RESEARCH PAPER

Formulation and Evaluation of an Antioxidant Peel-Off Gel Mask Containing Butterfly Pea (*Clitoria ternatea* L.) Flower Extract and Cucumber (*Cucumis sativus* L.) Extract

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ABSTRACT

Background: Plant-derived antioxidants are increasingly used in topical cosmetics, and peel-off gel masks are a convenient film-forming format for delivering them. **Objective:** To formulate and evaluate an antioxidant peel-off gel mask containing butterfly pea (*Clitoria ternatea* L.) flower extract and cucumber (*Cucumis sativus* L.) extract. **Methods:** Both plant materials were authenticated and macerated in methanol, and the extracts were characterized by Fourier-transform infrared (FTIR) spectroscopy. Five 30 g batches (F1–F5) were prepared with polyvinyl alcohol (PVA, 4.20 g) and hydroxypropyl methylcellulose (HPMC, 0.45 g) as film formers, butterfly pea extract at 0.50–1.50 g and cucumber extract at 0.30–1.50 g. The batches were evaluated for appearance, homogeneity, pH, spreadability, drying time, peelability and washability. Viscosity was measured for the selected batch, and in vitro 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was compared with ascorbic acid. **Results:** All batches were dark blue to dark purple, soft, homogeneous and washable. The pH of 10% dispersions ranged from 6.67 to 6.86, mean spreadability from 73.3 to 87.3 g·cm, and drying time was about 22 min. F4 had the highest spreadability, the shortest drying time and an easily peelable film, and was selected as the optimized formulation; its viscosity was 12,600 cP. DPPH inhibition by the gel increased from 3.23% to 85.33% over 10–320 µg/mL, and the concentration giving 50% inhibition was about 53 µg/mL for the gel and 3.3 µg/mL for ascorbic acid. **Conclusion:** A homogeneous, washable and peelable PVA/HPMC gel containing both extracts showed concentration-dependent in vitro antioxidant activity, lower than that of ascorbic acid. Stability and skin safety were not evaluated and are needed before any claim of skin benefit.

Keywords: Peel-off gel mask, *Clitoria ternatea*, *Cucumis sativus*, Polyvinyl alcohol, DPPH, Herbal cosmetics.
How to cite this article: R. Uma Prabha1* Rajakumari Rajendran1 Mithun N1 Tejashwini N1 Tharun K1 Varshitha A1. Formulation and Evaluation of an Antioxidant Peel-Off Gel Mask Containing Butterfly Pea (Clitoria ternatea L.) Flower Extract and Cucumber (Cucumis sativus L.) Extract. Int J Drug Deliv Technol. 2026;16(90s):1774-1780. DOI: 10.25258/ijddt.16.90s.178.
Source of support: Nil.
Conflict of interest: None.

INTRODUCTION

The skin is the largest organ of the body and the first barrier against ultraviolet radiation, pollutants, microorganisms and water loss. Its outer layer, the stratum corneum, together with the underlying epidermis and dermis, preserves hydration, elasticity and defence against environmental stress.[1,2] Reactive oxygen species (ROS) generated by ultraviolet exposure and pollution overwhelm the skin's own antioxidant defences, and the resulting oxidative damage to lipids, proteins and collagen contributes to wrinkling, loss of firmness and pigmentation.[3,4] Concern about long-term use of synthetic ingredients has increased interest in herbal cosmetics and cosmeceuticals, which use plant phenolics, flavonoids and anthocyanins as antioxidant actives.[5,6]

Among cosmetic formats, the peel-off mask is popular because it dries on the skin into a thin, flexible film that is lifted off, removing surface debris, sebum and loose corneocytes while keeping the active ingredients in contact with the skin for the duration of drying. Film-forming polymers such as PVA and HPMC, with a humectant plasticizer such as glycerin, are its usual functional excipients.[7,8] Herbal peel-off masks have been reported with fenugreek, green tea, lemon powder and honey,[9] with charcoal,[10] with bidara leaf extract,[11] with curcumin and *Rosa damascena* extract,[12] and with green clay and aloe vera in a PVA membrane.[13] Such products are characterized by pH, viscosity, spreadability, drying time and peelability.

