

# Formulation and Evaluation of a Polyherbal Gel Containing Solanum Xanthocarpum and Sarcostemma Acidum Plant Extracts

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## ABSTRACT

This study reports the formulation and evaluation of a polyherbal topical gel combining extracts of Solanum xanthocarpum and Sarcostemma acidum. The aim was to develop a stable, acceptable gel with enhanced antioxidant and antimicrobial properties for potential wound-care/dermatological application. Extracts were prepared by Soxhlet apparatus, standardized by phytochemical screening and total phenolic content (TPC). Gels were prepared using Carbopol 940 and Sodium CMC as gelling agent with glycerin and propylene glycol as humectants. The final formulations were evaluated for organoleptic properties, pH, viscosity, spreadability, homogeneity, extrudability, in vitro antioxidant, antimicrobial activity (agar-well diffusion), and accelerated stability. Results indicated good physical stability, pH compatible with skin.

**Keywords:** Solanum xanthocarpum, Sarcostemma acidum, polyherbal gel, Carbopol Sodium CMC, antioxidant, antimicrobial, topical formulation

## INTRODUCTION

### Topical Drug Delivery System

Topical drug formulations are designed to exert localized effects at the site of application by allowing the drug to penetrate the skin or mucous membrane layers<sup>1</sup>. One of the key advantages of this delivery route is the bypassing of first-pass metabolism, which can otherwise reduce drug effectiveness<sup>2</sup>. Additionally, topical preparations avoid the complications and discomforts associated with intravenous therapy and are not affected by gastrointestinal factors such as pH variation, enzymatic activity, or gastric emptying time<sup>3</sup>. Among the various types of topical formulations, semisolids—such as creams, gels, and ointments—are most commonly used. However, other forms like foams, sprays, medicated powders, solutions, and medicated adhesive patches are also widely utilized. Topical systems are often employed when other routes of drug delivery are ineffective or unsuitable, particularly in areas such as pain relief, birth control, and treatment of urinary incontinence.

### Advantages of Topical Drug Delivery Systems:

- Avoidance of first-pass metabolism.
- Convenient and easy to apply.
- Avoid the risks and inconveniences of intravenous therapy and the varied conditions of absorption, such as pH changes, the presence of enzymes, gastric emptying time, etc<sup>5</sup>.
- Achievement of efficacy with a lower total daily dosage of the drug by continuous drug input.
- Avoids fluctuation in drug levels, as well as inter- and inpatient variations.
- Ability to easily terminate the medications when needed.
- A relatively large area of application in comparison with the buccal or nasal cavity

### Disadvantages of Topical Drug Delivery Systems:

- Skin irritation of contact dermatitis
- Poor permeability of some medications through the Skin.
- Possibility of allergenic reactions.
- Can be used only for drugs that require minimal plasma concentration for action
- Enzymes in the epidermis may denature the drugs
- Drugs of larger particle size are not easy to absorb through the Skin

**Relevant conflicts of interest/financial disclosures:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



## Gels

Gels are semi-solid systems in which a liquid phase is dispersed within a three-dimensional polymer network, formed from natural or synthetic gums. These systems rely on a high degree of physical or chemical cross-linking to maintain their structure. Polymers commonly used in gel formulations include natural gums such as tragacanth, pectin, carrageenan, agar, and alginic acid, as well as synthetic and semi-synthetic agents like methylcellulose, hydroxyethyl cellulose, carboxymethyl cellulose, and Carbopols—a class of synthetic vinyl polymers containing ionizable carboxyl groups<sup>6</sup>.

## MATERIAL & METHODS

### 5.1 Preliminary Investigation

#### 2.1 Collection of Plant Material

*Solanum xanthocarpum* and *Sarcostemma acidum* specimens were gathered from the Bhopal region. Dr. S. N. Verma, professor and head of the Department of Botany at SAGE University, Indore, Madhya Pradesh, confirmed the authenticity of the collected plants. A voucher specimen (No. IOS/Bot/SLF-033 and IOS/Bot/SLF-034) has been duly archived in the department for future reference.

#### 2.1.2 Preparation of Plant Powder

After collection, the plant materials were shade-dried to preserve their phytochemical constituents. Once dried, they were coarsely powdered using a mechanical grinder. The powdered material was then passed through a #40 mesh sieve and stored in airtight containers for subsequent experimental procedures<sup>7</sup>.

#### 2.2 Preparation of Extracts

Approximately 250 g each of *Solanum xanthocarpum* and *Sarcostemma acidum* (dried powder) were subjected to Soxhlet extraction. Initially, defatting was performed using petroleum ether, followed by exhaustive extraction using the selected solvents for about 36 hours. The process temperature was maintained between 40°C and 50°C. Ethanol was chosen as the solvent for *S. xanthocarpum*, while methanol was used for *Sarcostemma acidum*. After extraction, the solvents were evaporated under reduced pressure. The concentrated extracts were then vacuum dried using a rotary flash evaporator to obtain a semisolid mass. (Reference: Kokate, Gokhale et al., 2005)

