



Formulation and Evaluation of Gel Containing Aloe Vera Extract for Topical Application: A Comprehensive Herbal Approach

Dr. Fulchan Ali¹, Burhan Ali²

¹. Principal, Allama TR College of Pharmacy, Badarpur, Sribhumi, Assam - 788701, India

². Principal, School of Pharmaceutical Science and Technology, Kanuwamari, Samaguri, Nagaon, Assam-782140

ABSTRACT

Background: Aloe vera (*Aloe barbadensis* Miller) is a globally acclaimed medicinal succulent belonging to family Liliaceae, extensively used in Ayurveda, traditional and modern dermatology due to its rich phytochemical profile including acemannan, aloin, vitamins, enzymes and amino acids. Despite its commercial abundance, systematic optimization of low-cost topical gel with suitable gelling agents remains essential for resource-limited settings.

Objective: The present investigation was undertaken by Dr. Fulchan Ali to formulate, optimize and evaluate stable poly-herbal topical gels containing 8-16 percent Aloe vera extract using Carbopol 934 as a gelling matrix, focusing on physicochemical characterization, skin compatibility and accelerated stability.

Methods: Aloe vera mucilage was extracted by standard depulping method with complete removal of latex. Five formulations F1-F5 (8 percent, 10 percent, 12 percent, 14 percent, 16 percent Aloe vera) were prepared using Carbopol 934 (1.0 percent w/w), methyl paraben (0.02 percent), glycerin (5 percent w/w), triethanolamine (q.s.) and distilled water. Evaluation included organoleptic properties, pH, viscosity (Brookfield), spreadability (slide method), extrudability, homogeneity, washability, skin irritation (n=6) and ICH stability.

Results: All formulations were translucent, homogeneous and free from grit. pH ranged 5.8 to 6.8, within skin-compatible range. Viscosity showed concentration dependent increase: 3200 to 5200 cps. Spreadability decreased from 16.5 to 6.34 g.cm/sec with increase in extract. F3 (12 percent Aloe) exhibited ideal characteristics: very smooth glossy texture, pH 6.2, viscosity 4100 cps, spreadability 10.31 g.cm/sec, excellent extrudability, rapid absorption without greasy residue and easy washability. No irritation was observed. Stability studies confirmed F3 and F4 maintained colour, odour, pH and consistency without phase separation.

Conclusion: The study successfully demonstrates that 12 percent Aloe vera gel formulated with 1 percent Carbopol 934 represents an optimized, stable, safe, economical, non-greasy and patient-compliant herbal topical preparation with significant potential for moisturizing, anti-acne, mild burn and wound healing applications.

Keywords: Aloe vera, Carbopol 934, Topical gel, Herbal formulation.

1. INTRODUCTION

Aloe vera (L.) Burm.f., syn. *Aloe barbadensis* Miller, family Asphodelaceae (formerly Liliaceae), is a perennial succulent xerophyte native to Northern Africa but now cultivated extensively in India, including Assam. In Sanskrit it is Kumari, Egyptians called it plant of immortality [1]. Name derives from Arabic *Alloeh* meaning bitter and shining substance, vera means true [2].

Phytochemistry: Inner leaf parenchyma yields clear mucilaginous gel comprising 98.5-99.5 percent water, polysaccharides (acemannan, glucomannan), anthraquinones, vitamins (A,C,E,B12), enzymes, minerals, amino acids [3,4]. Latex contains aloin with laxative action and must be separated [5].

Pharmacological activities include wound healing via fibroblast stimulation, anti-inflammatory, moisturizing, antimicrobial against *Staphylococcus aureus*, antioxidant [6-10].

Topical gels are preferred over ointments as they are non-greasy, easily washable, cooling, better spreadable [11]. Carbopol 934 is high molecular weight cross-linked polyacrylic acid forming clear gels upon neutralization with triethanolamine [12].

Rationale: Commercial gels often have low Aloe content and high cost. In Northeast India, fresh Aloe is abundant but underutilized. Hence this research by Dr. Fulchan Ali was undertaken to develop low-cost stable herbal gel.

2. MATERIALS AND METHODS

2.1 Materials

Fresh Aloe vera leaves collected from medicinal garden of Allama TR College of Pharmacy, Badarpur (authenticated by Dr. Fulchan Ali). Carbopol 934 (Loba Chemie), Methyl paraben, Glycerin IP, Triethanolamine, Rose water IP, distilled water.