Clitoria ternatea L. (butterfly pea; Fabaceae) petals contain ternatin-type anthocyanins, flavonol glycosides and cyclotides,[14,15] and petal extracts show antioxidant activity in vitro.[16,17] An eye gel containing the petal extract has been described,[18] and a peel-off gel mask of the extract has been evaluated for stability and antioxidant activity.[19] *Cucumis sativus* L. (cucumber; Cucurbitaceae) fruit is water-rich and widely used for its cooling and soothing effect; its extracts have shown free-radical scavenging activity,[20] antioxidant, anti-hyaluronidase and anti-elastase potential,[21] and, for an aqueous fraction, reduced angiotensin II-induced inflammation and oxidative stress in vitro.[22] The DPPH assay is a simple and widely used in vitro screen of radical-scavenging capacity.[23]

Peel-off formulations containing butterfly pea extract alone have been reported.[19] A literature search did not identify a previous report of a PVA/HPMC peel-off gel that combines butterfly pea and cucumber extracts. The combination was chosen to pair a polyphenol-rich flower extract with a water-rich fruit extract in one film-forming base. The aim of this work was to formulate such a gel, evaluate its physicochemical characteristics, and measure its in vitro antioxidant activity.

MATERIALS AND METHODS

Materials

PVA (film former), HPMC (thickener and film former), methanol (extraction solvent), glycerin (humectant and plasticizer), phenoxyethanol (preservative) and distilled water (vehicle) were used. For the DPPH assay, DPPH (Sigma, USA), methanol (Merck) and ascorbic acid (Sigma) were used. The overall workflow is summarized in Fig. 1.

Collection and authentication of plant materials

Fresh butterfly pea flowers and cucumbers were purchased from a local market in Bengaluru, Karnataka, and inspected for freshness and absence of damage, fungal infection and contamination. The samples were identified and authenticated by the Central Ayurveda Research Institute (CARI), Bengaluru (certificate dated 06/08/2026) as *Cucumis sativus* L., Cucurbitaceae (RRCBI-15367) and *Clitoria ternatea* L., Fabaceae (RRCBI-19968).

Preparation of the extracts

Butterfly pea extract. Flowers were cleaned, shade-dried and powdered in a blender. A known amount of powder was submerged in 50% aqueous methanol in a beaker covered with aluminium foil and left for 72 h at room temperature with periodic shaking. The mixture was filtered through Whatman No. 1 filter paper and muslin cloth, and the filtrate was concentrated in a water bath at 50 °C.

Cucumber extract. Cucumbers were washed with distilled water, chopped and blended to a smooth paste. A specified amount of paste was macerated in 100% methanol in a foil-covered glass beaker for 72 h at room temperature with periodic shaking. The mixture was filtered (Whatman No. 1 and muslin cloth) and the filtrate evaporated in a water bath at about 50 °C. The concentrate was stored refrigerated in an amber bottle.

Fig. 1. Workflow for extraction, formulation and evaluation of the peel-off gel mask.

FTIR characterization of extracts

Spectra of both concentrated extracts were recorded on a Bruker FTIR instrument operated with OPUS software (version 9.2.4), and peak positions were assigned to functional-group classes.

Formulation of the peel-off gel mask

Five 30 g batches (F1–F5) were prepared. PVA (4.20 g), HPMC (0.45 g), glycerin (0.90 g) and phenoxyethanol (0.24 g) were constant, butterfly pea extract (0.50–1.50 g) and cucumber extract (0.30–1.50 g) were varied, and distilled water was added to weight (Table 1). PVA was dissolved in distilled water at 80–90 °C with constant stirring to a clear solution. HPMC was dissolved separately in distilled water and added slowly to the PVA solution with stirring to form a homogeneous gel base. Glycerin was added with continuous stirring, followed by the concentrated extracts and then phenoxyethanol, and the weight was adjusted with distilled water. The gels were packed in clean, airtight, amber-coloured containers and stored at room temperature.