#### Plant Details-



**Fig 2.1: Plant of *Solanum xanthocarpum*.**

*Solanum xanthocarpum* holds a prominent place in Hindu Materia Medica and is traditionally used for its expectorant and antipyretic properties. It is especially valued for treating respiratory conditions such as

asthma, persistent cough, and catarrhal fever. Notably, it is one of the key constituents in Dashamula, a renowned Ayurvedic formulation comprising ten medicinal roots



**Fig 2.2: Plant of Sarcostemma acidum.**

*Sarcostemma acidum* has been documented to exhibit a broad spectrum of pharmacological effects. These include anti-inflammatory, analgesic, antiarthritic, spasmolytic, tocolytic, anti-asthmatic, antiallergic, bronchospasmolytic, hepatoprotective, and antioxidant activities. Additionally, the plant has shown potential in spermatogenesis regulation, larvicidal activity, immunomodulation, CNS depression, antimicrobial, anti-syphilitic, and anthelmintic properties.

### 2.3 Phytochemical Screening

The extracts obtained were analyzed for the presence of different classes of phytochemicals through standard qualitative tests.

#### 2.3.1 Tests for Carbohydrates and Glycosides

##### Molisch's Test:

A few drops of 1% alcoholic  $\alpha$ -naphthol solution were added to the sample, followed by gentle addition of concentrated sulfuric acid along the side of the test tube. Formation of a violet or brown ring at the junction indicates the presence of carbohydrates.

##### Borntrager's Test:

The extract was mixed with chloroform, and the chloroform layer was separated. An equal amount of dilute ammonia was added. Development of a pink hue in the ammoniacal layer indicates glycosides<sup>9</sup>.

#### 2.3.2 Test for Alkaloids

A small quantity of the extract was treated with dilute hydrochloric acid and then subjected to various reagents (e.g., Mayer's, Dragendorff's, Wagner's) to detect the presence of alkaloids.

The reagents are: -

- Dragendorff's reagent - Reddish brown ppt
- Wagner's reagent - Reddish brown ppt
- Mayer's reagent - Cream colour ppt
- Hager's reagent - Yellow colour ppt

#### 2.3.3 Test for Proteins and Free Amino Acids

- A small portion of the extract was dissolved in a few milliliters of distilled water and subjected to the following standard tests:
- Ninhydrin Test: Development of a purple or violet hue confirms the presence of amino acids and proteins.
- Biuret Test: Equal volumes of 5% sodium hydroxide and 1% copper sulfate solutions were mixed with the extract. The appearance of a violet or pinkish color signifies the presence of proteins and amino acids<sup>20</sup>

#### 2.3.4 Test for Tannins

- To detect tannins and phenolic compounds, a small amount of the sample was mixed with water and treated with the following reagents:
- Dilute Ferric Chloride (5%) – A violet coloration confirms the presence of phenolic compounds or tannins.

#### 2.3.5 Test for Flavonoids

- Alkaline Reagent Test: Upon adding a few drops of magnesium hydroxide solution to the extract, an intense yellow coloration develops. This yellow color turns colorless when a few drops of dilute acid are added, suggesting the presence of flavonoids.
- Shinoda Test: A small quantity of the extract was dissolved in ethanol. Magnesium turnings were added, followed by the dropwise addition of concentrated hydrochloric acid and gentle heating. The appearance of a magenta or pink color indicates the presence of flavonoids<sup>21</sup>.

### 2.3.6 Tests for Fixed Oils and Fats

- Spot Test: A small quantity of the extract was pressed between two pieces of filter paper. The presence of an oily translucent stain on the paper signifies the presence of fixed oils.
- Saponification Test: To another portion of the sample, a few drops of 0.5 N alcoholic potassium hydroxide and one drop of phenolphthalein were added. The mixture was heated in a water bath for 1–2 hours. The appearance of soap or partial neutralization of the alkali confirms the presence of fixed oils and fats.

### 2.3.7 Tests for Steroids and Triterpenoids

#### Libermann-Burchard Test:

A few drops of acetic anhydride were added to the sample, followed by gentle heating and subsequent cooling. Then, concentrated sulfuric acid was carefully introduced along the sides of the test tube. The presence of a brown ring at the interface of the layers and a greenish tint in the upper layer indicates steroids. A deep red coloration signifies the presence of triterpenoids<sup>21</sup>.

### 2.3.8 Test for Mucilages and Gums

A small amount of the sample was slowly introduced into 25 ml of absolute alcohol under constant stirring. The mixture was then filtered, and the precipitate was

dried in oil. The dried mass was observed for swelling behavior, which helps confirm the presence of mucilage and gum.

### 2.3.9 Test for Waxes

To the test solution, an alcoholic alkali reagent was added. The formation of soap-like substances due to saponification indicates the presence of waxes<sup>34</sup>.