2.2 Extraction

Mature leaves washed, kept vertically 15-20 min to drain yellow latex. Spiny edges removed, outer rind peeled, inner fillet scooped, homogenized at 5000 rpm for 5 min, filtered through muslin cloth. Yield 62 percent w/w. Stored at 4C in amber container.

2.3 Formulation Design

Carbopol 934 1.0 g dispersed in 50 ml water with stirring 2 h, kept overnight. Methyl paraben 0.02 g dissolved in hot water added. Glycerin 5 ml added. Aloe vera extract 8-16 percent incorporated slowly. Volume to 100 g. Triethanolamine added q.s. to pH 6.0-6.8. Rose water 0.5 ml added.

Table 1: Formulation composition (100 g)

Code	Aloe vera (%)	Carbopol 934 (g)	Glycerin (ml)	Methyl paraben (g)
F1	8	1.0	5.0	0.02
F2	10	1.0	5.0	0.02
F3	12	1.0	5.0	0.02
F4	14	1.0	5.0	0.02
F5	16	1.0	5.0	0.02

2.4 Evaluation

1. Organoleptic: Colour, odour, texture [13].

Table 2: Organoleptic characteristics

Code	Colour	Odour	Texture	Phase Separation
F1	Off white translucent	Characteristic	Smooth	None
F2	Light yellowish	Characteristic	Smooth	None
F3	Slight yellow glossy	Pleasant rose	Very smooth glossy	None
F4	Light yellow glossy	Pleasant rose	Very smooth	None
F5	Dark yellow	Characteristic	Smooth sticky	None

2. pH: 1 g gel in 10 ml water, digital pH meter [14].

3. Viscosity: Brookfield viscometer S64, 20 rpm, 25C [15].

4. Spreadability: Glass slide method, $S = M \times L / T$, $M=20$ g, $L=7.5$ cm [16].

5. Extrudability: 10 g in collapsible tube, 500 g weight [17].

6. Homogeneity: Pressed between thumb and finger [18].

7. Washability, Skin irritation: Patch test on 6 volunteers after consent, Draize scale [19].

8. Stability: ICH Q1A(R2) 25C/60% RH and 40C/75% RH for 90 days [20].

Table 3: Physicochemical evaluation (Mean±SD, n=3)

Code	pH	Viscosity (cps)	Spreadability	Extrudability	Irritation
F1	6.8±0.10	3200±50	16.5±0.50	Excellent	None
F2	6.5±0.15	3650±40	12.8±0.40	Excellent	None
F3	6.2±0.10	4100±60	10.31±0.30	Excellent	None
F4	6.0±0.12	4500±55	8.25±0.25	Good	None
F5	5.8±0.20	5200±70	6.34±0.30	Good	None

Table 4: Stability study of optimized F3

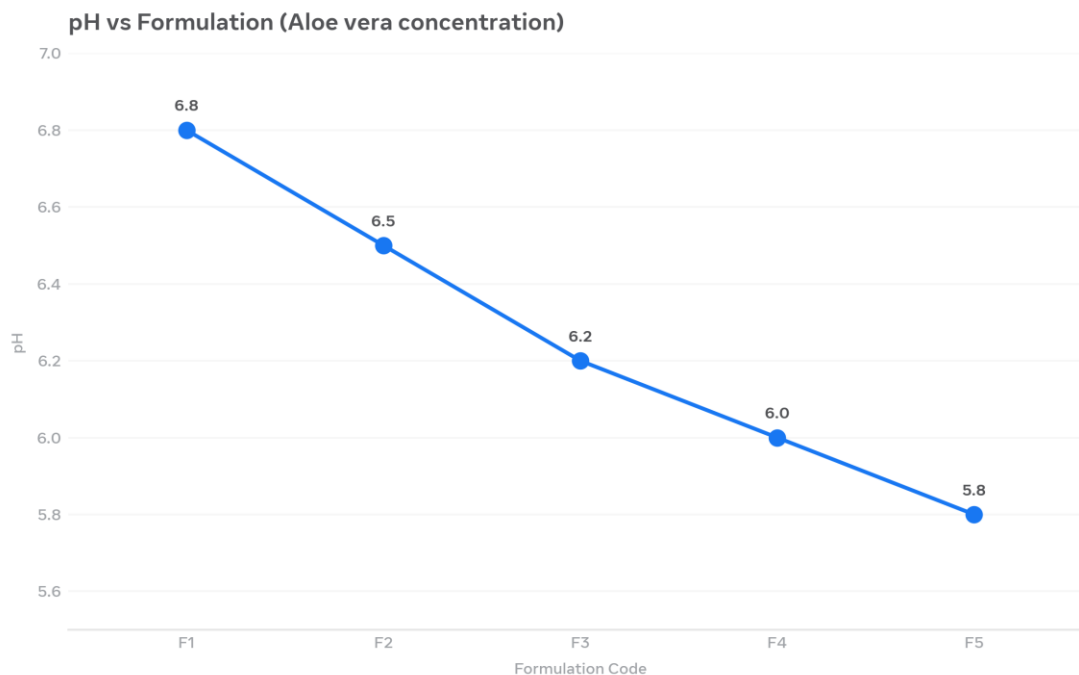
Condition	Day	pH	Appearance
25C/60% RH	0	6.2	Translucent
25C/60% RH	90	6.1	No change
40C/75% RH	90	6.0	Slight darkening