Table 1. Composition of peel-off gel mask formulations (30 g batch)

Ingredient (function)	F1	F2	F3	F4	F5
Polyvinyl alcohol (film former)	4.20 g	4.20 g	4.20 g	4.20 g	4.20 g
HPMC (thickener, film former)	0.45 g	0.45 g	0.45 g	0.45 g	0.45 g
Butterfly pea extract (antioxidant)	0.50 g	0.75 g	1.00 g	1.25 g	1.50 g
Cucumber extract (antioxidant)	0.30 g	0.45 g	0.60 g	0.75 g	1.50 g
Glycerin (humectant)	0.90 g	0.90 g	0.90 g	0.90 g	0.90 g
Phenoxyethanol (preservative)	0.24 g	0.24 g	0.24 g	0.24 g	0.24 g
Distilled water (vehicle)	q.s.	q.s.	q.s.	q.s.	q.s.

Evaluation of the gel mask

Appearance and homogeneity. Colour, odour and texture were assessed visually and by touch, and gels were inspected for lumps, phase separation and air bubbles. Homogeneity was judged visually and by gently rubbing the gel between the fingers. *pH.* About 1 g of each formulation was diluted with 10 mL of distilled water, and pH was read on a digital pH meter calibrated with standard buffer solutions. *Spreadability.* Gel (1 g) was placed between two glass slides and a 100 g weight was applied for 5 min. Spreadability was calculated as $S = M \times L / T$, where M is the weight on the upper slide (g), L the distance moved (cm) and T the time taken (min); each batch was tested in triplicate.

Viscosity. Viscosity of the optimized formulation (F4) was measured on a Brookfield (Ametek) viscometer with spindle RV6. About 10 g of sample was held at about 25.2 °C and rotated at 20 rpm for about 60 s until a constant reading was displayed (Poornayu Research Labs, Bengaluru; report dated 22/08/2026). *Drying time.* An equal quantity of each formulation was applied to a clean glass slide, and the time to form a completely dried film was recorded with a stopwatch. *Peelability and washability.* An even layer (1 g) on a clean glass slide was left to dry and the film was peeled from one side; ease of peeling was recorded qualitatively. The surface was then examined for residue and washed with tap water.

DPPH free radical scavenging assay

DPPH solution (0.1 mM) was prepared by dissolving 3.94 mg DPPH in methanol and making up to 100 mL, and was stored protected from light at 4 °C. Sample solutions of the gel (10, 20, 40, 80, 160 and 320 µg/mL) and of ascorbic acid as positive control (1, 2, 4, 8, 16 and 32 µg/mL) were prepared in methanol. DPPH solution (2 mL) was mixed with 2 mL of sample

solution or standard by vortexing, so that the concentration in the reaction mixture was half that of the sample solution; concentrations in this paper are those of the sample solutions. The control received 2 mL of methanol. After 30 min in the dark at room temperature, absorbance was read at 517 nm on a Shimadzu UV-1900i spectrophotometer. Scavenging activity (%) was calculated as $[(A_{control} - A_{sample}) / A_{control}] \times 100$. The concentration giving 50% inhibition (IC_{50}) was estimated by log-linear interpolation between the two concentrations bracketing 50% inhibition, and sigmoidal (four-parameter logistic) curves were fitted to % inhibition against log concentration using GraphPad Prism. A lower IC_{50} indicates higher potency.

Data handling

Spreadability is reported as mean ± sample standard deviation of three trials. All other physical evaluations were single determinations and are reported as observed. Percentage inhibition was recalculated from the recorded absorbances, and the curve fitting and graphs were prepared with GraphPad Prism and Microsoft Excel.