## 2.4 Formulation of A Suitable Topical Therapeutic System

### 2.4.1 Preparation of Hydrogel Containing Plant Extracts:

For hydrogel preparation, different ratios of Carbopol 934 and Sodium Carboxymethyl Cellulose (CMC)—including 3:0, 3:1, 2:1, 1:1, 0:3, 1:2, and 1:3—were dispersed in 50 ml of distilled water with constant stirring. Separately, 5 ml of distilled water was used to dissolve the necessary quantities of methyl and propyl parabens by heating on a water bath. After cooling, 5% w/v of propylene glycol was added to this solution and mixed with the polymer dispersion. Plant extracts of *Solanum xanthocarpum* (1 g) and *Sarcostemma acidum* (1 g) were dissolved in a minimal quantity of ethyl alcohol and then incorporated into the polymer solution. The total volume was adjusted to 100 ml with distilled water. All components were thoroughly blended to form a uniform gel base. To achieve the desired pH (between 6.8 and 7) and optimal consistency, triethanolamine was added gradually. Some batches (F1, F2, F6,) showed turbidity and clumping and were therefore discarded. Only stable and clear batches (F3, F4, F5 and FH) were selected for further evaluation. A control gel was prepared following the same procedure but without incorporating any plant extract<sup>37</sup>.

## RESULT -

### 3.0 Characterization and Evaluation of Formulation

**Table 3.1 (a): Preliminary phytochemical screening of different extract of Solanum xanthocarpum**

Sr. No.	Constituents	Test	Aqueous Extract	Ethanollic Extract	Methanol	Petroleum ether Extract	Chloroform Extract
1.	Alkaloids	Mayer's test	-	-	-	-	-
		Dragendroff' test	+	+	+	-	+
		Hager's test	-	-	-	-	-
		Wagner's test	-	-	-	-	-
2.	Carbohydrates	Molisch's test	-	+	+	-	-
		Fehling's test	-	-	-	-	-
3.	Glycosides	Molisch's test	+	+	+	-	-
		Legal's test	-	+	+	-	+
		Keller-Killani Test	+	+	+	+	+
4.	Tannins	FeCl <sub>3</sub>	-	+	+	-	-
		Lead acetate test	-	+	+	-	-
		Alkaline reagent	-	-	-	-	-
5..	Protein and amino acid	Million's test	+	-	-	-	-
		Ninhydrin test	+	-	-	-	-
		Biuret test	-	-	-	-	-
6.	Flavanoids	With NaOH	-	-	-	-	-
		Shinoda test	-	-	-	-	-
7.	Steroids and triterpenoids	Libermann's Burchard test	-	+	+	+	+
		Salkowski's test	-	+	+	+	+
		With 90% alcohol gum	+	-	-	-	-
9.	Waxes	With alc. KOH	-	-	-	-	-

(+ Present, - Absent)

**Table 3.2(b): Preliminary phytochemical screening of different extract of S. acidum.**

Sr. No	Constituents	Test	Aqueous Extract	Ethanollic Extract	Methanol	Petroleum ether Extract	Chlorof orm Extract
1.	Alkaloids	Mayer's test	-	+	+	+	-
		Dragendroff' test	+	+	+	-	+
		Hager's test	-	-	-	-	-
		Wagner's test	-	+	+	+	-
2.	Carbohydrates	Molisch's test	-	-	-	-	-
		Fehling's test	-	-	-	-	-
3.	Glycosides	Molisch's test	+	+	+	-	-
		Legal's test	+	+	+	-	+
		Keller-Killani Test	+	+	+	+	+
4.	Tannins	FeCl <sub>3</sub>	-	-	-	-	-
		Lead acetate test	+	+	+	+	+
5.	Protein and amino acid	Million's test	-	-	-	-	-
		Ninhydrin test	-	-	-	-	-
		Biuret test	-	-	+	-	-
6.	Flavanoids	With NaOH	-	-	-	-	-
		Shinoda test	+	+	+	-	+
7.	Steroids and triterpenoids	Libermann's Burchard test	-	-	-	-	-
		Salkowski's test	-	-	-	-	-
		With 90% alcohol gum	+	-	-	-	-

8.	Mucilage and gum	With 90% alcohol	-	-	-	-	-
9.	Waxes	With alc. KOH	-	-	-	-	-

(+ Present, - Absent)

**Table 3.3(a): Extractive values of Solanum xanthocarpum.**

Sr. No.	Solvents	Extractive values (%w/w)
1.	Pet-ether	2.62
2.	Water	17.2
3.	Chloroform	6.9
4.	Ethanol	15.5
5.	Methanol	14.5

**Table 3.4(b): Extractive values of Sarcostemma acidumr**

Sr. No.	Solvents	Extractive values (%w/w)
1.	Pet-ether	0.60
2.	Water	1.6
3.	Chloroform	1.2
4.	Ethanol	1.8
5.	Methanol	2.7

Since the major active constituents are present in extract of Solanum xanthocarpum and extract of S. acidum,

#### 4. Evaluation of Gel Formulation

##### 4.1 Physical Assessment

Each gel formulation was examined visually for its organoleptic properties, including color, consistency, and overall appearance.

##### 4.2 pH Determination

The pH of each formulation was assessed using a calibrated digital pH meter. For this, one gram of gel was mixed with 100 mL of distilled water and allowed to stand for two hours to equilibrate. Measurements were taken three times for each sample, and the mean value was recorded for accuracy.

