Formulation and Evaluation of Anti-inflammatory Herbal Gel containing Annona Squamosa Linn. Leaf Extract.

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***Abstract*—Herbal formulations have grown in importance because of their therapeutic efficacy and fewer side effects than synthetic drugs. The current study's objective was to use Annona squamosa Linn leaf extract to make and evaluate a topical anti-inflammatory herbal gel. The leaves were collected, dried in the shade, powdered into a powder, and then extracted by cold maceration using a hydroalcoholic solvent system. Pre-formulation research, including organoleptic evaluation, pH measurement, solubility tests, UV–visible spectrophotometric analysis, calibration curve development, and FTIR spectroscopy, were used to evaluate the extract's physicochemical properties and compatibility**

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***Index Terms*—Annona squamosa Linn., Anti-inflammatory activity, Carbopol 934, Herbal gel, Phytoconstituents**

I. INTRODUCTION

A physiological defensive mechanism against infections, toxins, and tissue damage is inflammation. On the other hand, prolonged inflammation can lead to skin diseases, dermatitis, edema, and arthritis. Traditional anti-inflammatory drugs like corticosteroids and NSAIDs can be beneficial, but they can also have unfavourable side effects include kidney damage, gastrointestinal distress, skin hypersensitive reactions, and ulcers [1]. As a result, numerous studies on safer herbal alternatives are being conducted.

The Annonaceae family includes the Custard Apple, or Annona squamosa Linn., which is found in many tropical nations, including India [2]. The leaves contain significant phytoconstituents such as flavonoids, alkaloids, acetogenins, glycosides, tannins, and phenolic compounds that have anti-inflammatory, antioxidant, antibacterial, analgesic, and wound-healing activities [3], [4]. Previous studies have related the anti-inflammatory characteristics of Annona squamosa leaf extract to the inhibition of inflammatory and antioxidant mediators [5].

Topical gels are widely used drug delivery systems because they provide localized action, better patient compliance, simplicity of administration, and fewer systemic adverse effects [6]. Carbopol-based herbal gels are particularly popular because to their superior viscosity, durability, and spreadability [7]. The current work was carried out to develop and evaluate an anti-inflammatory herbal gel using Annona squamosa Linn. leaf extract for topical administration.

II. LITERATURE REVIEW

Annona squamosa Linn.'s pharmacological and therapeutic properties have been extensively studied. Flavonoids, alkaloids, acetogenins, tannins, and phenolic compounds are responsible for the leaves' anti-inflammatory, antioxidant, antibacterial, analgesic, and wound-healing qualities [8]. Numerous studies have confirmed Annona squamosa's therapeutic potential in pharmaceutical formulations and herbal medicine [9], [10].

Research has demonstrated that Annona squamosa leaf extract has a potent anti-inflammatory impact by suppressing inflammatory mediators and reducing inflammation in animal models [11], [12]. GC-MS and phytochemical investigations revealed a variety of bioactive compounds that contribute to its

pharmacological effects [13], [14]. The leaves' antioxidant and anti-inflammatory qualities are mostly caused by flavonoids and phenolic compounds [15].

Topical herbal gels have become more important because to their targeted activity, improved spreadability, ease of administration, and less side effects [16]. Carbopol polymers are widely used as gelling agents due to their high viscosity, durability, and compatibility with herbal extracts [17]. Aloe vera gel is also commonly used in topical formulations because of its anti-inflammatory, moisturizing, and soothing properties [18], [19].

According to the literature review, Annona squamosa Linn. can be utilized in topical herbal formulations and has potent anti-inflammatory properties. Studies on anti-inflammatory herbal gels using Annona squamosa leaf extract, however, are scarce. The current study was initiated to develop and evaluate a stable herbal anti-inflammatory gel for topical use.

III. MATERIAL AND METHODS

1) Plant Materials

Fresh Annona squamosa Linn leaves. (Custard Apple) were collected from a healthy plant source in Pune, Maharashtra, India. The gathered leaves were thoroughly cleaned with distilled water to remove dust and other impurities before being dried and extracted.

