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Formulation and Evaluation of an Anti-Inflammatory Herbal Gel from Moringa Oleifera Leaves Extract

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Abstract: ***Background:*** *The present study was aimed at the formulation and evaluation of an anti-inflammatory herbal gel containing Moringa oleifera leaves extract. Inflammation is a common physiological response associated with pain, redness, swelling, and tissue damage. Conventional anti-inflammatory drugs are effective but may produce adverse effects such as gastric irritation, ulceration, and kidney toxicity during long-term use. Therefore, herbal medicines have gained increasing attention due to their safety, effectiveness, and fewer side effects.*

Moringa oleifera is a medicinal plant rich in flavonoids, phenolic compounds, tannins, alkaloids, and isothiocyanates, which possess significant anti-inflammatory and antioxidant properties. In the present work, Moringa oleifera leaves were collected, dried, powdered, and extracted using a suitable solvent extraction method. The obtained extract was incorporated into a gel base prepared using Carbopol 934 and Hydroxypropyl methylcellulose K4M (HPMC K4M) as a gelling agent along with other excipients such as propylene glycol, methyl paraben, and triethanolamine. The formulated herbal gel was evaluated for various physicochemical parameters including appearance, color, homogeneity, pH, viscosity, spreadability, and extrudability.. The formulated gel showed good homogeneity, acceptable pH, satisfactory spreadability, and stability. The anti-inflammatory study demonstrated significant inhibition of protein denaturation, indicating effective anti-inflammatory potential of the herbal formulation. The results suggest that Moringa oleifera leaves extract can be successfully formulated into a stable and effective topical anti-inflammatory gel. Thus, the herbal gel may serve as a safer and cost-effective alternative to conventional topical anti-inflammatory preparations.

Keywords: Moringa Oleifera, Gel, Anti-inflammatory Activity, Extract.

I. INTRODUCTION

Topical drug delivery systems are gaining increased in popularity, and several drugs have been successfully delivered by this route for both local and systemic action. Gels have better potential as a vehicle to administer drug topically in comparison to the ointment because they are non-sticky, requires low energy during formulation [1]. Drug delivery through the skin has been a promising concept for a long time because the skin is easy to access, has a large surface area with vast exposure to the circulatory and lymphatic networks and the route is non-invasive. Gel consists of a natural or synthetic polymer forming a three-dimensional matrix throughout a dispersion medium or hydrophilic liquid. After application, the liquid evaporates leaving the drug entrapped in a thin film of the gel–forming matrix physically covering the skin . The presence of a network formed by the interlocking of particles of the gelling agent gives rise to the rigidity of a gel. The nature of the particles and the type of form that is responsible for the linkages determine the structure of the network and the property of the gel [2,3]. Moringa oleifera has been reported to possess anti-inflammatory activity mainly due to the presence of flavonoids because flavonoids act as antioxidant and potential

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inhibitors of cyclooxygenase, lipoxygenase, and nitric oxide synthase . Topical drug delivery systems such as gels are preferred for the treatment of inflammation because they provide localized action, improved patient compliance, easy application, and faster absorption through the skin. Herbal gels are non-greasy, easily washable, and capable of delivering active constituents directly to the affected site with reduced systemic side effects. Therefore, formulation of a herbal gel using Moringa oleifera leaves extract can be considered as a promising and effective approach for anti-inflammatory therapy.[4]

Anti-Inflammatory Activity Of Moringa Oleifera

Moringa oleifera, commonly known as drumstick tree or miracle tree, is an important medicinal plant belonging to the family Moringaceae. The leaves of Moringa oleifera are rich in phytoconstituents such as flavonoids, tannins, alkaloids, saponins, vitamins, minerals, and phenolic compounds. These constituents exhibit various pharmacological activities including anti-inflammatory, antioxidant, antimicrobial, and wound healing properties. Due to these medicinal properties, Moringa oleifera leaves are widely used in traditional and modern herbal medicine.