**Table 6.4: Formulations of Gel containing Plants extract.**

Ingredient	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>	F <sub>7</sub>	FH
Carbopol 934 (gm)	3	3	2	1	-	1	1	1
Sodium CMC (gm)	-	1	1	1	3	2	3	2
<i>S. xanthocarpum</i> (% w/w)	1	1	1	1	1	1	1	1
<i>Sarcostemma acidum</i> (% w/w)	1	1	1	1	1	1	1	1
Propylene glycol 400 (5%)	5	5	5	5	5	5	5	5
Methyl Paraben (0.5%) (ml)	0.2ml	0.2 ml	0.2 ml	0.2 ml	0.2 ml	0.2 ml	0.2 ml	0.2 ml
Propyl Paraben (0.2%) (ml)	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml
Triethanolamine (ml)	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Distilled water (ml)	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml	q.s. to 100ml

Each formulation contains distilled water up to 100 ml.

FE = Ethosome gel containing S. xanthocarpum and S. acidum plant extract

F<sub>1</sub> to F<sub>7</sub> = Hydrogel, FH = Hydroalcoholic gel

## 5. Formulation Characterization and Evaluation of Topical Therapeutic System

### 5.1 Evaluation of Gel Formulation

During the formulation trials, varying concentrations of Carbopol and Sodium CMC were tested. As the concentrations were increased or decreased, issues related to uniformity, spreadability, and viscosity emerged in certain batches (F1, F2, F5, and FH) containing both plant extracts. Due to these inconsistencies, those specific batches were excluded

from further analysis. The remaining batches (F3, F4, and F6) demonstrated acceptable physical and performance characteristics and were selected for continued evaluation<sup>41</sup>. Among them, batch FH exhibited favorable results, showing a greenish, semi-transparent appearance with smooth texture and no lumps. It also had optimal spreadability, consistent viscosity, appropriate pH, and satisfactory drug content. Furthermore, the formulation remained stable in terms of appearance, spreadability, pH, and active content during accelerated stability testing. Based on these results, a hydroalcoholic gel was prepared using the FH formulation, which also showed promising physicochemical properties.

**Table 5.2: Physical evaluation of all formulation**

Batch	Color	Appearance	Spreadability (gm.cm/sec)	Consistency (60 mm)	Viscosity (cps)	Ph	Drug content (%)
F3	Greenish	Homogeneous	23.81	8	16915	7.00	99.95
F4	Greenish	Homogeneous	24.22	8	16995	7.00	99.97
F6	Greenish	Homogeneous	24.34	8	16924	7.00	99.95
FH	Greenish	Homogeneous	24.96	8	16974	7.00	99.95

### Compatibility studies:

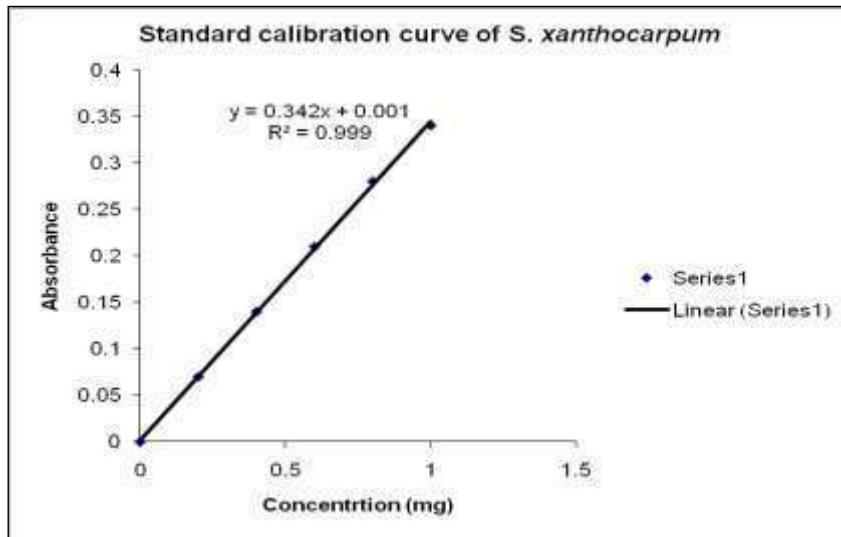
#### FTIR Spectral Analysis and Standard Calibration Curve

The Fourier Transform Infrared (FTIR) spectroscopy method was employed to assess any potential physical or chemical interactions between the plant extracts and the excipients used in the gel formulation. As illustrated in Figures, no significant shifts or disappearance of characteristic peaks were observed in the IR spectra of the extract-polymer combinations. This suggests that there were no notable interactions

between the active compounds and the excipients. The spectral peaks of the formulation matched those of the individual plant extracts, confirming their compatibility within the formulation.

