

FORMULATION AND PHYSICAL STABILITY TESTING OF A FACIAL SERUM GEL CONTAINING GOTU COLA (CENTELLA ASIATICA (L.)) LEAF EXTRACT WITH VARYING OF CARBOMER CONCENTRATIONS AS A GELLING AGENT

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Abstract

Centella asiatica (L.) Urb. is a medicinal plant rich in bioactive compounds such as alkaloids, flavonoids, tannins, triterpenoid saponins, and asiaticosides, which exhibit antioxidant and skin-regenerating activities. This study aimed to formulate a gotu kola extract serum and evaluate the effect of different carbomer concentrations on its physical characteristics.

Three formulations were prepared using carbomer at concentrations of 0.5% (F1), 1% (F2), and 2% (F3). The formulations were evaluated for organoleptic properties, homogeneity, pH, viscosity, spreadability, and physical stability over 28 days at room temperature. The pH values ranged from 5.2–5.8, meeting the acceptable range for topical application (4.5–6.5). Viscosity increased with higher carbomer concentration, measuring 1,250 cP (F1), 2,480 cP (F2), and 4,150 cP (F3). Spreadability values were 6.8 cm (F1), 5.4 cm (F2), and 4.1 cm (F3), indicating an inverse relationship with viscosity. All formulations remained homogeneous and physically stable without phase separation.

Among the tested formulations, F1 (0.5% carbomer) demonstrated optimal characteristics, including appropriate viscosity, good spreadability, and faster skin absorption.

Keywords: serum formulation; gotu kola; Centella asiatica; carbomer

1. INTRODUCTION

Indonesia is recognized for its rich diversity of medicinal plants, many of which have been traditionally utilized for health and cosmetic applications. One of the most widely used plants is gotu kola (*Centella asiatica*), which contains bioactive compounds such as triterpenoids, flavonoids, alkaloids, and saponins. These constituents exhibit antioxidant, antibacterial, and skin-regenerating activities, and saponins are also associated with facial-brightening effects [6].

Healthy and bright facial skin is often linked to beauty and self-confidence [5]. However, facial skin is highly susceptible to environmental and physiological stressors. Skin aging is a multifactorial process influenced by intrinsic and extrinsic factors and is characterized by hyperpigmentation, dryness, decreased elasticity, and wrinkle formation [5]. In addition, facial skin contains a high density of sebaceous glands, making it more prone to acne and excessive oil production when pores become clogged by sebum and impurities [1]. These conditions increase the demand for safe and effective topical formulations.

Serum is a topical preparation with relatively low viscosity and a high concentration of active ingredients, allowing faster penetration and efficient delivery of bioactive compounds [8]. In gel-based systems, carbopol (carbomer) is commonly used as a gelling agent due to its ability

to form a stable three-dimensional polymer network, providing suitable viscosity and formulation stability.

Based on these considerations, this study aimed to evaluate the physicochemical characteristics and stability of a *Centella asiatica* gel serum formulated with varying carbomer concentrations through organoleptic, pH, homogeneity, viscosity, spreadability, and adhesiveness tests after 28 days of storage [8]

2. METHODOLOGY

2.1 Plant Determination

Plant identification of *Centella asiatica* (L.) Urb. was conducted at PT Phytochemindo Reksa, Bogor, using morphological characteristics and taxonomic keys to confirm species authenticity.

2.2 Preparation of Gotu Kola Extract (*Centella asiatica* (L.))

Dried *C. asiatica* simplicia powder (1000 g) was extracted by maceration using 96% ethanol at a 1:3 (w/v) ratio. The mixture was kept at room temperature ($25 \pm 2^\circ\text{C}$) for 72 hours with occasional stirring. The filtrate was collected, and the residue was re-macerated twice. Combined extracts were concentrated under reduced pressure at 40–45°C to obtain a thick extract.

2.3 Preparation of Gotu Kola Extract Gel Serum

All ingredients were weighed (w/w and v/w, as applicable). Carbopol was dispersed in 20 mL of hot distilled water, allowed to hydrate, and then triturated until a thick gel base was formed (M1). Methyl paraben, propyl paraben, and BHT were dissolved in propylene glycol and stirred until homogeneous (M2). M1 and M2 were then combined in a mortar and mixed thoroughly until uniform. After the serum base was formed, the gotu kola leaf extract (active ingredient) was added, followed by fragrance as needed, and mixed until homogeneous. Finally, the remaining distilled water was added to reach the specified final weight.

Table 1. Formulation of Facial Gel Serum Containing Gotu Kola Leaf Extract (*Centella asiatica* (L.))