M.oleifera leaves, flowers, roots, gums, fruits, and seeds are all used to treat inflammation. Anti inflammatory and hepatoprotective effects have been found in various M. oleifera tissues.[5]

II. MATERIAL AND METHOD

2.1. Materials

Table No.1.Chemical Used In Formulation of Gel

SR.NO.	Drug/Excipients	Uses
1.	Moringa oleifera	Anti-Inflammatory
2.	Carbopol 934	Polymer
3.	HPMC K4M	Polymer
4.	Triethanolamine	Emulsifier
5.	Methyl parabean	Preservative
6.	Propyl parabean	Preservative
7.	Purified Water	Solvent

Table No. 2. Instrument Used For the Preparation of Herbal Gel

SR.NO.	NAME	MAKE/MODEL
1.	Analytical Balance	Ace Electronic compact scale

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2.	pH meter	MK VI
3.	Mechanical Stirrer	LALCO scientific instrument AN ISO 9001:2008 CO.
4.	Homoginizer	LMHH-A102 Handheld
5.	Brookfield viscometer	DVNext
6.	Buchner Funnel	United Scientific JBF2000

2.2. Method

- **Collection of Plant**

The fresh leaves of moringa oleifera were collected from its natural habitat from Bramhapuri, Maharashtra in India

- **Preparation of Moringa Oleifera Leaves Extract**

The powdered leaves were macerated by transferring the powder into aspirator bottle containing distilled water and mixture were allowed to stand for about 72 hours at room temperature with intermittent shaking to extract the active components. The resulting extract was drained through Whatman no. 1 filter paper. Following the solvent being removed with the rotary evaporator model, the crude extract underwent phytochemical analysis [6,7].

Fig.1 Extraction of Moringa Oleifera Leaves

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Phytochemical Screening

The analysis was carried out to determine the presence of the following: Alkaloids, tannins, terpenes, flavonoids, steroids, and saponins [8]

Alkaloids Test

The extract was diluted with 10% HCl, then filtered. Wagner's reagent (diluted iodine solution), 2 ml, and the filtrate extract (0.5 ml) were added to a test tube. A reddish-brown precipitate was seen forming in the reaction mixture which showed the presence of an alkaloid.

Steroids Test

A small amount of the extract was taken in a test tube and completely dissolved with a small amount of chloroform, and then a few drops of concentrated sulfuric acid were added to the test tube by the sides, this is Salkowski's method. The formation of a red colour confirmed the presence of steroids.

Saponin Test

The presence of saponin can be determined using the frothing test, which involves a small quantity of the extract dissolved in a small amount of distilled water in a test tube. The solution was shaken vigorously and observed for a stable, persistent froth, which indicates the presence of saponin.

Flavonoid Test

The presence of flavonoids was estimated by Shinoda. The extracts were treated with few drops of concentrated HCl and magnesium ribbon. The appearance of pink or tomato red colour within few minutes indicated the presence of flavonoids.

Tannin Test

The extract (2ml) was added to 1% lead acetate, a yellowish precipitate indicates the presence of tannins. Terpenoids Test The extract (2 ml) wastransfer into test tube and 1 ml of chloroform was added, followed by a few drops of concentrated sulphuric acid. A reddish brown precipitate produced immediately indicated the presence of terpenoids.

Fig.2 Phytochemical Screening of Moringa Oleifera

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Preparation of gel formulation

Various gel formulations were prepared from Moringa oleifera leaves extract using carbopol-934 alone, HPMC K4M alone and a mixture of carbopol-934, HPMC K4M as gelling agents. Gels were prepared by cold mechanical method described by Schmolka et al. [9]. Required quantity of polymer (Carbopol 934, HPMC K4M) was weighed individually, and sufficient amount of distilled water were mixed in a separate beaker, after which it was continuously stirred by mechanical stirrer till the polymer is soaked in the water and kept for 24 h at room temperature.