#### Standard Calibration Curve of *Solanum xanthocarpum* Extract

A standard calibration curve for the *Solanum xanthocarpum* extract was established by measuring absorbance at 206 nm across different concentrations, in accordance with Beer's Law. The results of this calibration are presented in Table



5.4: Standard calibration curve of *S. xanthocarpum* at 206 nm

Table 5.5: Standard calibration curve of *S. xanthocarpum* at 206 nm

S. No	Concentration (µg/ml)	Absorbance
1.	Blank	0.000
2.	0.2	0.059
3.	0.4	0.141
4.	0.6	0.212
5.	0.8	0.283
6.	1.0	0.341

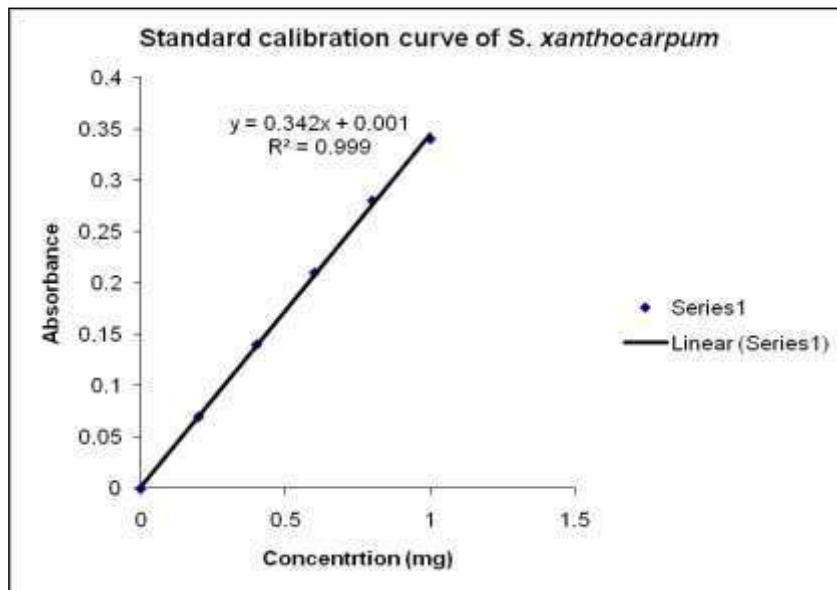


Figure 5.7: Standard calibration curve of *S. xanthocarpum* at 206 nm.

Table 5: Standard calibration curve of *S. xanthocarpum* at 206 nm.

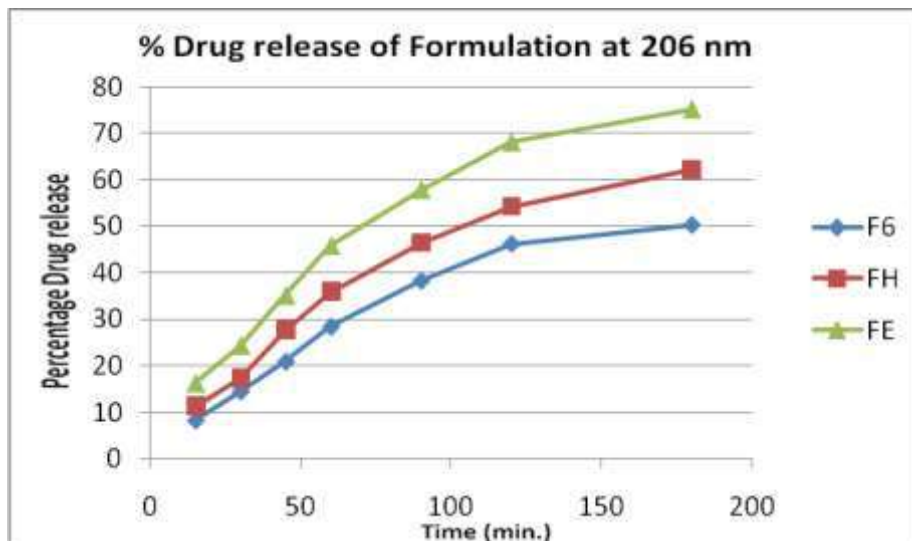
S. No.	Concentration (µg/ml)	Absorbance
1.	Blank	0.000
2.	0.2	0.059
3.	0.4	0.141
4.	0.6	0.212
5.	0.8	0.283
6.	1.0	0.341

**Standard calibration curve of *S. acidum* plant extract for its active constituent**

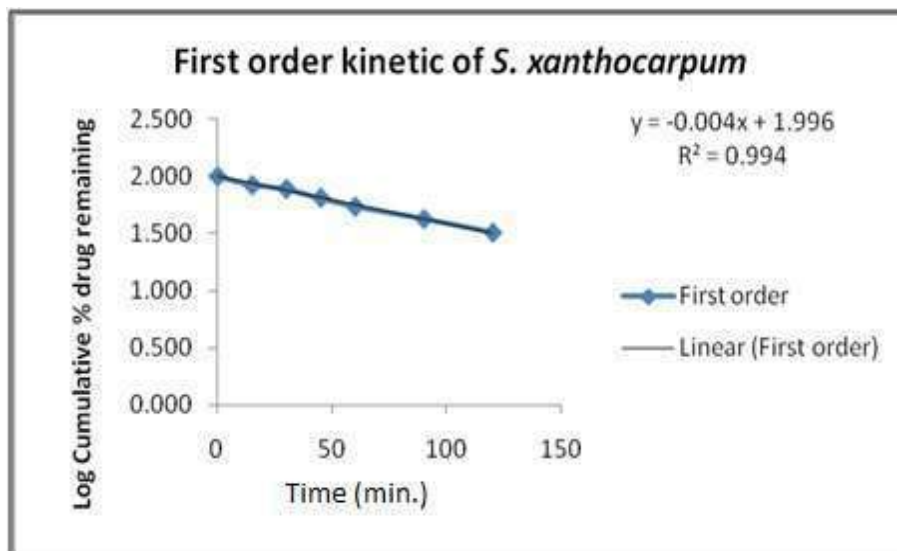
Standard calibration curve of *S. acidum* extract was determined by plotting absorbance vs concentration at 359 nm and it follow the beer’s law. The results are shown in Table.