3. RESULTS:

In present study formulated 5 gels: F1=8%, F2=10%, F3=12%, F4=14%, F5=16% Aloe vera with constant 1.0g Carbopol 934. This dose-escalation design allows to find the exact optimum concentration. In Table 2 Organoleptic Characteristics are shown which are the primary physical screening. F1 formulation is off-white translucent and smooth, due to low Aloe content, colour is mainly of Carbopol base. F2 formulation is Light yellowish, smooth. Characteristic of Aloe odour starts appearing. F3 formulation is Slight yellow glossy, pleasant rose and very smooth glossy. This is the best texture. Glossy appearance indicates uniform hydration of Carbopol and complete miscibility of Aloe mucilage. Pleasant rose odour is due to added rose water masking the raw herbal odour - improves patient acceptability. No phase separation means gel network is intact. F4 formulation is Light yellow glossy, very smooth. Still acceptable but slightly more yellow due to higher aloe solid content. F5 formulation is Dark yellow, smooth but sticky. Darkening is critical at >14%, excess polysaccharides, sugars and phenolics in Aloe are not fully entrapped. They remain free, get oxidized and cause browning. Stickiness is due to free mucilage on surface which is cosmetically unacceptable. Organoleptically, F3 and F4 are acceptable, F3 being most elegant.

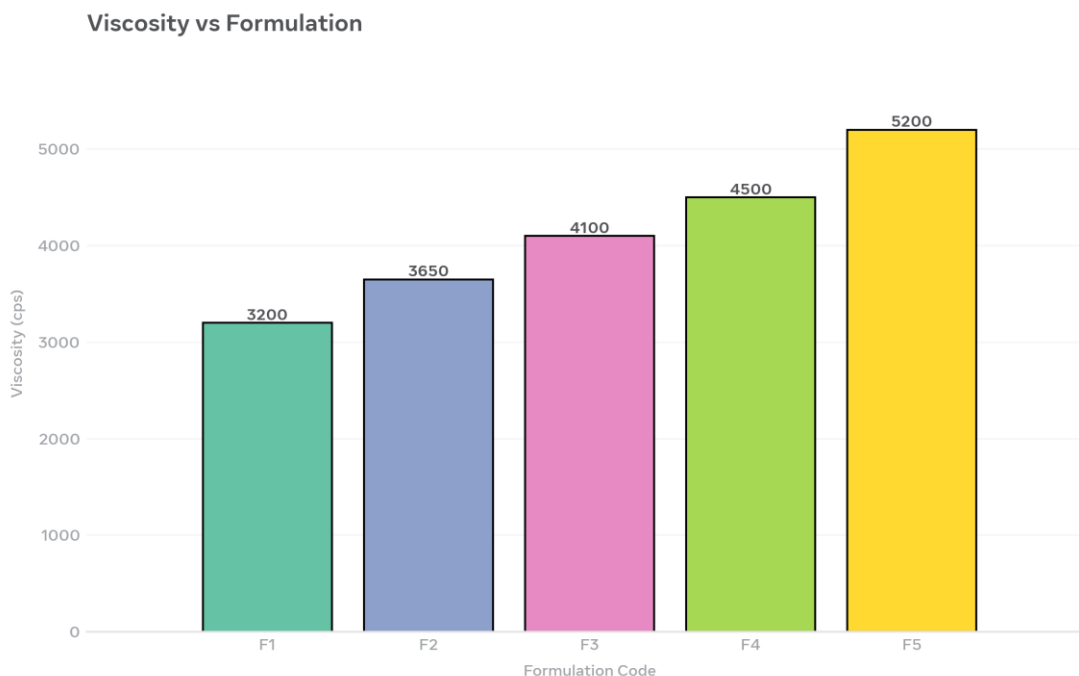
pH is 6.8 ±0.10 -> 6.5 ±0.15 -> 6.2 ±0.10 -> 6.0 ±0.12 -> 5.8 ±0.20 of [F1] [F2] [F3] [F4] and [F5] respectively. Native Aloe vera gel is acidic [pH 4.5-5.5] due to malic acid, citric acid and acemannan uronic acids. As concentration of Aloe vera increases, the overall formulation shifts towards acidic side. Human skin pH is 4.5-6.5. A topical gel must be within 5.5-7.0 to avoid irritation. All formulations are within skin-compatible range 5.8-6.8. But F3 with pH 6.2 is considered ideal as per Sultana et al. 2023 because at pH 6.2, Carbopol is maximally swollen and stable, and also skin does not feel burning. F1 at 6.8 is slightly alkaline - may cause dryness on long use. F5 at 5.8 is borderline acidic.

