Formulation and Evaluation of Herbal Hydrogel Containing *Dodonaea viscosa* Linn. Extract for Treatment of Inflammation

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***Abstract*—Background: Herbal medicine delivery methods are safe, effective, and have fewer side effects, they have attracted a lot of attention. The medicinal plant *Dodonaea viscosa* Linn. has anti-inflammatory, antioxidant, and wound-healing qualities.**

Objective: The present study was undertaken to develop and evaluate a herbal hydrogel containing *Dodonaea viscosa* Linn. extract for the management of inflammatory conditions.

Materials and Methods: The Soxhlet extraction method was used after gathering, shade-drying, and powdering the leaves of *Dodonaea viscosa* Linn. Carbopol 934 was used to manufacture the hydrogel, which was then assessed for a number of physicochemical characteristics, including as appearance, pH, viscosity, spreadability, homogeneity, and stability. To find the presence of bioactive components, phytochemical screening was carried out. Diclofenac sodium was used as the reference standard in the protein denaturation assay to evaluate the hydrogel's anti-inflammatory properties.

Results: Flavonoids and diterpenoids were identified in the extract using phytochemical screening. The formulated hydrogel exhibited satisfactory physicochemical characteristics, including a skin-compatible pH of 6.7, viscosity of approximately 32,500 cP, and spreadability of 12.5 g·cm/sec. Stability studies revealed no significant changes in the physicochemical properties of the formulation during the study period. Furthermore, Promising anti-inflammatory action was shown by the hydrogel's concentration-dependent reduction of protein denaturation, which increased from 10.39% at 20 µg/ml to 59.09% at 100 µg/ml.

Conclusion: The created *Dodonaea viscosa* Linn. herbal hydrogel showed excellent physicochemical properties, stability, and encouraging anti-inflammatory activity, implying its potential as a safe and effective topical formulation for managing inflammatory conditions.

***Index Terms*—Dodonaea viscosa Linn., Herbal Hydrogel, Anti-inflammatory Activity, Topical Drug Delivery.**

I. INTRODUCTION

Inflammation is a complex biological response of the body to tissue injury, infection, or harmful stimuli. Prolonged or severe inflammation can cause tissue damage and a number of clinical disorders, even if it acts as a protective mechanism. Although conventional anti-inflammatory medications are frequently used to treat inflammatory conditions, long-term use of these medications is frequently linked to side effects such kidney damage, gastrointestinal discomfort, and other systemic issues. (1)

Herbal medicine plays crucial role in keeping up the health and wealth of mankind. Larger part of world population uses herbal drugs. The World Health Organization (WHO) reports that around 21,000 plants have been used for therapeutic purposes

Herbs have proven their worth over time due to their safety, effectiveness, cultural acceptance, and minimal side effects. (3)

Herbal medicines have gained increasing attention as alternative therapeutic agents due to their safety, efficacy, affordability, and reduced side effects. (2,4)

Numerous bioactive components found in medicinal plants have strong pharmacological effects, such as

anti-inflammatory, antioxidant, antibacterial, and wound-healing qualities. [5]

Dodonaea viscosa Linn., a member of the family Sapindaceae, is a well-known medicinal plant traditionally used for the treatment of various ailments. [6] Flavonoids, diterpenoids, tannins, and other bioactive substances that support its medicinal potential have been identified by phytochemical studies. [6,7,8] Its anti-inflammatory, antioxidant, antibacterial, analgesic, and wound-healing properties have been documented in a number of research. [9,10,11]

Hydrogels are three-dimensional networks of polymers that can hold a lot of water without losing their structural integrity. [12,13] Because of their excellent biocompatibility, ease of application, and prolonged residence time on the skin, hydrogels are widely employed as topical drug delivery systems. [14] Recent studies have shown that herbal hydrogels can enhance the therapeutic efficacy of plant extracts and improve patient compliance. [15,16,17]

Thus, the goal of this work was to create and assess a herbal hydrogel that contains *Dodonaea viscosa* Linn. extract and to investigate its anti-inflammatory potential through physicochemical evaluation and protein denaturation assay.