RESULTS AND DISCUSSION

Extracts and FTIR findings

The butterfly pea macerate was deep blue-black and the cucumber macerate light green (Fig. 2). The butterfly pea extract showed FTIR bands at 3262.68, 2933.81, 1632.85, 1511.89, 1406.93, 1358.85, 1260.04, 1054.18 and 922.51 cm^{-1}, and the cucumber extract at 3255.90, 2929.20, 1637.98, 1408.86, 1303.07, 1258.04, 1149.46, 1056.09 and 1032.23 cm^{-1} (Fig. 3, Table 2). In both, a broad band near 3255–3263 cm^{-1} is consistent with O–H groups and bands near 2930 cm^{-1} with aliphatic C–H. Bands near 1633–1638 cm^{-1} were assigned to C=O/C=C stretching and bands between about 1000 and 1300 cm^{-1} to C–O stretching. The 1511.89 cm^{-1} band of the butterfly pea extract was assigned to aromatic C=C, consistent with phenolic constituents. These assignments are at the level of functional-group class. Crude polar extracts also contain carbohydrates and other oxygenated compounds that absorb in the same regions, so the spectra do not identify anthocyanins, flavonoids or any specific compound.

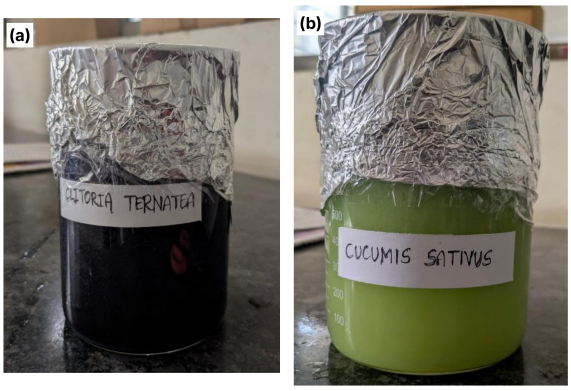

Fig. 2. Methanolic macerates of (a) *C. ternatea* flowers and (b) *C. sativus* fruit after 72 h maceration.

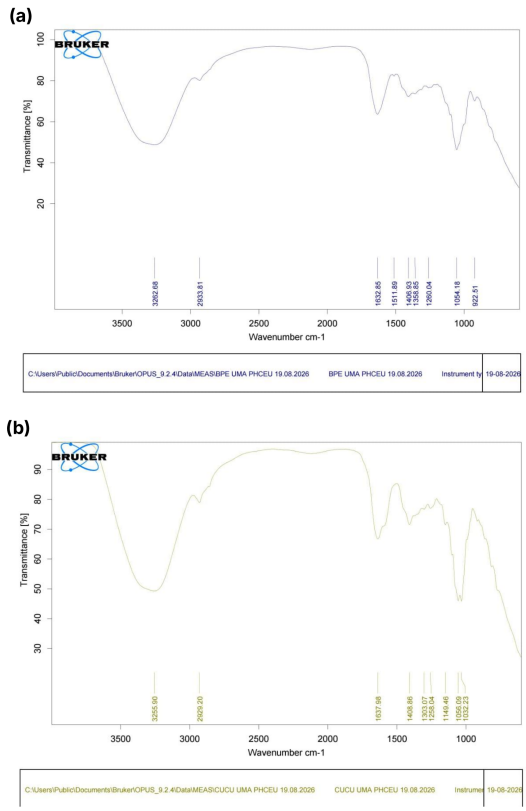

Fig. 3. FTIR spectra of (a) *C. ternatea* extract and (b) *C. sativus* extract, with peak positions (cm^{-1}).