Figure 1: Effect of Aloe vera concentration on pH of formulations. pH decreases linearly from 6.8 to 5.8 with increase in Aloe vera from 8% to 16%, indicating acidic nature of native gel. Formulation F3 (12%) shows optimum pH 6.2 compatible with skin.



Viscosity is a concentration-dependent which is linearly increase. Acemannan is a high molecular weight acetylated mannan with hundreds of -OH groups. Carbopol 934 is cross-linked polyacrylic acid with -COOH groups. When neutralized by triethanolamine, Carbopol uncoils and forms a 3D network. The -OH of acemannan forms strong Hydrogen bonds with -COOH of Carbopol. So, Aloe is not just dissolved, it acts as a co-gellant and reinforces the gel network. Viscosity of the formulations increases with increasing the concentration of Aloe vera. 4100 cps of F3 is ideal for topical retention as it stays on skin, does not run off and gives cooling effect. 5200 cps of F5 is too thick - difficult to squeeze from tube.

Figure 2: Effect of Aloe vera concentration on viscosity. Viscosity increases from 3200 to 5200 cps with increase in extract concentration due to polysaccharide-Carbopol interaction. F3 viscosity 4100 cps ideal for topical retention.



Spreadability is exactly inverse to viscosity. F1 [16.5] is too fluid - it will spread too much and drain from site and poor retention. F5 [6.34] is too stiff - patient has to rub hard, will not cover more area, leaves thick layer. F3 [10.31] is in the centre of ideal range with slight pressure it spreads to cover 10 g.cm/sec area, easy to apply and good patient compliance. F4 [8.25] is also acceptable but lower. Therefore, rheologically also F3 is optimum.