Time Interval (Min)	% Drug release of Formulation	
	F6	FH
15	8.31	11.23
30	14.56	17.31
45	20.91	27.56
60	28.38	35.91
90	38.23	46.38
120	46.15	54.23
180	50.21	62.15

**Table Percentage Drug release of Formulated Hydroalcoholic Gel at 206 nm.**



**Figure: Release profile of Hydrogel F-6 and Hydroalcoholic gel FH**



**Figure First order kinetics of formulation FH through fabricated diffusion cell.**

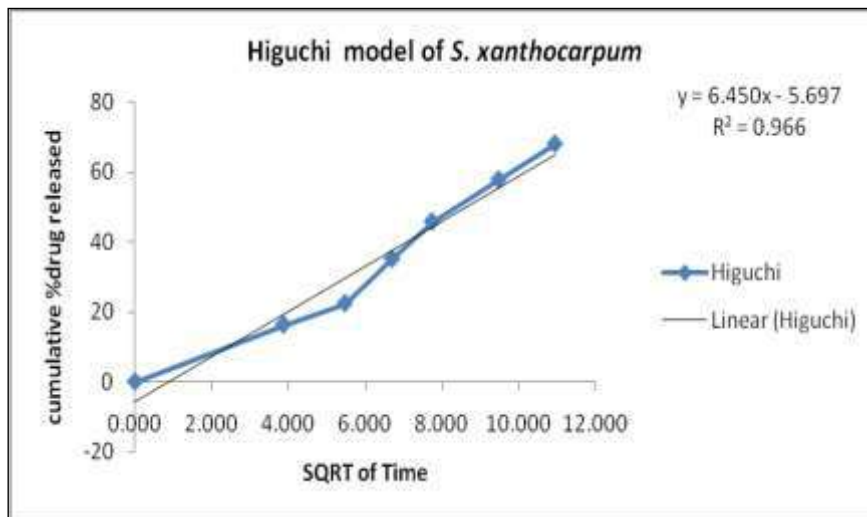


Figure 6.: Higuchi model of formulation FH through fabricated diffusion cell

### 6.15 Stability Study

The formulated gels were subjected to stability studies. No colour fading was observed for all prepared gels. The pH of all formulations remained

unchanged and was within the range of 6.2-7.2. The viscosity and spreadability of all gels remained unaltered and were found to be within the range. The drug content was within the 90% -103% limit for all gel formulations.

Table: Accelerated Stability study of formulated gel

Batch	Color	Appearance	Spreadability (gm.cm/sec)	Consistency (60 Sec)	Viscosity (cps)	Ph	Drug content (%)
F <sub>6</sub>	Greenish	Homogeneous	19.53	5	22230	6.98	99.77
FH	Greenish	Homogeneous	22.13	8	16951	7.01	99.86

(F<sub>6</sub>= Hydrogel, FH=Hydroalcoholic gel)

### CONCLUSION

The present investigation focused on the formulation, characterization, and evaluation of a topical therapeutic system using extracts from *Solanum xanthocarpum* and *Sarcostemma acidum*. Various gel formulations—including hydrogel and hydroalcoholic gel—were developed and optimized for enhanced effectiveness.

#### Key outcomes of the study include:

- Extraction and Screening:** Dried plant of *S. xanthocarpum* and dried plant material of *S. acidum* were extracted using ethanol, methanol, chloroform, and petroleum ether via Soxhlet extraction. Phytochemical analysis indicated that extract of *S. xanthocarpum* and extract of *S. acidum* were the most enriched in active

constituents. Hence, these were selected for further development.

- Gel Formulation:** Hydrogel and hydroalcoholic gel formulations were prepared using various concentrations of Carbopol 934 and Sodium CMC polymers. During formulation trials, some batches (F1, F2, F5,) exhibited issues related to viscosity, homogeneity, and spreadability and were therefore excluded. The remaining formulations (F3, F4, and F6, FH) were further evaluated for their physical and chemical properties.
- Drug Release Profile:** Among all formulations, hydroalcoholic gel FH containing both plant extracts demonstrated the highest drug release—24.43% at 30 minutes and 75.09% at 180 minutes. The inclusion of ethanol significantly improved drug permeation, suggesting enhanced release properties. Based on these findings, the FH formulation shows potential for future

development as an effective anti-inflammatory topical product.