With continuous stirring, now the appropriate quantity of methyl parabean and propyl parabean was added which acts as a preservative. Small quantities of triethanolamine were added with continuous stirring to achieve neutral pH. Finally extract was added to gel with continuous stirring till drug get dispersed completely. The prepared gel was filled and sealed in the aluminium collapsible tube.

Table No.3.Composition of gel formulation

SR.NO.	INGREDIENTS	G1	G2	G3
1.	Moringa oleifera extract	5	5	5
2.	Carbopol 934	1.0	-	1.0
3.	HPMC K4M	-	1.0	1.0
4.	Triethanolamine	q.s	q.s	q.s
5.	Methyl parabean	1.5 ml	1.5 ml	1.5 ml
6.	Propyl parabean	0.5 ml	0.5 ml	0.5 ml
7.	Purified water	100 ml	1oo ml	100 ml

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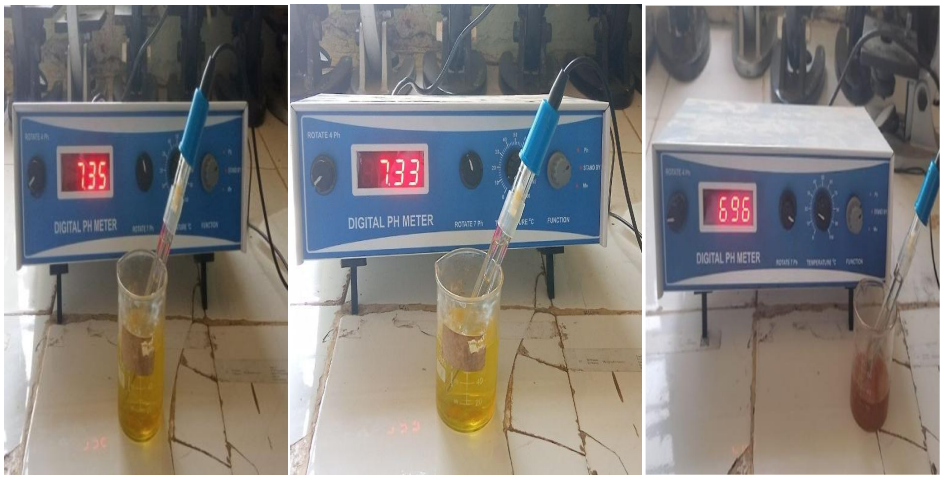
Fig.3 Preparation of Gel

Evaluation of gel formulations

Prepared formulations were evaluated for various physicochemical parameters such as colour, homogeneity, pH, spreadability, viscosity and drug content (total phenolic content).

Measurement of pH

5 gm of gel formulation was dispersed separately in 45 ml of water, and the pH of the suspension was determined using digital pH meter (digital pH meter, 335, systronics, Noroda, Ahmedabad). Measurements of pH of all formulations were carried out in triplicate and the averages of three readings were noted [10].



G1 **G2** **G3**

Fig.4 Measurement of pH

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Homogeneity

Homogeneity refers to the uniform distribution of components throughout a system, meaning that the composition and properties are the same in every part of the sample. A homogeneous system looks the same throughout, and you cannot distinguish its individual components with the naked eye.

Formulations were tested for homogeneity by visual inspection after the formulations have been set in the container. They were tested for their appearance and presence of any aggregates.