II.SUPPLIES AND PROCEDURES

2.1 Gathering and Verifying Plant Material

Fresh *Dodonaea viscosa* Linn. leaves were gathered from the Sangli district of Maharashtra, India. After being properly cleaned with distilled water to get rid of dirt and other contaminants, the gathered leaves were shade-dried. A mechanical grinder was used to powder the dried leaves, which were then kept in an airtight container for later use. [10]

2.2 Preparation of Plant Extract

Soxhlet extraction was performed on powdered *Dodonaea viscosa* Linn. leaves using ethanol as the extraction solvent. [6,10] The extraction process was continued until complete extraction was achieved. The obtained extract was concentrated by evaporating the solvent and stored in a desiccator until further use. [6]

2.3 Phytochemical Screening

Using conventional qualitative techniques, the ethanolic extract of *Dodonaea viscosa* Linn. was put through a preliminary phytochemical screening to identify different bioactive ingredients, including flavonoids, diterpenoids, alkaloids, tannins, glycosides, and phenolic compounds. [8]

2.4 Herbal Hydrogel Formulation

Carbopol 934 was used as the gelling agent to create the herbal hydrogel. [13] With constant stirring, the necessary amount of Carbopol 934 was dissolved in distilled water. [12] The ethanolic extract of *Dodonaea viscosa* Linn. was incorporated into the hydrated polymer base. To create a homogenous hydrogel with the right consistency, the formulation's pH was changed and suitable excipients were added. [15,16,17]

Table 1: Formulation Table

Sr. No	Ingredients	F1	F2	F3	F4
1.					
2.		1.5	1.6	2	1
3.	Extract of *Dodonaea Viscosa* Linn.	375	375	375	375
4.	Carbopol 934 (mg)	5	5	5	5
5.	Propylene Glycol (ml)	1	1	1	1
6.	Glycerine (ml)	0.18	0.18	0.18	0.18
7.	Methyl Paraben (gm)	0.02	0.02	0.02	0.02
8.	Propyl Paraben (gm)	1	1	1	1
9.	Triethanolamine (ml)	Q.S	Q.S	Q.S	Q.S
	Distilled Water (ml)	Q.S	Q.S	Q.S	Q.S
	Menthol				

III. OUTCOMES AND CONVERSATION

3.1 Screening for Phytochemicals

Initial phytochemical analysis of *Dodonaea viscosa* Linn's ethanolic extract confirmed the presence of flavonoids and diterpenoids. Positive results were obtained in the Shinoda, alkaline reagent, and lead acetate tests for flavonoids, while bromine and Salkowski tests confirmed the presence of diterpenoids. These results are in line with earlier research showing that *Dodonaea viscosa* Linn contains flavonoids, phenolic compounds, diterpenoids, and other bioactive components that have a variety of pharmacological actions, such as anti-inflammatory and antioxidant effects. [7,9] These phytoconstituents may enhance the hydrogel's medicinal efficacy.

3.2 Physical Evaluation of Hydrogel

The prepared hydrogel exhibited a greenish to pale-yellow colour with a characteristic herbal odour. The formulation showed a smooth semi-solid texture, non-greasy nature, and uniform appearance without any visible signs of phase separation or aggregation. These observations indicate successful incorporation of the plant extract into the Carbopol gel matrix and suggest acceptable aesthetic characteristics for topical application.

Similar observations have been reported for herbal hydrogel formulations prepared using Carbopol polymers, were smooth texture and non-greasy characteristics improved patient acceptability and compliance. [16,18]

3.3 pH Determination

The pH of the optimized hydrogel formulation was found to be 6.7, which is within the normal physiological range of skin pH (4.5–7.0). Maintaining pH close to that of the skin is essential to minimize irritation and enhance compatibility during topical administration. [19]

The obtained result suggests that the formulation is suitable for prolonged topical application without causing significant disturbance to the natural skin barrier.