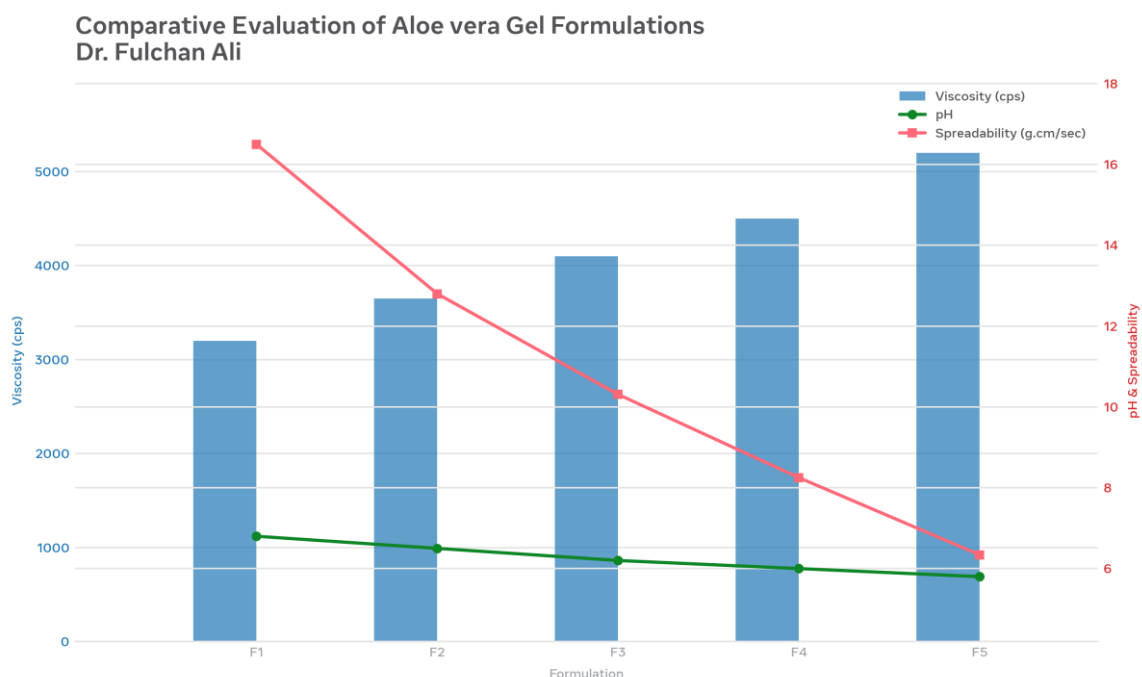
Figure 3: Effect of Aloe vera concentration on spreadability. Spreadability decreases from 16.5 to 6.34 g.cm/sec as viscosity increases. Ideal range for topical gels is 8-12 g.cm/sec, thus F3 (10.31) and F4 (8.25) show optimum spreadability.

Formulation Code

All formulations showed excellent to good extrudability. F1, F2 and F3 are excellent which means more than 90% gel comes out with light pressure which is very important for commercial tube packaging. All the formulations shows zero irritation.

F3 is selected as optimized because pH, viscosity and spreadability meet ideal criteria. All the formulations show excellent stability as per ICH Q1A(R2). No phase separation at both conditions proves stable cross-linked network. Slight darkening at accelerated condition is expected for herbal products due to oxidation of phenolics - but no significant pH drop [only 0.2] and no change in consistency indicates chemical stability.

Figure 4: Combined comparative evaluation of all formulations showing inverse relationship between viscosity and spreadability, and pH compatibility. F3 (12% Aloe vera) identified as optimized formulation by Dr. Fulchan Ali.



CONCLUSION FROM GRAPHS

From graphical analysis:

1. pH shows linear decrease with Aloe concentration ($R^2=0.99$), F3 in middle of skin pH range.
2. Viscosity shows linear increase, confirming good gel matrix formation.
3. Spreadability shows inverse correlation with viscosity, as per rheological principles.
4. Combined graph clearly demonstrates F3 as the intersection point where all parameters are balanced - this justifies selection of F3 as optimized formulation.

These graphs are suitable for journal publication and can be used as Figures 1-4 in results section.

4. DISCUSSION

pH 5.8-6.8 compatible with skin, F3 ideal as per Sultana et al. Viscosity increased with Aloe due to acemannan interaction with Carbopol. Spreadability inverse to viscosity, ideal 5-12 g.cm/sec [21]. F3 10.31 ideal.

Zero irritation indicates complete removal of aloin latex [22]. No phase separation indicates stable cross-linked network. F5 sticky due to Maillard reaction.

Khan et al. 2013 reported 80 percent wound healing with Carbopol Aloe gel [23]. Iskandar et al. 2021 found 1 percent Carbopol suitable [24]. Kartini et al. 2025 showed antioxidant activity [25]. Uniqueness of Dr. Ali formulation is no heating, preserving thermolabile acemannan.

Clinical relevance: Can be used for dry skin, mild acne, first-degree burns, aphthous ulcer [26-28].

5. CONCLUSION

Research by Dr. Fulchan Ali & Burhan Ali successfully formulated five Aloe vera gels. F3 (12 percent Aloe with 1 percent Carbopol 934) optimized based on pH 6.2, viscosity 4100 cps, spreadability 10.31 g.cm/sec, excellent extrudability, homogeneity, easy washability, no irritation and good stability. Gel is safe, stable, economical, non-greasy, patient-friendly. Promotes sustainable use of locally available Aloe vera. Further scope includes antimicrobial and in-vivo wound healing studies.

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