2) Chemicals and Excipients

Analytical-grade ingredients and excipients were used in the formulation of the herbal gel. Aloe vera gel was used as a relaxing and moisturizing agent, triethanolamine as a pH-adjusting agent, carbopol 934 as a gelling agent, methyl and propyl paraben as preservatives, and propylene glycol and glycerin as humectants. Distilled water was used to make formulations and solutions during the experiment.

Table 1: List of chemicals used

Sr. No.	Chemicals/Ingredients
1	Annona squamosa Linn. Leaf Extract
2	Aloe vera Gel
3	Carbopol 934
4	Propylene Glycol
5	Glycerin
6	Methyl Paraben
7	Propyl Paraben
8	Triethanolamine
9	Distilled Water

IV. DRUG PROFILE OF ANNONA SQUAMOSA LINN.

Annona squamosa Linn., a member of the Annonaceae family, is widely distributed throughout tropical and subtropical regions of the world, including India, and is frequently referred to as Custard Apple or Sugar Apple. The plant has been used extensively in traditional medical systems because of its significant pharmacological and therapeutic properties [20]. The plant's many parts, including leaves, bark, roots, seeds, and fruits, have historically been used to treat wounds, inflammation, fever, ulcers, diarrhea, diabetes, and skin disorders *[21].*

Among the important phytoconstituents present in Annona squamosa leaves are alkaloids, flavonoids, acetogenins, glycosides, tannins, and phenolic compounds. Numerous biological actions, including as anti-inflammatory, antioxidant, antibacterial, analgesic, antidiabetic, and wound-healing properties, are attributed to these substances [22]. These pharmacological properties have made Annona squamosa leaf extract increasingly important in herbal medical formulations, particularly for topical anti-inflammatory treatments [23].

VI. FORMULATION OF HERBAL GEL

Carbopol 934 was used as the gelling agent in three anti-inflammatory herbal gel formulations that contained Annona squamosa Linn. leaf extract. Propylene glycol and glycerin were utilized as humectants, and aloe vera gel was added as a calming and hydrating agent. Triethanolamine was used to regulate pH, while methyl and propyl parabens were utilized as preservatives.

Table 2: composition of herbal gel formulations:

INGRRDIENTS	F1	F2	F3
Custard apple leaf extract	0.80 g	0.80 g	0.80 g
Aloe vera gel	2.0 g	2.0 g	2.0 g
Carbopol 934	0.40 g	0.36 g	0.30 g
Propylene glycol	2.0 g	1	1.2 g
Glycerine	2.0 g	1.6 g	1.2 g
Methyl paraben	0.072 g	0.072 g	0.072g

Propyl paraben	0.008 g	0.007 g	0.005 g
Triethanolamine	q.s.	q.s.	q.s.
Distilled water	q.s.	q.s.	q.s.

VI. FORMULATION OF HERBAL GEL

Step 1: Preparation of gel base

With constant stirring, precisely weighed Carbopol 934 was gradually dissolved in the necessary amount of distilled water. The dispersion was given between thirty and forty-five minutes to fully hydrate. After that, propylene glycol and glycerin were added and thoroughly blended. Propyl and methyl parabens were added to the mixture after being individually dissolved.

Step 2: Adding the active components

The hydrated gel basis was gradually mixed with the hydroalcoholic extract of Annona squamosa Linn. leaves while being gently stirred continuously. After that, fresh aloe vera gel was added to the mixture and thoroughly blended to ensure even distribution.

Step 3: Adjustment of PH

To get a smooth gel consistency, triethanolamine was added dropwise while being continuously stirred. The gel's pH was changed to a range that was suitable for skin.

Step 4: Final preparations

Distilled water was added to complete the total weight of the mixture. The resulting gel was properly mixed to achieve a uniform consistency before being placed in sanitary containers with clear labels for additional assessment.

Step 5: Preparation of different batches

Three different formulations (F1, F2, and F3) were prepared by varying the concentration of Carbopol 934, propylene glycol, and glycerin in order to optimize viscosity, spreadability, and consistency of the herbal gel formulation.

VII. EVALUATION OF FORMULATED HERBAL GEL

To ascertain if the generated herbal gel compositions were suitable for topical use, a number of physicochemical properties were assessed. Organoleptic properties, pH determination, viscosity measurement, spreadability test, skin irritation research, and stability assessment were among the evaluation tests.