Table 2. FTIR peaks (cm^{-1}) of the extracts and class-level assignments

Assignment	*C. ternatea* extract	*C. sativus* extract
O–H stretch (hydroxyl-containing compounds)	3262.68	3255.90
C–H stretch (aliphatic)	2933.81	2929.20
C=O / C=C stretch	1632.85	1637.98
Aromatic C=C stretch	1511.89	–
C–H / O–H bending	1406.93; 1358.85	1408.86
C–O stretch / O–H bending	–	1303.07
C–O stretch (phenols, ethers)	1260.04	1258.04
C–O–C / C–O (ethers, carbohydrates, glycosides)	–	1149.46
C–O stretch (alcohols, glycosides, polysaccharides)	1054.18	1056.09; 1032.23
C–H / C–O fingerprint vibrations	922.51	–

Formulation composition and appearance

The five batches (Fig. 4) kept polymer, humectant and preservative constant and differed in extract content. PVA provides the cohesive, elastic film, HPMC increases viscosity and film strength, and glycerin acts as a plasticizer that limits brittleness of the dried film. Butterfly pea and cucumber extracts were raised together from F1 to F4 at a fixed weight ratio of 1.67:1, whereas in F5 the cucumber extract was 1.50 g (ratio 1.00:1). Extract content was therefore varied together with extract ratio, and the design does not allow the contribution of each extract to be separated.

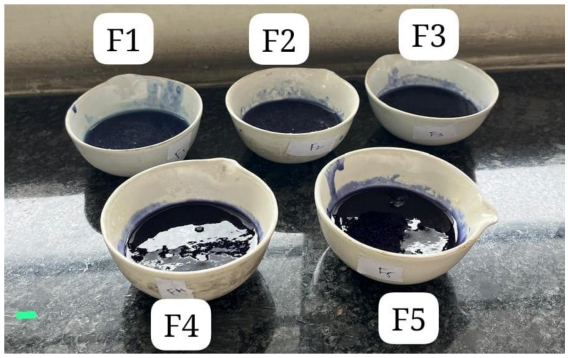

Fig. 4. Peel-off gel mask formulations F1–F5.

All batches were dark blue, with F4 and F5 shading to dark purple, and had a sweet characteristic odour. F1 and F2 were soft, and F3–F5 soft and smooth (Table 3). All five gels showed uniform extract distribution by visual and finger-touch assessment. Colour and texture were judged by eye without grading or colorimetry, so differences between batches are descriptive.

Table 3. Organoleptic characteristics and homogeneity of the formulations

Batch	Colour	Odour	Texture	Homogeneity
F1	Dark blue	Sweet, characteristic	Soft	Uniform
F2	Dark blue	Sweet, characteristic	Soft	Uniform
F3	Dark blue	Sweet, characteristic	Soft and smooth	Uniform
F4	Dark blue to dark purple	Sweet, characteristic	Soft and smooth	Uniform
F5	Dark blue to dark purple	Sweet, characteristic	Soft and smooth	Uniform

pH, spreadability, drying time, peelability and washability

The pH of the 10% dispersions ranged from 6.67 (F1) to 6.86 (F5) (Table 4), slightly above the 4.5–6.5 range generally preferred for skin products. The pH was measured on a 1:10 aqueous dilution, which may differ from that of the neat gel, and a future reformulation may need pH adjustment, taking into account the dependence of anthocyanin colour on pH. No skin-irritation testing was carried out, so the pH data alone do not establish that the gels are non-irritant.

Mean spreadability (n = 3) was 81.33 (F1), 73.33 (F2), 83.67 (F3), 87.33 (F4) and 82.67 (F5) g·cm. F4 had the highest mean and F2 the lowest, but the trial-to-trial variation (SD 2.3–5.0) overlaps between batches, so the differences are descriptive and no statistical comparison was made. Drying times on glass slides were 22 min 1 s (F1), 22 min 3 s (F2), 22 min 6 s (F3), 22 min 0 s (F4) and 22 min 8 s (F5). F4 was shortest, but the whole range is 8 s, which is within what manual stopwatch timing would be expected to cover, and does not indicate a meaningful difference. F1 and F4 were rated easily peelable and F2, F3 and F5 peelable, and all films were washable with no residue noted. Peelability and washability were qualitative and were tested on glass, not on skin.

