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Research Article

Formulation and Evaluation of Rosemary Hydrogel for Inflammation

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Abstract

The primary goal of this study is to develop and assess an herbal anti-inflammatory hydrogel utilizing ethanolic extracts derived from *Rosmarinus officinalis* and *Curcuma longa*. The hydrogels were formulated using Carbopol 934, varying concentrations of rosemary and turmeric extracts, propylene glycol, methylparaben, propylparaben, sodium benzoate, and distilled water as per requirement. Triethanolamine was incrementally added to maintain the skin's pH. The prepared formulations underwent assessment for physical appearance, pH levels, spreadability, viscosity, homogeneity, and skin irritation. The herbal hydrogel exhibited a synergistic effect in comparison to individual gels, suggesting its potential utility in treating local inflammation.

Keywords: Hydrogel; Inflammation; Herbal

Introduction

Inflammation presents a multifaceted process often linked with pain, encompassing events like heightened vascular permeability, increased protein denaturation, and membrane modifications [1]. This defensive reaction is typified by redness, pain, heat, swelling, and impaired function in the affected region [24]. Primary triggers for inflammation include infections, burns, trauma, and various immune responses [2].

In this current study, the hydrogel formulation incorporates multiple active ingredients, including herbal extracts from *Rosmarinus officinalis* and *Curcuma longa* [25]. These botanical extracts are known to possess anti-inflammatory properties individually [26]. However, when combined, they exhibit synergistic effects, enhancing their ability to reduce inflammation. This synergism not only improves the therapeutic outcomes but also offers additional benefits to patients, such as potentially faster relief and a broader spectrum of anti-inflammatory activity [3].

Rosemary (*Rosmarinus officinalis L.*)

Family – Lamiaceae.

Figure 1: *Rosmarinus officinalis.*

Biological source - It is extracted through distillation from the flowering tops of the leafy twigs of *Rosmarinus officinalis* [4].

Rosemary (*Rosmarinus officinalis* L.) is a perennial shrub belonging to the Lamiaceae family. In its natural habitat, it can grow to heights ranging from approximately 1 meter to as tall as 2.5 meters [5]. The plant stems are four-sided (quadrangular), upright, and tend to become woody in their second year. They are densely adorned with small, needle-like leaves that lack stalks (sessile).

These leaves are linear in shape, with smooth edges that may slightly curl inward (revolute). They exhibit a dark green coloration on the upper surface and are lighter in color with a tomentose (hairy) texture on the underside [6].

Rosmarinus officinalis has demonstrated potent anti-inflammatory properties in numerous studies [27]. Both rosemary essential oil and extract have been shown to significantly inhibit the migration of leukocytes (white blood cells) *in vivo*, thereby reducing their accumulation at the site of inflammation and eliciting an anti-inflammatory response [28]. Additionally, rosemary extract has inhibited other pro-inflammatory substances, including nitric oxide and inflammation-associated genes [7].

While compounds like carnosol and carnosic acid stand out for their importance in these effects, the anti-inflammatory activity of rosemary likely arises from a synergistic interplay among its various components [22]. Research indicates that the anti-inflammatory potency of *R. officinalis* is notably robust; in fact, studies have revealed that the anti-inflammatory activities of pure carnosol and carnosic acid are nine times higher than that of indomethacin, a commonly used anti-inflammatory medication [8].

Turmeric (*Curcuma longa*)

Figure 2: *Curcuma longa.*

Family – Zingiberaceae.

Biological source – It is dried rhizome of *Curcuma longa* Linn [9].

Turmeric is often hailed as the "golden spice" due to its remarkable array of health benefits [10]. *Curcuma longa* L., commonly known as turmeric, is a rhizomatous herbaceous perennial plant that typically reaches a height of three to five feet [29]. It is cultivated extensively in various regions across Asia, including India, China, and other countries with tropical climates [11].

Curcumin, a natural compound found in turmeric, holds tremendous promise for the treatment of various diseases. Numerous studies have highlighted its diverse biological activities, with its anti-inflammatory effects being particularly noteworthy [12].