#### Key findings from the study include:

- Extraction of the plant of *S. xanthocarpum* of *S. acidum* was performed using Soxhlet extraction with ethanol, methanol, chloroform, and petroleum ether. Phytochemical screening indicated that the ethanolic extract of *S. xanthocarpum* and methanolic extract of *S. acidum* contained the most significant concentration of bioactive compounds. Hence, these specific extracts were selected for formulation development.
- Hydrogel and hydroalcoholic gel formulations were prepared using varying ratios of Carbopol and Sodium CMC polymers. During preliminary trials, some formulations (F1, F2, F5,) were excluded due to challenges related to uniformity, spreadability, and viscosity. The remaining batches (F3, F4, and F6, FH) exhibited acceptable properties and were selected for further evaluation.
- Among these, the hydroalcoholic gel formulation labeled FH, containing both plant extracts, showed a notable drug release profile—24.43% at 30 minutes and 75.09% at 180 minutes. The inclusion of ethanol enhanced the gel's permeability, thereby improving the drug diffusion rate. Formulation FH was determined to have the most efficient release characteristics, supporting its potential as a promising anti-inflammatory formulation.
- With the growing preference for plant-based alternatives over synthetic drugs—largely due to their perceived safety and lower side effect profile—this study reinforces the therapeutic relevance of herbal formulations. The hydroalcoholic gel developed with *S. xanthocarpum* and *S. acidum* extracts.

#### REFERENCE

1. Bozzuto Anne (2000). Homeopathy, Herbs and Hypnosis Common Practices, In Complementary and Alternative Medicine, Jacksonville Medicine.
2. The Ayurvedic Pharmacopoeia of India., Government of India., Ministry of Health and Family Welfare., New Delhi.1999, Part I, Vol III, pp 235
3. Kokate C.K., Purohit A.P. and Gokhale S.B. (2005). A Text-book of Pharmacognosy, 31st edition, Nirali Prakashan.
4. Mukherji P.K. (2001). Quality Control of Herbal Drugs, Business Horizon Publication, 1st Edition 1, 183-219.
5. Singh S. K. (2002). Proceedings of Global Promotion of Tradition Medicine in View of Institute Industry Relationship, Faculty of Ayurveda, Banaras Hindu University, pp. 112–115.
6. Duke J. A. and Bogenschutz-Godwin M. J. (1999). Natural Products from Plants, CRC Press, Boca Raton, FL, USA, 183–205.
7. Ara Tachjian (2010). Use of Herbal Products and Potential Interactions in Patients with Cardiovascular Diseases” Journal of the American College of Cardiology,
8. G. Ulrich-Merzenich et al. “Drug development from natural products: exploiting synergistic effects”, International Journal of experimental biology,48, 2010, 208-219.
9. Smith JK, Dykes R, Douglas JE, Krishnaswamy G and Berk S. (1999). Long-term exercise and atherogenic activity of blood mononuclear cells in persons at risk of developing ischemic heart disease. JAMA, 12; 281(18):1722-7.
10. McFarlin BK, Flynn MG, Phillips MD, Stewart LK and Timmerman KL (2005). Chronic resistance exercise training improves natural killer cell activity in older women. J Gerontol A Biol Sci Med Sci., 60(10):1315-8.
11. Stewart LK, Flynn MG, Campbell WW, Craig BA, Robinson JP, McFarlin BK, Timmerman KL, Coen PM and Felker J (2005). Talbert E. Influence of exercise training and age on CD14+ cell-surface expression of toll-like receptor 2 and 4. Brain Behav Immun., 19(5):389-97.
12. Gleeson M. (2006). Immune system adaptation in elite athletes. Curr Opin Clin Nutr Metab Care. 9(6):659-65.
13. Pedersen BK and Hoffman-Goetz L. 2000Exercise and the immune system: regulation, integration, and adaptation. Physiol Rev., 80(3):1055-81.