3.4 Viscosity Study

The viscosity values obtained for the hydrogel samples were 32,400 cP, 32,550 cP, and 32,600 cP, with an average viscosity of approximately 32,500 cP. The high viscosity observed may be attributed to the efficient gel-forming properties of Carbopol 934, which forms a stable three-dimensional polymeric network upon neutralization with triethanolamine.

An appropriate viscosity is necessary to ensure prolonged residence time at the site of application and to prevent rapid runoff of the formulation from the skin surface. [15] The viscosity value obtained in the present study indicates adequate consistency and suitability for topical drug delivery.

3.5 Spreadability

The spreadability of the hydrogel was found to be 12.5 g·cm/sec. Good spreadability is a desirable characteristic for topical formulations because it facilitates easy application and uniform distribution of the medicament over the affected area. [20]

The observed spreadability may be attributed to the balanced concentration of Carbopol 934, glycerine, and propylene glycol, which provided adequate rheological properties while maintaining user convenience. Similar findings have been reported for other herbal hydrogel formulations developed for topical therapeutic applications. [16]

3.6 Homogeneity

The formulated hydrogel exhibited excellent homogeneity with a smooth and uniform appearance. No evidence of lumps, coarse particles, or phase separation was observed throughout the formulation.

Homogeneity is an important parameter that ensures uniform distribution of active constituents within the formulation and contributes to dose consistency during application. [18] The present findings indicate successful formulation development and proper incorporation of the extract into the gel base.

3.7 Stability Studies

At 40 ± 2°C and 75 ± 5% relative humidity, accelerated stability testing was conducted. Following storage, the viscosity altered from 32,400 cP to 32,200 cP and the pH marginally dropped from 6.7 to 6.2. There were no discernible alterations in colour, texture, homogeneity, or phase separation.

These findings indicate that the formulation retained its physicochemical integrity during storage. The minor variations observed in pH and viscosity remained within acceptable limits and did not

adversely affect the quality of the formulation. Similar stability profiles have been reported for Carbopol-based herbal hydrogels. [15,21]

3.8 In vitro Reduction of Inflammation

The protein denaturation assay method was used to assess the hydrogel's anti-inflammatory efficacy. The formulation exhibited concentration-dependent inhibition of protein denaturation. The percentage inhibition also markedly increased when the concentration rise from 20 µg/mL to 100 µg/mL. The hydrogel demonstrated a 59.09% reduction of protein denaturation at a dose of 100 µg/mL, while the conventional medication Diclofenac sodium demonstrated an 87.01% inhibition at the same concentration.

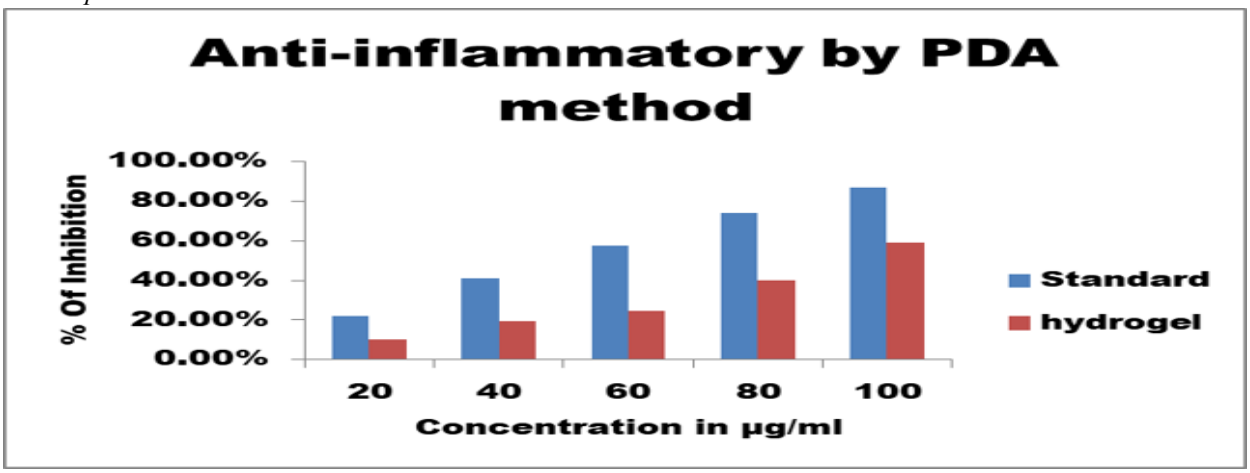
Diclofenac sodium had an IC50 value of 52.21 µg/mL, while the hydrogel's IC50 value was 90.91 µg/ml. Although the standard drug demonstrated stronger activity, the hydrogel showed significant inhibitory effects at higher concentrations.