Curcumin exhibits anti-inflammatory, anti-oxidative, and immunomodulatory properties [30]. It functions by inhibiting T cell activation, proliferation, and the production of pro-inflammatory factors [13]. This action is achieved through its interaction with key signaling pathways such as MAPKs (Mitogen-Activated Protein Kinases), AP-1 (Activator Protein 1), and NF-κB (Nuclear Factor kappa-light-chain-enhancer of activated B cells). By modulating these pathways, curcumin helps to dampen inflammatory responses and alleviate inflammation-associated conditions [14].

Methods and Preparation

Soxhlet method

Extraction of *Rosmarinus officinalis*

- Weigh out 20 grams of dried rosemary.
- Place the dried rosemary in a thimble-shaped filter paper.
- Set up the Soxhlet apparatus by attaching a water condenser to the top of the Soxhlet extractor.
- Add 200 ml of ethanol solvent to the round-bottom flask of the Soxhlet apparatus.
- Place the thimble containing the rosemary in the Soxhlet extractor.
- Heat the round-bottom flask containing the ethanol solvent to 60°C using a heating mantle.
- Allow the Soxhlet apparatus to operate for 8 hours. During this time, the solvent will vaporize, rise to the top of the apparatus, condense in the water-cooled condenser, and drip down onto the rosemary material in the thimble.
- The condensed solvent will extract the active compounds from the rosemary material as it cycles through the Soxhlet apparatus.

- After 8 hours, the extract will collect in the round-bottom flask, containing the desired compounds from the rosemary.
- Carefully remove the round-bottom flask from the heating mantle and allow it to cool before further processing or analysis.

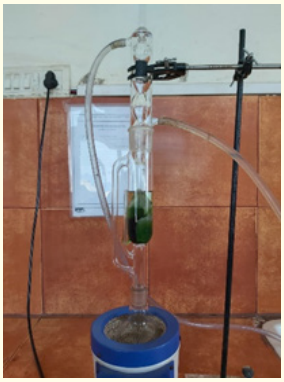

Figure 3: *Curcuma longa.*

Extraction of *Curcuma longa*

- Weigh out 20 grams of dried curcuma.
- Place the dried rosemary in a thimble-shaped filter paper.
- Set up another Soxhlet apparatus by attaching a water condenser to the top of the Soxhlet extractor.
- Add 200 ml of ethanol solvent to the round-bottom flask of the Soxhlet apparatus.
- Place the thimble containing the rosemary in the Soxhlet extractor.
- Heat the round-bottom flask containing the ethanol solvent to 60°C using a heating mantle.
- Allow the Soxhlet apparatus to operate for 8 hours. During this time, the solvent will vaporize, rise to the top of the apparatus, condense in the water-cooled condenser, and drip down onto the rosemary material in the thimble.
- The condensed solvent will extract the active compounds from the rosemary material as it cycles through the Soxhlet apparatus.
- After 8 hours, the extract will collect in the round-bottom flask, containing the desired compounds from the rosemary.
- Carefully remove the round-bottom flask from the heating mantle and allow it to cool before further processing or analysis.

Figure 4: Curcuma extraction.

Procedure for centrifugation

- Fill the tube of the centrifuge machine with both extracts, ensuring that the tubes are filled evenly to maintain balance during centrifugation.
- Cap the tubes securely to prevent any leakage during centrifugation.
- Place the filled tubes inside the centrifuge machine, ensuring they are positioned symmetrically to maintain balance.
- Close the cover of the centrifuge machine securely to ensure safe operation.
- Set the centrifuge machine to run at a speed of 2500 rpm (revolutions per minute).
- Start the centrifuge machine and allow it to run for 15 minutes at the specified speed.
- During centrifugation, the machine will rapidly spin the tubes, causing the denser components of the extracts to settle at the bottom of the tubes.
- After 15 minutes, carefully stop the centrifuge machine and wait for it to come to a complete stop before opening the cover.
- Once the centrifugation process is complete, remove the tubes from the centrifuge machine and handle the extracted samples as needed for further analysis or processing.

Filtration of extracts

After centrifugation, both extracts should be filtered using a funnel and Whatman filter paper.