Table 4. Physicochemical evaluation of the peel-off gel formulations

Batch	pH	Spreadability (g·cm), mean ± SD	Drying time	Peelability	Washability
F1	6.67	81.33 ± 3.06	22 min 1 s	Easily peelable	Washable
F2	6.82	73.33 ± 5.03	22 min 3 s	Peelable	Washable
F3	6.85	83.67 ± 2.89	22 min 6 s	Peelable	Washable
F4	6.84	87.33 ± 2.31	22 min 0 s	Easily peelable	Washable
F5	6.86	82.67 ± 3.06	22 min 8 s	Peelable	Washable

Spreadability: three trials per batch (sample SD). pH: 1 g gel in 10 mL distilled water.

Viscosity and selection of the optimized formulation

The optimized formulation F4 had a viscosity of 12,600 cP (Brookfield, spindle RV6, 20 rpm, 25.2 °C). Viscosity was measured for this batch only, at a single speed, so no relationship between extract content and viscosity can be drawn. F4 was taken forward for viscosity and antioxidant testing because it had the highest mean spreadability, the shortest drying time, an easily peelable film and a soft, smooth texture. It was not best on every parameter: F1 had the pH closest to the intended range and was also easily peelable. The selection was therefore a qualitative judgement, without a scoring scheme or inferential testing, and F4 is not claimed to be statistically superior.

DPPH antioxidant activity

The gel showed concentration-dependent scavenging of DPPH radicals, from 3.23% at 10 µg/mL to 85.33% at 320 µg/mL, and ascorbic acid from 34.86% at 1 µg/mL to 89.32% at 32 µg/mL (Fig. 5, Table 5). Interpolating between the bracketing concentrations, 50% inhibition was reached at about 53 µg/mL for the gel (between 40 and 80 µg/mL) and about 3.3 µg/mL for ascorbic acid (between 2 and 4 µg/mL), so on a mass basis the gel was roughly 16-fold less potent than the standard. Sigmoidal curve fitting gave similar values (about 53 and 3.5 µg/mL). The midpoints of the fitted curves (about 38 and 7 µg/mL) differ from these, because the fitted lower asymptote of ascorbic acid is already about 33% and the midpoint of a curve is not the concentration at 50% inhibition; the 50%-inhibition concentrations are therefore reported as IC_{50}. The activity is consistent with the phenolic and hydroxyl-rich constituents indicated by FTIR, but the gel is a mixture of extracts and excipients, and the activity cannot be assigned to particular compounds.

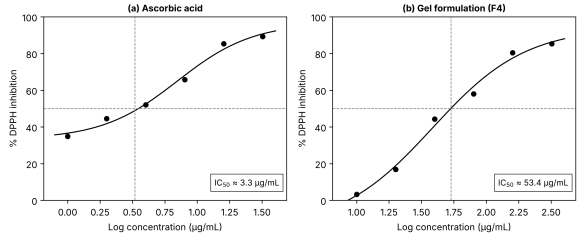

Fig. 5. DPPH concentration–response curves (% inhibition against log concentration) of (a) ascorbic acid and (b) the gel formulation F4. Dashed lines mark 50% inhibition and the corresponding IC_{50}.

Table 5. DPPH radical scavenging activity (517 nm) of ascorbic acid and the gel formulation (F4)

Sample	Sample conc. (µg/mL)	Absorbance	Inhibition (%)	IC_{50} (µg/mL)
Ascorbic acid	Control	0.740	0	≈ 3.3
	1	0.482	34.86	
	2	0.410	44.59	
	4	0.355	52.03	
	8	0.253	65.81	
	16	0.108	85.41	
	32	0.079	89.32	
Gel formulation (F4)	Control	0.743	0.00	≈ 53
	10	0.719	3.23	
	20	0.618	16.82	
	40	0.414	44.28	
	80	0.312	58.01	
	160	0.145	80.48	
	320	0.109	85.33	

IC_{50}: concentration giving 50% inhibition, by log-linear interpolation between the bracketing concentrations.