Dodonaea viscosa Linn. extracts have been shown to have strong anti-inflammatory properties in both in-vitro and in-vivo models in earlier research, which supports the findings of this study. Consequently, the herbal hydrogel's therapeutic potential is confirmed by the observed inhibition of protein denaturation.

Table 2: Observation Table

SR.NO	Sample code	Concentration (µg/mL)	Protein Denaturation Assay					
			Absorbance at 660 nm				% of Inhibition	IC_{50} (µg/mL)
			Test 1	Test 2	Test 3	Mean		
1	Control	20	1.54	1.54	1.54	1.54	-	
2	Standard (Diclofenac Sodium)	40	1.20	1.20	1.22	1.20	22.08%	52.21
		60	0.91	0.89	0.93	0.91	40.91%	
		80	0.67	0.65	0.63	0.65	57.79%	
		100	0.40	0.37	0.44	0.40	74.03%	
			0.21	0.18	0.23	0.20	87.01%	
3	Hydrogel	20	1.39	1.34	1.42	1.38	10.39%	90.91
		40	1.27	1.24	1.21	1.24	19.48%	
		60	1.12	1.18	1.17	1.16	24.68%	
		80	0.88	0.91	0.96	0.92	40.26%	
		100	0.63	0.65	0.61	0.63	59.09%	

3.9 Graphical Data



IV. DISCUSSION

The present study successfully formulated a Carbopol 934-based herbal hydrogel containing *Dodonaea viscosa* Linn. extract and evaluated its physicochemical and biological characteristics. The formulation exhibited desirable properties including appropriate pH, satisfactory viscosity, excellent spreadability, and good homogeneity. These characteristics are important for ensuring patient acceptability and effective topical delivery.

Furthermore, the hydrogel demonstrated significant concentration-dependent anti-inflammatory activity. The biological activity observed can be correlated with the phytochemical composition of *Dodonaea viscosa* Linn, particularly the presence of flavonoids and diterpenoids, which are well documented for their anti-inflammatory effects. The formulation's suitability for storage and practical usage was further validated by the stability experiments.

Overall, the results point to *Dodonaea viscosa* Linn. hydrogel as a potentially safe, stable, and useful herbal substitute for the treatment of inflammatory diseases. However, further in-vivo studies and clinical investigations are recommended to establish its therapeutic efficacy and safety in human subjects.

V. CONCLUSION

The present study successfully formulated and evaluated a *Dodonaea viscosa* Linn. extract-loaded herbal hydrogel for topical anti-inflammatory application. The hydrogel exhibited satisfactory physicochemical properties, including suitable pH, good viscosity, excellent spreadability, homogeneity, and stability. The presence of flavonoids and diterpenoids, which are in charge of the therapeutic action, was verified by phytochemical screening. In the protein denaturation test, the formulation demonstrated strong concentration-dependent anti-inflammatory efficacy, with 59.09% inhibition at 100 µg/mL. These results imply that the created hydrogel is a potential and successful herbal topical formulation for the treatment of inflammatory diseases and call for additional in-vivo and clinical research.

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