14. Ploeger HE, Takken T, de Greef MH and Timmons BW (2009). The effects of acute and chronic exercise on inflammatory markers in children and adults with a chronic inflammatory disease: a systematic review. *Exerc Immunol Rev.*; 15:6-41.
15. Timmerman KL, Flynn MG, Coen PM, Markofski MM and Pence BD. (2008). Exercise training-induced lowering of inflammatory (CD14+CD16+) monocytes: a role in the anti-inflammatory influence of exercise? *J Leukoc Biol.*, 84(5):1271-8.
16. Mackinnon LT. (2000). Chronic exercise training effects on immune function. *Med Sci Sports Exerc.*, 32(7 Suppl): S369-76.
17. Suzuki K, Nakaji S, Yamada M, Liu Q, Kurakake S, Okamura N, Kumae T, Umeda T and Sugawara K. (2003). Impact of a competitive marathon race on systemic cytokine and neutrophil responses. *Med Sci Sports Exerc.*, 35(2):348-55.
18. Pilon Brad. (2011). Inflammation Affects Your Ability to Build Muscle. *Inflammation Theory, Inflammation, Chronic Inflammation, Muscle Building, Health.* Web. <http://www.inflammationtheory.com>
19. Yonehara, N., Shibutani, T., and Inoki, R. 1987, *J. Pharmacol. Exp. Ther.*, 242, 1071.
20. Kulkarni, R.R., Patki, P.S. Jog, V.P., Gandage, S.G. and Patwardhan, B. 1991, *J. Ethnopharmacol.*, 33, 91.
21. Saxena, R.C., Nath, R., Palit, G., Nigam, S.K., and Bhargava, K.P. 1979, *Indian J. Pharmacol.*, 11, 39.
22. M. Anilkumar (2010). Ethnomedicinal plants as anti-inflammatory and analgesic agents In *Ethnomedicine: A Source of Complementary Therapeutics*, Editor: Debprasad Chattopadhyay, Research Signpost, Trivandrum, Kerala, India, 267-293 ISBN: 978-81-308-0390-6.
23. Kang, S.S., Cordell, A., Soejarto, D.D., and Fong, H.H.S. 1985, *J. Natural Products*, 48, 155.
24. Jain S.K. (1991). *Dictionary of Indian Folk Medicine and Ethnobotany*, Deep Publications, New Delhi.
25. Anonymous (1992). *Wealth of India: Raw materials. III.* CSIR Publication and Information Directorate, New Delhi, 8.
26. Sofowora A. (1993). *Medicinal plants and traditional medicine in Africa*, Polygraphic Ventures Ltd. Ibdan, 207.
27. Sandoval-Chacon, M., Thompson, J.H., Zhang, X.J., Manick, E.E., Sadowska-
28. Srivastava, K.C., and Mustafa, T.1992, *Med. Hypotheses*, 39, 342
29. Surver, C. and Davis, F.A., *Bioavailability and Bioequivalence*, In Walter, K.A. (Ed.), *Dermatological and Transdermal Formulation*, Marcal Dekker, INC. NewYork , 119,2002, pp. 403,323,326,327,403.
30. Stan-posthumd J.J., Vink J., Lecessies, Bruijn J.A., et al., "Topical Tretinoin Under Oocclusion on a Typical Navei", 1998, 548.
31. Ansel H.C., Allen L.V., "Pharmaceutical Dosage Forms and Drug Delivery System", 7th edition, Lippincott Willams and Wilkens, Baltimore, 2000, 244-246,249-251, 253-255,264-265.
32. Nayank S.H., Nkhat P.D., and Yeole P.G., "The Indian Pharmacist", Vol. III, No. 27, Sept. 2004, 7-14.
33. Misra A.N., "Controlled and Novel Drug Delivery", CBS Publishers and Distributors, New Delhi,1997, 107-109.
34. Misra A.N., "Controlled and Novel Drug Delivery", CBS Publishers and Distributors, New Delhi,1997, 107-109.
35. Banker G.B.S., Rodes C.T., "Modern Pharmacist", 2nd edition, Vol. 40, Marcel Dekker, New York, 1979, 263-273, 283,286-287,299-311.
36. Kikwai, L., Babu, R. J., Kanikkannan, N., Singh, M., Preformulation stability of spantide 2, A promising topical anti – inflammatory agent for the treatment of psoriasis and contact dermtises. *J. Pharm. Pharmacol.* 2005;56 (1): 19 – 25.
37. Elias, P.M., Epidermal lipids, barrier function and desquamation. *J. Invest. Dermatol.* 1983;80: 44-49.
38. Schreier, H., and Bouwstra, J., Liposomes and niosomes as topical drug carriers: dermal and transdermal drug delivery. *J. Control. Rel.* 1991; 30:1-15.
39. Hadgraft, J., Recent developments in topical and transdermal delivery. *Eur. J. Drug Metab. Pharmacokinet.* 1996: 21: 165 – 173
40. Jain, S., Tiwari, A. K., *Topical products*, edited by Jain, N. K., 2005, In: *Pharmaceutical Product*

Development, CBS Publication and Distributor, New Delhi, 2005;221-249.

41. Bedde, H. E., Holman, F., Spies, A., Ponec, M., Freeze fracture electron microscopy on in vitro reconstructed human epidermis. *J. Invest. Dermatol.* 1989;95: 108 – 116.
42. Touitou, E., Dayan. N., Bergelson. L., Gidin, B., Eliaz, M., Ethosomes – novel vesicular carrier for enhanced delivery: characterization and skin penetration properties. *J. Control Rel.* 2000; 65: 405-418.
43. Sun, Y. M., Huang, J. J., Lin, F. C., Lal, J. Y., *Biomaterials.* 1997;18: 527 – 533.
44. Touitou E, Godin B and Weiss C. Enhanced delivery of drugs into and across the skin by Hydroalcoholic carriers. *Drug Development Research.* 2000; 50: 406-415.
45. Touitou et al, Ethosomes- efficiently delivering active agents to skin personal care, Jan.2005; 6(1): 71-74.
46. Sanjay, Ethosomes:A promising tool for transdermal delivery of drug. [www.pharmainfonet.com](http://www.pharmainfonet.com)
47. Bendas ER, Tadros MI. Enhanced transdermal delivery of Salbutamol Sulfate via ethosomes. *AAPS PharmSci Tech.* 2007; 8(4): Article 107.
48. Touitou E, Dayan N and Bergelson L. Ethosomes-novel vesicular carriers for enhanced delivery: characterization and skin penetration properties. *J Control Release.* 2000;65: 403-418.
49. Cevc. G, lipid vesicles and other colloids as drug carriers on the skin; *Advanced drug delivery Reviews* 2004; 56:675-711.

**HOW TO CITE:** Dr. Sachin Jain, Tushar Prajapati\*, Formulation and Evaluation of a Polyherbal Gel Containing Solanum Xanthocarpum and Sarcostemma Acidum Plant Extracts, *Int. J. Sci. R. Tech.*, 2025, 2 (10), 180-192. <https://doi.org/10.5281/zenodo.17328257>