Formulation and quality considerations

Several features of the present gel bear on its further development. First, methanol was the extraction solvent, and residual solvent was not quantified; for a leave-on or rinse-off cosmetic, a cosmetically acceptable solvent such as ethanol–water, or a validated residual-solvent limit, would be required. Second, anthocyanins are pH-sensitive pigments that shift in colour with pH, so the dark blue to purple colour, its stability and the possibility of skin staining need to be examined together with any pH adjustment. Third, the extract levels (about 3–10% w/w of the batch) were chosen to give a workable gel and were not optimized; a designed study varying the two extracts independently would show which one drives antioxidant activity and film properties. Finally, the antioxidant result is a chemical screen of the gel as a whole. Skin penetration or retention from a film that remains on the skin for about 20 min was not measured, and the practical benefit of a peel-off format for actives delivery should be tested with appropriate in vitro permeation or in vivo methods.

The main characteristics of the optimized formulation F4 and the points still open are summarized in Table 6.

Table 6. Summary of the optimized formulation F4

Attribute	Observation for F4	Remark
Appearance and texture	Dark blue to dark purple, soft and smooth	Visual assessment only
Homogeneity	Uniform	No lumps or phase separation seen
pH (1 g in 10 mL water)	6.84	Slightly above the 4.5–6.5 skin range
Spreadability	87.33 ± 2.31 g·cm	Highest mean of the five batches
Drying time	22 min 0 s on glass	Differences between batches negligible
Peelability, washability	Easily peelable; washable	Tested on glass, not skin
Viscosity	12,600 cP (RV6, 20 rpm, 25.2 °C)	Single batch, single speed
DPPH, 50% inhibition	About 53 µg/mL (ascorbic acid about 3.3 µg/mL)	No placebo or replicates
Stability, safety	Not evaluated	Required before skin-benefit claims

Limitations and scope for further work

This was a single-batch study in which most tests were single determinations and no statistical analysis was performed. Each DPPH sample was tested as one concentration series without SD or confidence intervals, no placebo gel (base without extracts) was tested, and the blue anthocyanin-containing gel may absorb near 517 nm, so the activity cannot be attributed with certainty to the extracts. Extract yield and standardization were not determined, and viscosity was measured for F4 only. Stability, microbial quality, preservative efficacy, skin irritation and in vivo performance were not evaluated, and peelability and washability were assessed on glass. Further work should include placebo-controlled and replicated antioxidant assays, pH adjustment, accelerated stability studies and a patch test before any claim of skin benefit.

CONCLUSION

Five PVA/HPMC peel-off gel batches containing butterfly pea and cucumber extracts were prepared. All were homogeneous, soft, washable and peelable on glass, with pH 6.67–6.86, mean spreadability 73.3–87.3 g·cm and a drying time of about 22 min. F4 was selected on a qualitative basis, and its viscosity was 12,600 cP. The gel showed concentration-dependent DPPH scavenging, with 50% inhibition at about 53 µg/mL compared with about 3.3 µg/mL for ascorbic acid. The formulation is a candidate herbal antioxidant peel-off mask, and placebo-controlled antioxidant testing, stability studies and safety evaluation are required before any claim about skin benefit.

ACKNOWLEDGEMENTS

The authors thank the Principal and the Department of Pharmaceutics, The Oxford College of Pharmacy, Bengaluru; the Central Ayurveda Research Institute, Bengaluru, for plant authentication; and Poornayu Research Labs, Bengaluru, for viscosity measurement. The authors also acknowledge Amulya R, Pallavi TR, Aijaz Mohammed Bhat and Sadhik Ahmed Borbhuyan, whose B.Pharm project work (2024–2025) generated the experimental data reported here.

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