Preparation of hydrogel

Table 1: Formula for hydrogel.

S. No.	Ingredients	Quantity Taken (%)
1.	Carbopol 934	5%
2.	Propylene glycol	5%
3.	Propyl paraben / methyl paraben	1%
4.	Triethanolamine	0.5%
5.	Sodium benzoate	0.5%
6.	Distilled water	70%
7.	Rosemary extract	10%
8.	Curcuma extract	8%

Procedure

- Carbopol 934, accurately weighed, was placed in a beaker and dispersed in 50 ml of distilled water. The beaker was then set aside to allow the Carbopol to swell for 30 minutes. Subsequently, mechanical or lab stirring at 1200 rpm was performed for an additional 30 minutes.
- In another beaker, 5 ml of propylene glycol and the required amount of extract were combined. Separately, another 5 ml of propylene glycol was taken in a beaker, and weighed quantities of propyl paraben and methyl paraben were added and thoroughly stirred.
- Once the Carbopol was fully dispersed, herbal extracts and the preservative solutions were added to the mixture while stirring constantly. Finally, the volume was adjusted to 100 ml by adding the remaining distilled water. Triethanolamine was then added dropwise to the formulations to achieve the desired skin pH range of 6.8-7 and to attain the gel at the desired consistency.

Evaluation parameters

The prepared hydrogel underwent evaluation for various parameters, including appearance, pH, consistency, spreadability, extrudability, viscosity, and irritability [15].

Appearance

The herbal hydrogel that was prepared underwent assessment for its odor and color. It was observed that the color of the hydrogel appeared greenish yellow, and its odor was noted to be characteristic [16].

Figure 5: Herbal hydrogel product.

Ph

The pH of the prepared hydrogel was determined by applying a small amount of the hydrogel onto pH paper. The pH paper indicated a pH value of 7.0 for the hydrogel [17].

Spreadability

To assess the spreadability of the hydrogel, a small amount was placed on a glass slide, followed by the placement of another glass slide on top of the hydrogel. A wooden weight was then applied onto the upper glass slide to facilitate spreading [23]. The time taken for the hydrogel to spread and the resulting area covered were measured. These measurements provide insights into the efficiency of the hydrogel's spreadability [18].

Extrudability

A small amount of hydrogel was inserted into a collapsible ointment tube, with one end sealed and the other end left open. Gentle pressure was applied to the closed end of the tube. The time taken for the hydrogel to extrude and the quantity of gel extruded were observed and recorded [19].

Viscosity

The viscosity of the hydrogel was measured using a Brookfield viscometer [20].

Irritability

A small amount of the hydrogel was applied to the skin and left for a few minutes. After observation, it was determined that the hydrogel was non-irritating [21].

Result

Table 2: Evaluation of hydrogel.

S. NO.	Parameters	Observation
1.	Colour	Greenish yellow
2.	odor	Characteristics
3.	Consistency	Good
4.	pH	7.0
5.	Viscosity	1.4580 poise
6.	Spreadability	6.72g.cm/sec
7.	Irritability	Non irritant
8.	Extrudability	Easily extruded

Conclusion

The present study aims to develop a hydrogel for anti-inflammatory activity. Hydrogel-based delivery systems are versatile and can be applied orally, ocularly, epidermally, or subcutaneously due to their high water content and soft consistency, resembling natural living tissue more closely than other synthetic biomaterials. Recent advancements in polymer science and technology have led to the development of various stimuli-sensitive hydrogels, including pH and temperature-sensitive hydrogels. A novel approach involves immobilizing different proteins simultaneously, expanding the potential applications of hydrogels.

Hydrogels with unique properties will continue to play a crucial role in drug delivery and tissue regeneration. Rosemary leaf hydrogel, known for its anti-inflammatory properties, is utilized to alleviate pain, and irritation, promote wound healing, and hydrate the skin. Incorporating it into daily skincare routines can enhance overall skin health. The developed hydrogel was evaluated using various parameters and found to be satisfactory for skin application, offering the potential to promote healthy, glowing skin without adverse effects.

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