G1 **G2** **G3**

Fig.5 Measurement of Homogeneity

Measurement of viscosity

Viscosity of the gel is determined using a Brookfield viscometer with spindle No. 1, which is suitable for low to medium viscosity samples. In this method, the gel is placed in a clean beaker and maintained at a constant temperature to ensure accurate results. The spindle No. 1 is attached to the viscometer and immersed vertically into the gel up to the specified mark, ensuring that no air bubbles are present. The viscometer measures the (resistance) offered by the gel to the rotating spindle and displays the viscosity in centipoise (cP). [11]

G1 **G2** **G3**

Fig.6 Measurement of Viscosity

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Spreadability

Spreadability was determined by wooden block and glass slide apparatus [12]. The apparatus consists of a wooden block, which was provided by a pulley at one end. By this method, spreadability was measured on the basis of slip and drag characteristics of formulations. An excess of the formulation (about 2 g) was placed on this ground slide and then formulation was sandwiched between this slide and another glass slide (movable) having the dimension of fixed ground slide and provided with the hook. A weight of 50 g was placed on the top of the two slides for some time to expel air and to provide a uniform film of the gel between the slides. A shorter interval indicates better spreadability. Spreadability was calculated using the following formula:

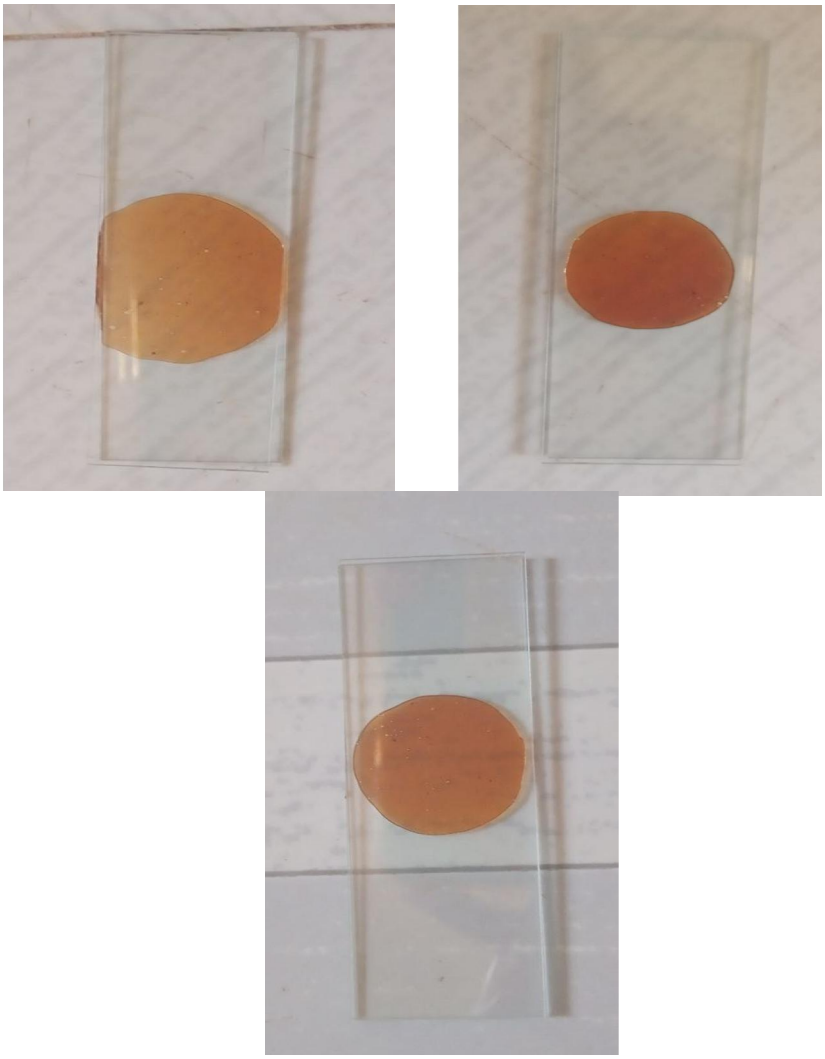
$$S = M \times L/T$$

Where, S = Spreadability

M = Weight in the pan (tied to the upper slide),

L = length of glass slide

T = Time (in sec.) taken to separate the slide completely each other



G1 G2 G3

Fig.7 Measurement of Spreadability

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III. RESULT

3.1. Result of the phytochemical screening

SR.NO.	Phytochemical Screening	Method	Result
1.	Alkaloid	Wagner's test	Present
2.	Steroid	Salkowski's test	Present
3.	Saponin	Fronting test	Present
4.	Flavonoid	Shinoda test	Present
5.	Tannis	Lead acetate test	Absent
6.	Terpene	Salkwoski's test	Present