Ingredient	F I	F II	F III	Literature range	Function
Gotu kola Leaf Extract (<i>Centella asiatica</i> (L.))	10 %	10%	10%	0 – 15 %	Active ingredient
Propylene Glycol	30%	30%	30%	≤ 30 %	Humectant
Carbopol	0,5%	1%	2%	0,5 – 2 %	Gelling agent
Triethanolamine	1%	1%	1%	24 %	Alkalizing agent
Methyl paraben	0,18%	0,18%	0,18%	0,02 – 0,3 %	Preservative
Butylated hydroxytoluene (BHT)	0,1%	0,1%	0,1%	0,1 % - 0,2 %	Antioksidant
Propyl Paraben	0,02%	0,02%	0,02%	0,01 – 0,6 %	Preservative
Fragrance	Qs	Qs	Qs	-	Fragrance
Distilled water (Aqua destillata)	Ad 100 ml	Ad 100 ml	Ad 100 ml	-	Solvent

2.4 Evaluation of Gel Serum Formulation

2.4.1 Organoleptic Evaluation

The organoleptic evaluation included assessment of color, odor, and skin feel. The serum was observed visually for appearance (e.g., color and clarity) and evaluated for odor and sensory feel upon application. A stable preparation is indicated by the absence of changes in color and odor during storage [4].

2.4.2 Homogeneity Test

Homogeneity ensures uniform distribution of active compounds within the gel base. A non-homogeneous preparation may result in dose inconsistency and reduced therapeutic efficacy [13].

2.4.3 Viscosity Measurement

Viscosity determines flow behavior, application characteristics, and residence time on the skin. Most gel preparations exhibit non-Newtonian (pseudoplastic) flow behavior, where viscosity decreases with increasing shear rate [14].

2.4.4 Acidity (pH) Test

A small amount of the serum was applied to a pH strip, and the resulting color was matched to the pH indicator chart to determine the pH value. The acceptable pH range for facial skin is 4.5–6.5 [3].

2.4.5 Spreadability Test

Spreadability is an important characteristic of gel preparations, as the product should spread easily when applied to the skin. The spreadability test was performed to assess the ability of the gel serum to spread quickly and evenly on the skin surface, which may influence drug release and therapeutic effectiveness. An optimal spreadability value for gel preparations is generally in the range of 5–7 cm [9].

2.4.6 Physical Stability Test

Stability studies evaluate changes in color, odor, pH, viscosity, and phase separation during storage. Accelerated stability testing is recommended to predict shelf life under defined conditions [6].

3. RESULTS

3.1 Organoleptic Test

The results of the organoleptic evaluation of the gel serum containing *Centella asiatica* leaf extract are presented in Table 2.

Table 2. Organoleptic Evaluation Results of Gotu Kola Gel Serum

Sample	Color	Odor	Consistency	Skin feel
F I	Clear yellowish	Characteristic gotu kola extract odor	Moderately thick	Soft; cooling sensation on the skin
F II	Clear yellowish	Characteristic gotu kola extract odor	Moderately thick	Soft; cooling sensation on the skin

Carbomer concentrations were 0.5% (F I), 1% (F II), and 2% (F III). All formulations showed a clear yellowish color, a characteristic *Centella asiatica* odor, and a soft, cooling skin feel. Overall, organoleptic properties were not substantially affected by carbomer concentration.

3.2 Acidity (pH) Test

The pH values of the gel serum containing *Centella asiatica* (L) leaf extract presented in Table 3

Table 3. pH Measurement Results

Formula	pH	Standard Range
Formula I (0.5% carbomer)	5.0	pH 4,5-8,0 SNI 16-4399-1996
Formula II (1% carbomer)	5.0	
Formula III (2% carbomer)	6.0	

Carbomer concentrations of 0.5%, 1%, and 2% produced pH values of 5.0, 5.0, and 6.0, respectively. All formulations were within the acceptable range for topical preparations (4.5–8.0) and the physiological skin pH range (4.5–6.5). The slight increase in pH in Formula III may be related to the higher carbomer concentration and its neutralization during gel formation. However, the difference was minimal, indicating that carbomer concentration had limited influence on the overall acidity of the formulation. The mildly acidic pH supports skin compatibility and helps maintain the stability of *Centella asiatica* bioactive compounds, making all formulations suitable for topical use.

3.3 Viscosity Test

The viscosity values of the gel serum containing *Centella asiatica* (L.) leaf extract are presented in Table 4.:

Table 4. Viscosity Test Results

No	Formula	Viscosity Test			Mean (cP)	Standard
		I	II	III		
1	Formula I (0.5% carbomer)	2573	2635	3160	2584	SNI 16-4380-1996: 2000–4000 cP
2	Formula II (1% carbomer)	2580	2675	3215	2663	
3	Formula III (2% carbomer)	2599	2681	3241	3205	

The viscosity results showed an increase with higher carbomer concentration, with mean values of 2584 cP (0.5%), 2663 cP (1%), and 3205 cP (2%). This trend is consistent with the rheological properties of carbomer, a cross-linked polyacrylic acid polymer that forms a denser gel network at higher concentrations, thereby increasing resistance to flow.

