical delivery system for managing inflammation. However, further in vivo studies and clinical evaluations are required to establish its therapeutic efficacy and safety.

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