3.2.Physicochemical evaluation of topical formulation of moringa oleifera

Formulation code	Colour	Homogenisity	pH	Spreadability g.cm/sec
G1	Brownish	Good	7.35	36.76
G2	Brownish	Good	7.33	38.27
G3	Brownish	Good	6.96	35.71

3.3. Measurement of viscosity of topical formulation moringa oleifera

Formulation Code	Viscosity (cps) at rpm 3	6	12	30
G1	83220	62000	40100	36270
G2	29000	25900	24000	11900
G3	26150	22580	15800	6460

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IV. DISCUSSION

Gel formulations were prepared using polymers such as carbopol-934 and HPMC K4M as gelling agent. Triethanolamine was used in formulations to neutralize the pH and methyl parabean; propyl parabean were used as preservatives. Gel formulations showed green colour, aromatic odour, good homogeneity and spreadability. The pH of gel formulations was in the range of 6.9-7.3 which lies in the normal pH range of the skin. The viscosity of gel formulation containing carbopol-934 alone as gelling agent was found to be high with less spreadability than gels formulated with HPMC K4M. Drug content of all the formulation was found to be more than 94%.

The present study focused on the formulation and evaluation of an anti-inflammatory herbal gel using Moringa oleifera leaves extract, with the aim of developing a safe and effective topical drug delivery system. The results obtained from the formulation and evaluation studies indicate that Moringa oleifera possesses significant potential as a natural anti-inflammatory agent due to its rich phytochemical composition. Preliminary phytochemical screening confirmed the presence of bioactive constituents such as flavonoids, tannins, phenolic compounds, and saponins. These compounds are well known for their ability to inhibit inflammatory mediators and reduce oxidative stress. Flavonoids and phenolic, in particular, play a major role in stabilizing free radicals and suppressing enzymes like cyclooxygenase (COX) and lipoxygenase (LOX), which are involved in inflammation pathways. The presence of these phytoconstituents supports the therapeutic potential of the extract. The formulated gel showed satisfactory physicochemical properties.

The pH of the gel was found to be within the acceptable range for topical application, indicating its compatibility with skin and reduced chances of irritation. The viscosity and spreadability of the gel were appropriate, ensuring ease of application and uniform distribution on the skin surface. Good homogeneity and absence of grittiness indicated proper incorporation of the extract into the gel base. Stability studies further suggested that the formulation remained stable under different storage conditions, with no significant changes in physical appearance, pH, or consistency. The in vitro anti-inflammatory activity of the formulated gel demonstrated significant inhibition of protein denaturation, which is a widely accepted method for screening anti-inflammatory agents.

V. CONCLUSION

Topical gels containing Moringa oleifera extract can be successfully prepared using carbopol-934 and HPMC K4M as gelling agents. The topical gel prepared from mixture carbopol-934 and HPMC K4M will be better gelling agent for making an ideal topical preparation. Moringa Oleifera Leaves extract in the form of gel possess significant topical anti-inflammatory properties, supporting their traditional use for the treatment.

The present work successfully demonstrated the formulation and evaluation of an anti-inflammatory herbal gel containing Moringa oleifera leaves extract. The phytochemical investigation confirmed the presence of important bioactive constituents such as flavonoids, tannins, and phenolic compounds, which are responsible for its anti-inflammatory activity. The formulated gel exhibited satisfactory physicochemical characteristics including appropriate pH, good viscosity, homogeneity, and excellent spreadability, making it suitable for topical application.

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