1) Organoleptic Characteristics

A tiny amount of the prepared gel was put on a spotless glass slide, and its color, smell, texture, and appearance were all visually assessed in daylight. Additionally, the gel's homogeneity and consistency were manually assessed. Color, smell, texture, appearance, and homogeneity were all noted.

2) pH Determination

To get a homogeneous dispersion, one gram of gel was mixed with ten milliliters of distilled water and thoroughly swirled. Standard buffer solutions with pH values of 4, 7, and 9 were used to calibrate the pH meter. The pH was measured at room temperature after the electrode was submerged in the gel dispersion [30].

3) Spreadabilty Test

By sandwiching a predetermined amount of gel between two spotless glass slides, the gel's spreadability was assessed. To create a thin, even layer of gel between the slides, a normal weight was placed over the upper slide. Spreadability was computed by timing how long it took the upper slide to travel a given distance as a result of the applied weight [32].

4) Skin Irritation Test

A tiny amount of the prepared gel was applied to a small patch of skin, and any symptoms of irritation, redness, itching, or erythema were monitored for a whole day. If there was no obvious irritation, the composition was deemed safe [33].

5) Viscosity measurement

A Brookfield viscometer was used to measure the gel's viscosity. The sample container was filled with about 10 g of gel, and the spindle was thoroughly submerged in the mixture. Using the proper spindle at 50 rpm, the viscosity was determined at 25°C [31].

VIII. COMPARATATIVE STUDY OF F1, F2, F3.

To maximize the formulation's physicochemical characteristics, three distinct herbal gel formulations (F1, F2, and F3) were created by adjusting the concentrations of Carbopol 934, propylene glycol, and

glycerin. The maximum concentration of Carbopol 934 (0.40 g) was found in Formulation F1, which led to a thicker gel consistency and higher viscosity. When applied topically, the increased viscosity decreased spreadability and created a somewhat heavy feel despite the formulation's good endurance. The lowest concentration of Carbopol 934 (0.30 g) was found in Formulation F3, which led to a lower viscosity and comparatively inferior consistency. The gel's spreadability and retention on the skin's surface were impacted by its seeming instability and fluidity. Formulation F2 demonstrated the best features of all the formulations. A balanced proportion of glycerin, propylene glycol, and Carbopol 934 (0.36 g) resulted in great homogeneity, a smooth texture, enhanced spreadability, and a viscosity that was acceptable. Furthermore, the mixture had a suitable pH and no signs of skin irritation. According to normal pharmacological principles, a higher concentration of polymer was shown to increase viscosity and decrease spreadability [35]. Based on the overall evaluation criteria, Formulation F2 was determined to be the most effective formulation for topical anti-inflammatory use.

IX. RESULTS

Table 3: Result Data

Sr. No.	Parameters	Result
1	**Organoleptic Characteristics**	
	▪ **Colour**	Light brown
	▪ **Odour**	Characteristic
	▪ **Appearance**	Glossy and Uniform gel
	▪ **Texture**	Homogenous
2	**pH Test**	5.5 – 6.5
3	**Spreadability Test**	333 g.cm/s
4	**Skin Irritation Test**	No irritation observed
5	**Viscosity Test**	55,000 – 65,000 cps

X. CONCLUSION

This work successfully developed and evaluated a topical anti-inflammatory herbal gel including leaf extract from Annona squamosa Linn. The hydroalcoholic extract of Annona squamosa leaves was successfully incorporated to a carbopol-based gel formulation using the appropriate excipients. Pre-formulation tests confirmed the presence of important phytoconstituents and demonstrated that the extract had suitable physicochemical characteristics. The proposed herbal gel formulations showed sufficient appearance, homogeneity, pH, viscosity, spreadability, and stability for topical application. F2 was found to be the best formulation of all due to its balanced viscosity, smooth texture, sufficient spreadability, and lack of skin irritation. Because of the beneficial properties of the gel base and the anti-inflammatory properties of Annona squamosa leaf extract, the formulation may be a potential natural alternative for the treatment of inflammatory skin problems. Thus, the study demonstrates that Annona squamosa Linn. leaf extract can be used to create a stable and effective herbal anti-inflammatory gel for topical administration. Further pharmacological and clinical research may be carried out to ascertain its medicinal efficacy and commercial usefulness.

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