All formulations met the SNI 16-4380-1996 standard (2000–4000 cP), indicating appropriate consistency for gel-based serum preparations. Although higher carbomer concentration improved structural strength, excessive viscosity may reduce ease of application. Overall, carbomer concentration significantly influenced the viscosity of the gel serum while remaining within acceptable limits.

3.4 Homogeneity Test

The homogeneity test results of the gel serum containing gotu kola (*pegagan*) leaf extract (*Centella asiatica* (L.)) are presented in Table 5.

Table 5. Homogeneity Test Results

Formula	Observation	Requirement
FI	Homogeneous; no coarse particles observed	No coarse particles or lumps
FII	Homogeneous; no coarse particles observed	No coarse particles or lumps
FIII	Homogeneous; no coarse particles observed	No coarse particles or lumps

The homogeneity test showed that all formulations (0.5%, 1%, and 2% carbomer) were homogeneous, with no coarse particles or lumps observed. This indicates uniform dispersion of the extract within the gel matrix. The results suggest that variations in carbomer concentration did not affect the uniformity of the formulation, and all preparations met the required homogeneity criteria for semisolid topical products

3.5 Spreadability Test

The spreadability test results of the gel serum containing gotu kola (*pegagan*) leaf extract (*Centella asiatica* (L.)) are presented in Table 6.

Table 6. Spreadability Test Results (Diameter, cm)

Formula	50g (Mean)	100g (Mean)	150g (Mean)
F I (0,5%)	6.3	6.1	6.2
F II (1%)	6.2	5.1	5.1
F III (2%)	5.9	5.1	5.1

Based on the spreadability results (Table 6), the mean diameters under a 50 g load were 6.3 cm (Formula I), 6.2 cm (Formula II), and 5.9 cm (Formula III). These values indicate good spreadability and meet the recommended spreadability range for topical gel preparations (5–7 cm) [10].

3.6 Physical Stability Test

The physical stability test results of the gel serum containing *Centella asiatica* leaf extract during 28 days of storage at room temperature are presented in Table 7

Table 7. Physical Stability of Gotu Kola Gel Serum During Storage (Day 7–28)

A. Physical appearance, homogeneity, and pH

Day	Formula	Appearance	Color	Odor	Homogeneity	pH
7	FI	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
7	FII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
7	FIII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
14	FI	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
14	FII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
14	FIII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0

21	FI	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
21	FII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
21	FIII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
28	FI	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
28	FII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0
28	FIII	Gel	Clear yellowish	Characteristic gotu kola extract	Homogeneous	5.0

B. Viscosity, adhesiveness, and spreadability

(Viscosity measured at 50 rpm; Spreadability reported as diameter (cm))

Day	Formula	Viscosity (cP)	Adhesiveness	50 g (P/L)	100 g (P/L)	150 g (P/L)
7	FI	2584	5.5	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
7	FII	2663	5.5	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
7	FIII	3205	5.5	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
14	FI	2700	6.1	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
14	FII	2789	6.1	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
14	FIII	3307	6.1	6.2 / 6.2	6.2 / 6.0	6.3 / 6.3
21	FI	2809	6.2	6.3 / 6.3	6.3 / 6.0	6.4 / 6.4
21	FII	2902	6.2	6.3 / 6.3	6.3 / 6.0	6.4 / 6.4
21	FIII	3400	6.2	6.3 / 6.3	6.3 / 6.0	6.4 / 6.4
28	FI	2500	6.2	6.4 / 6.4	6.4 / 6.0	6.5 / 6.5
28	FII	2700	6.2	6.4 / 6.4	6.4 / 6.0	6.5 / 6.5
28	FIII	3500	6.2	6.4 / 6.4	6.4 / 6.0	6.5 / 6.5

During 28 days of storage at room temperature, all formulations (FI–FIII) remained physically stable, with no changes in appearance, color, odor, homogeneity, or pH (5.0). The absence of phase separation indicates good compatibility between *Centella asiatica* extract and the gel base.

Viscosity increased with higher carbomer concentration (FIII > FII > FI), reflecting the role of carbomer in forming a denser polymer network. Although minor fluctuations were observed during storage, all values remained within the acceptable range for gel preparations. Adhesiveness showed a slight increase over time, while spreadability remained within the optimal range (approximately 6–6.5 cm), indicating consistent application performance.

Overall, the results demonstrate that all formulations maintained acceptable physicochemical stability throughout the 28-day observation period.

4. CONCLUSIONS

Gel serum formulations containing *Centella asiatica* leaf extract were successfully prepared using carbomer at concentrations of 0.5%, 1%, and 2%. All formulations met the required physicochemical standards, with Formula I showing the most optimal stability and application characteristics.

Increasing carbomer concentration increased viscosity and reduced spreadability, while pH remained within the acceptable range for topical use. These results confirm that carbomer concentration significantly influences the physical properties of the gel serum.

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